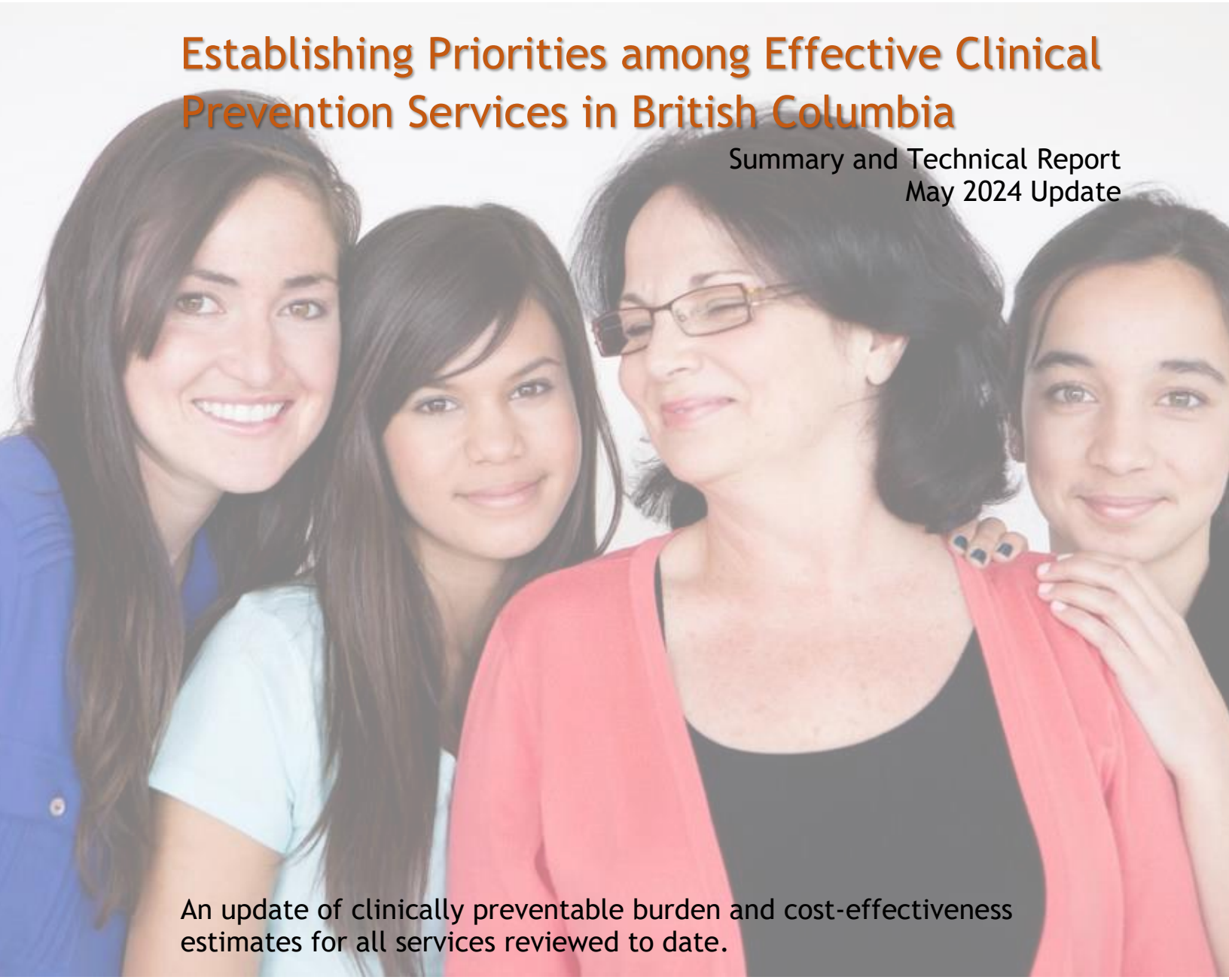
The Lifetime Prevention Schedule

Establishing Priorities among Effective Clinical Prevention Services in British Columbia

Summary and Technical Report
May 2024 Update



An update of clinically preventable burden and cost-effectiveness estimates for all services reviewed to date.

BRITISH COLUMBIA

Acknowledgments

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Establishing Priorities among Effective Clinical Prevention Services in British Columbia: *2023/24 Update*

Executive Summary

Background

The report, *A Lifetime of Prevention*, was published by the Clinical Prevention Policy Review Committee (CPPRC) in December of 2009.[1] A key goal of the CPPRC was to determine which clinical prevention services are worth doing in British Columbia (BC), culminating in a proposed Lifetime Prevention Schedule (LPS). Clinical prevention services were included on the LPS if they were considered to be effective, had a significant positive impact on population health and were cost-effective.

Clinical prevention services (CPS) are defined as:

> *Manoeuvres pertaining to primary and early secondary prevention (i.e., immunization, screening, counselling and preventive medication/device) offered to the general population (asymptomatic) based on age, sex and risk factors for disease and delivered on a one-provider-to-one-client basis, with two qualifications:*
>
> > *(i) the provider could work as a member of a care team or as part of a system tasked with providing, for instance, a screening service; and*
> >
> > *(ii) the client could belong to a small group (e.g. a family, a group of smokers) that is jointly benefiting from the service.*

This definition does not refer to the type of provider or the type of funding. This allows for the evaluation of the appropriate implementation of the service as a separate program planning matter.

Since 2009, a total of 31 CPS have been reviewed by the Lifetime Prevention Schedule Expert Committee (LPSEC) for potential inclusion in the LPS.

In the past two fiscal years (2022/23 and 2023/24) major updates have been made to the following four CPS; preventing tobacco use in children and youth, screening for cervical cancer, screening for primary prevention of fragility fractures and screening for prediabetes / type 2 diabetes. In addition, the LPSEC completed an evidence update for routine aspirin use for the prevention of cardiovascular disease and colorectal cancer, screening for chlamydial / gonococcal infections and the use of fluoride varnish for the prevention of dental caries in children. A new CPS, screening and interventions to reduce anxiety in children and youth was also modelled. Finally, all other existing models were given a 'light' refresh to update costs

[1] Clinical Prevention Policy Review Committee. *A Lifetime of Prevention: A Report of the Clinical Prevention Policy Review Committee*. 2009. Available at http://www.health.gov.bc.ca/library/publications/year/2009/CPPR_Lifetime_of_Prevention_Report.pdf. Accessed July 2017.

from 2017 to 2022 Canadian dollars. As such, all costs in this document are in 2022 Canadian dollars unless stated otherwise.

Note that this document has a companion document, the *Reference and Key Assumptions Document*, in which all key model assumptions are recorded in one location.

CPS Intervention Rate

Table ES-1 provides a one-page summary of the CPS reviewed by the LPSEC to date. Included on the table are the relevant cohort and the frequency with which the service is to be provided. In addition, an estimated rate of coverage for the service in British Columbia and the best rate in the world is provided.

For example, the best available evidence suggests that screening for colorectal cancer is effective in the general asymptomatic population ages 45 to 75 (the relevant cohort). Ideally, screening should take place every 2 years (frequency) using a fecal immunochemical test (FIT). An estimated 50% (rate of coverage in BC) of the relevant cohort in BC are currently receiving screening at this frequency. International evidence suggests that this rate could be improved to 77% (best rate in the world).

Table ES1: Potential Clinical Prevention Services in B.C.
Summary of the Applicable Cohort, Service Frequency and Coverage

Clinical Prevention Services	Cohort / Timing	Frequency / Intensity	Estimated Coverage B.C.	Estimated Coverage 'BiW'(1)
Screening for Asymptomatic Disease or Risk Factors - Children/Youth (C/Y)				
Vision screening for amblyopia	Ages 3-5	At least once	93%	93%
Screening for depression	Ages 12 - 18	Annually	Unknown	57%
Screening for anxiety	Ages 8 - 18	Annually	Unknown	57%
Behavioural Counseling Interventions - Children/Youth (C/Y)				
Growth monitoring and healthy weight management in children and youth	Ages 6 - 17	Screening - At all appropriate primary care visits	Unknown	13%
		Intervention - Attendance at >70% of ten 2-hour sessions.	7.2%	7.2%
Promotion of breastfeeding	During pregnancy and after birth	Multiple sessions	Unknown	46%
Preventing tobacco use (school-aged children & youth)	Ages 6 - 17	Annually	Unknown	53%
Preventive Medication / Devices - Children				
Dental sealants	On permanent teeth at time of tooth eruption (ages 6 - 12)	4 times (on 1st and 2nd bicuspids & molars)	Unknown	59%
Screening for Asymptomatic Disease or Risk Factors - Adults				
Screening for breast cancer	Ages 50 - 74	Every 2 -3 years	52%	88%
Screening (cytology-based) for cervical cancer	Ages 25 - 69	Every 3 years	69%	69%
Screening (HPV-based) for cervical cancer	Ages 25 - 69	Every 5 years	0%	69%
Screening for colorectal cancer	Ages 45 - 75	FIT every 2 years	50%	77%
Screening for lung cancer	Ages 55 - 74 with a 30 pack-year smoking history	Annually for 3 consecutive years	Unknown	6%/60%
Screening for hypertension	Ages 18 and older	Screening - At least once every 2 years	Unknown	88%
Screening for cardiovascular disease risk and treatment (with statins)	Ages 40 -74	Screening - Once every 5 years	Unknown	48%
		Management - Ongoing	Unknown	30%
Screening for prediabetes / type 2 diabetes	Ages 35 - 70 with overweight or obesity	Every 3 years	Unknown	81%
Screening for depression	Nonpregnant adults ages 18+	At least once	Unknown	12%
Screening for depression	Pregnant and postpartum women	At least once per birth by 8 weeks postnatally	Unknown	39%
Screening for fragility fractures	Females age ≥ 65	Every 8 years	Unknown	58%
Screening for abdominal aortic aneurysm	Males age 65 who have ever smoked	One-time	Unknown	86%
Screening for Sexually Transmitted Infections and Blood Borne Pathogens - Adults				
Screening for human immunodeficiency virus	Ages 15 - 65	Low risk - Once	20%	45%
		Increased risk - Every 3 - 5 years		63%
		Very high risk - Every year		83%
		During all pregnancies	96%	97%
Screening for hepatitis C virus	Adults born between 1945 - 1965	One-time	31%	83%
Behavioural Counseling Interventions - Adults				
Prevention of sexually transmitted infections (STIs)	All sexually active adolescents and adults who are at increased risk for STIs	30 min to ≥2 hours of intensive behavioral counseling	Unknown	29%
Counselling and interventions to prevent tobacco use	Ages 18 and older	Up to 90 min of total counseling time, during multiple contacts	19%	51%
Alcohol misuse screening and brief counseling	Ages 18 and older	Screening - Annually during primary care visits	Unknown	93%
		Screening - Pregnant women	Unknown	97%
		Brief Intervention - Three 10-minute sessions (30 minutes)	Unknown	41%
Screening and interventions to reduce unhealthy drug use	Ages 18 and older	Simple screen annually	Unknown	40%
		If simple screen positive, detailed screen	Unknown	15%
		If detailed screen positive, brief intervention	Unknown	33%
Screening for and management of obesity	Ages 18 and older	Screening - Ongoing	Unknown	73%
		Management - At least one-time of 12 - 26 sessions in a year	Unknown	33%
Preventing falls	Community–dwelling elderly ages 65+	Screening for risk - Every year	Unknown	18%
		Exercise or physical therapy - At least 150 minutes of moderate intensity / week	Unknown	Unknown
		Vitamin D supplementation - 800 IU / day for at least 12 months	Unknown	61%
Preventive Medication / Devices - Adults				
Folic acid supplementation for the prevention of neural tube defects	Reproductive-age females	0.4 to 0.8 mg (400 - 800µg) of folic acid daily	Unknown	34%

(1) 'BiW' = best in world; (2) CPB = clinically preventable burden; (3) CE = cost-effectiveness

Summary of the Clinically Preventable Burden and Cost-Effectiveness

Table ES-2 also provides a one-page summary of the CPS reviewed by the LPSEC to date. Included on this table, however, is information on the clinically preventable burden (CPB) and cost-effectiveness (CE) associated with each of the maneuvers.

CPB is defined as the total quality-adjusted life years that could be gained if the clinical preventive service was to be delivered at recommended intervals to a BC birth cohort of 40,000 individuals over the years of life that a service is recommended. CE is defined as the average net cost per QALY gained by offering the clinical preventive service at recommended intervals to a BC birth cohort over the recommended age range.

The *CPB* columns identify the clinically preventable burden (in terms of quality adjusted life years or QALYs) that is being achieved in BC based on current coverage, and the potential CPB if the best coverage rate in the world (BiW) could be achieved. For example, if coverage for colorectal cancer screening were as high as the BiW (77%), we would expect a CPB of 3,617 QALYs. Since BC's coverage is at 50%, a CPB of 2,349 QALYs is being achieved. This is 1,268 QALYs short of the potential 3,617 QALYs achievable based on BiW coverage, as identified in the *Gap* column.

Note that coverage rates in BC are only known for 8 of the maneuvers reviewed by the LPSEC to date.

The *CE* columns identify the cost-effectiveness ratio associated with a service stated in terms of the cost per QALY. The ratio is given based on the use of a 1.5% and a 0% discount rate. For example, the cost/QALY associated with colorectal cancer screening in BC is estimated at $18,064, based on a discount rate of 1.5%. If a 0% discount rate is used, then the cost/QALY would be reduced to $12,562.[2]

[2] For a discussion on discounting, see the section on *Discounting* in the companion *Reference and Key Assumptions Document*.

Table ES2: Potential Clinical Prevention Services in B.C.
Summary of the Clinically Preventable Burden and Cost-Effectiveness

Clinical Prevention Services	CPB(2) (0% Discount) B.C.	'BiW'(1)	Gap	CE(3) (% Discount) 1.5%	0%
Screening for Asymptomatic Disease or Risk Factors - Children/Youth (C/Y)					
Vision screening for amblyopia	2.4	2.4	0	$5,169,538	$453,110
Screening for depression (ages 12-18)	Unknown	1,880		$28,359	$26,423
Screening for anxiety (ages 8-18)	Unknown	3,247		$12,552	$12,200
Behavioural Counseling Interventions - Children/Youth (C/Y)					
Growth monitoring and healthy weight management in children and youth	195	195	0	$33,680	$20,756
Interventions to support breastfeeding	6,299	9,291	2,992	Cost-saving	Cost-saving
Preventing tobacco use (school-aged children & youth)	Unknown	22,935		Cost-saving	Cost-saving
Preventive Medication / Devices - Children					
Dental sealants	Unknown	157		Cost-saving	Cost-saving
Screening for Asymptomatic Disease or Risk Factors - Adults					
Screening for breast cancer	815	1,380	565	$20,211	$18,783
Screening (cytology-based) for cervical cancer	4,034	4,034	0	$5,077	$3,808
Screening (HPV-based) for cervical cancer	0	4,215	4,215	$2,502	$1,610
Screening for colorectal cancer	2,349	3,617	1,268	$18,064	$12,562
Screening for lung cancer	Unknown	2,060		$2,122	$1,969
Screening for hypertension	Unknown	16,548		Cost-saving	$269
Screening for cardiovascular disease risk and treatment (with statins)	Unknown	7,102		$4,487	$2,105
Screening for prediabetes and type 2 diabetes mellitus	Unknown	3,655		Cost-saving	Cost-saving
Screening for depression in general adult population	Unknown	-7		Dominated	Dominated
Screening for depression in pregnant and postpartum women	Unknown	99		$24,425	$21,003
Screening for fragility fractures	Unknown	348		$18,832	$15,205
Screening for abdominal aortic aneurysm	Unknown	495		$9,300	$7,479
Screening for Sexually Transmitted Infections and Blood Borne Pathogens - Adults					
Screening for human immunodeficiency virus	Unknown	360		$18,930	$18,930
Screening for hepatitis C virus	*	555		$3,846	$1,632
Behavioural Counseling Interventions - Adults					
Prevention of sexually transmitted infections (STIs)	Unknown	3,267		$12,454	$12,454
Counselling and interventions to prevent tobacco use	3,704	5,904	2,200	Cost-saving	Cost-saving
Screening and behavioural counseling interventions to reduce unhealthy alcohol use	Unknown	5,703		$10,147	$10,147
Screening and interventions to reduce unhealthy drug use	Unknown	325		$62,440	$48,951
Screening for and management of obesity	Unknown	2,278		$14,150	$13,292
Preventing falls	Unknown	450		$35,988	$35,988
Preventive Medication / Devices - Adults					
Folic acid supplementation for the prevention of neural tube defects	Unknown	74		$398,537	$231,765

(1) 'BiW' = best in world; (2) CPB = clinically preventable burden; (3) CE = cost-effectiveness

** More than 31% of the 1945-1964 birth cohort in BC has been screened for hepatitis C. The CPB for this CPS is calculated based on the 1945 - 1964 birth cohort that has not yet been screened.*

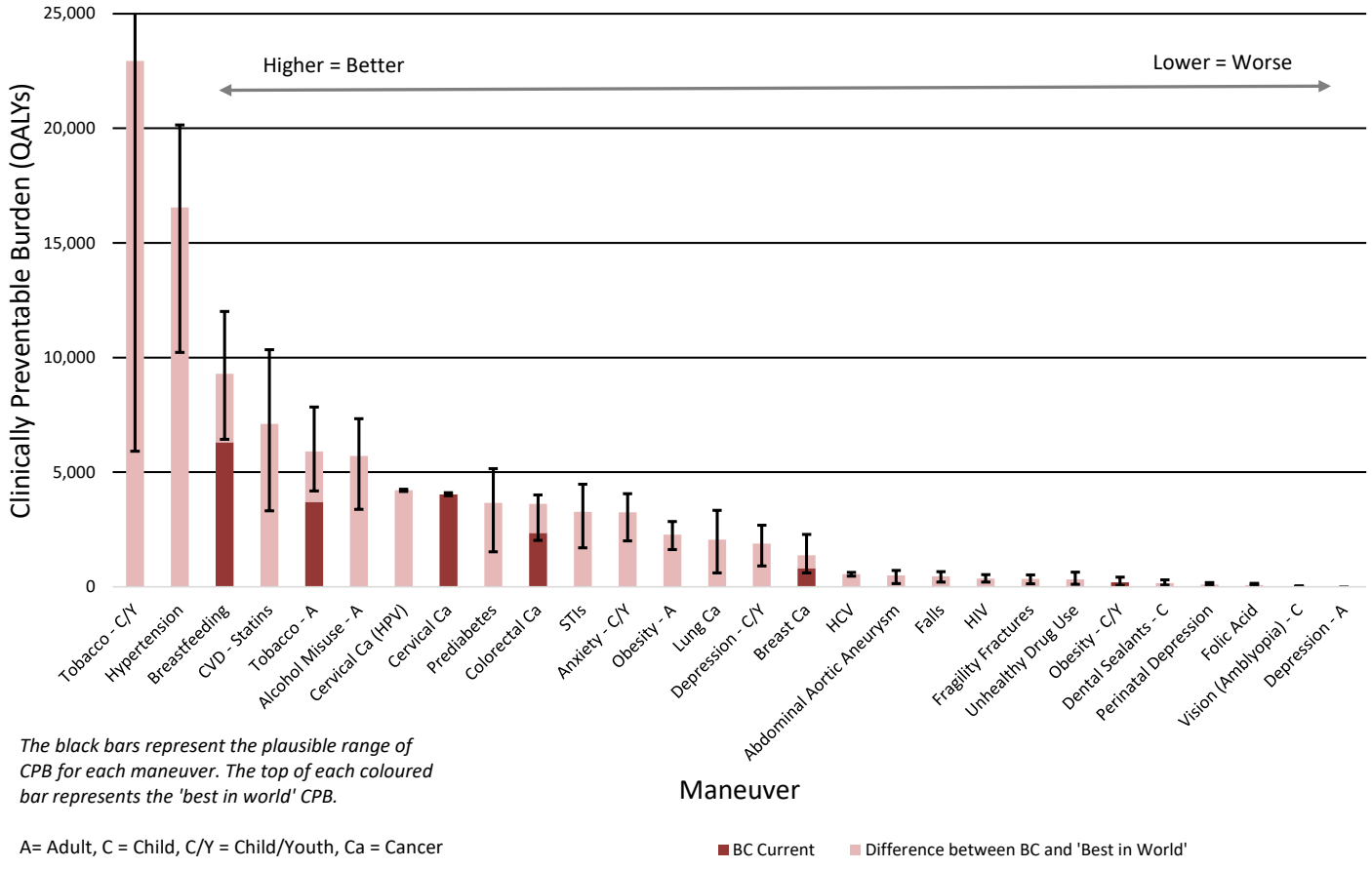
Comparison by Clinically Preventable Burden

Figure ES-1 provides a summary of the CPB associated with each service. Results are displayed based on a 0% discount rate. Results based on a 1.5% discount rate are available in the main body of this document. Using a 1.5% discount rate tends to reduce the CPB.[3] The results are organized from left to right based on the services with the highest to lowest potential CPB. For example, full implementation of the service *preventing tobacco use in children and youth* (Tobacco – C/Y) (i.e., achieving levels that are comparable to the best in the world) would result in a CPB of 22,935 QALYs, the highest of any service reviewed.

For the eight services for which BC coverage rates are known, we have indicated (by the darker bar insert) what proportion of the potential BiW rate is currently being achieved in BC.

The black bars associated with each service represent a potential range in CPB based on one-way sensitivity analysis. That is, the range is based on varying (over a plausible range) the one assumption that has the largest effect on the results generated by the model. Simultaneously varying more than one assumption would increase the potential range. A larger range suggests a higher sensitivity to the assumptions used.

Figure ES1: ***Clinically Preventable Burden*** Based on Providing Clinically Effective Services to a B.C. Birth Cohort of 40,000
(0% Discount Rate)



The black bars represent the plausible range of CPB for each maneuver. The top of each coloured bar represents the 'best in world' CPB.

A= Adult, C = Child, C/Y = Child/Youth, Ca = Cancer

[3] For a discussion on discounting, see the section on *Discounting* in the companion *Reference and Key Assumptions Document*.

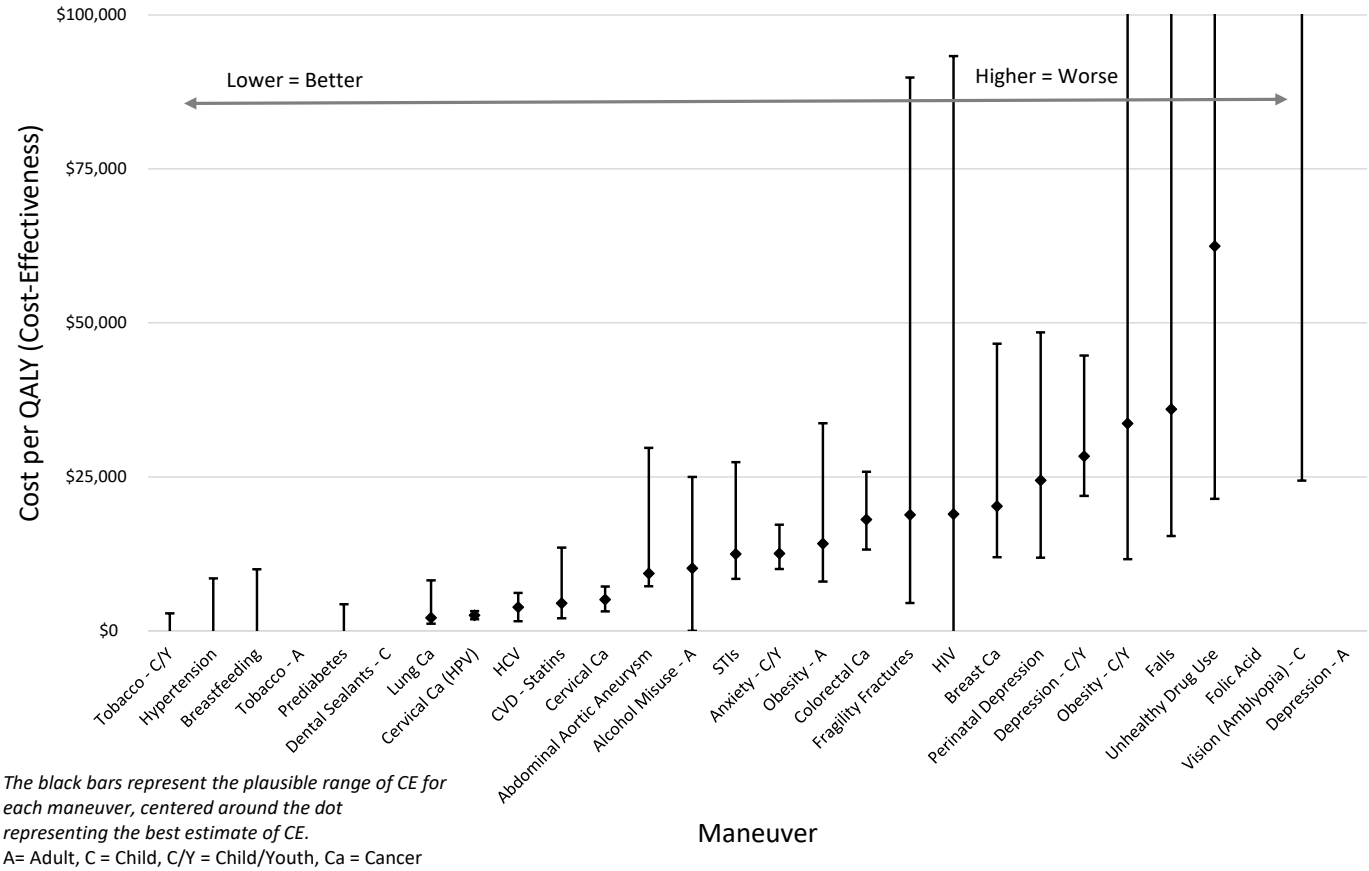
Note that the labels on the horizontal axis in Figures ES-1 and ES-2 refer to the CPS included in Table ES-1. The 'A' refers to adults, the 'C' to children, the 'C/Y' to children/youth and the 'Ca' to cancer.

Comparison by Cost-Effectiveness

Figure ES-2 provides a summary of the CE associated with each service. Results are displayed based on a 1.5% discount rate. Results based on a 0% discount rate are available in the body of the text. Using a 0% discount rate tends to improve the CE. Furthermore, the results are organized from left to right based on the services with the best to worst potential CE, including a plausible range for each service based on sensitivity analysis. Six of the CPS are cost-saving (far left of the chart). These six have been ordered from left to right based on the highest to lowest CPB. For four of the six, the sensitivity analysis indicates that the results could move out of the cost-saving range. For the other two (*counselling and interventions to prevent tobacco use in adults* and *dental sealants in children*) the sensitivity analysis suggests that the intervention is cost-saving, regardless of the changes in model assumptions.

On the far right of the chart are three CPS in which the results indicate a cost per QALY that is greater than $100,000, including *folic acid supplementation for the prevention of neural tube defects* (with a CE of $398,537 per QALY ranging from $280,380 to $989,319), *vision screening for amblyopia* (with a CE of $5,169,538 per QALY ranging from $24,390 to $12,921,661) and *screening for depression in adults* (the model results for this CPS suggest that the harms likely outweigh the benefits, thus the CPS is not worth doing at any cost).

Figure ES2: ***Cost per QALY*** (Cost-Effectiveness) Based on Providing Clinically Effective Services to a B.C. Birth Cohort of 40,000
(1.5% Discount Rate)



The black bars represent the plausible range of CE for each maneuver, centered around the dot representing the best estimate of CE.
A= Adult, C = Child, C/Y = Child/Youth, Ca = Cancer

The base models include an estimate of costs associated with a person's time used in accessing the preventive service. The most significant effect of these inclusions/exclusions is seen in services that require frequent contact with health care providers, such as behavioural counselling to prevent alcohol misuse in adults. For this service, the cost/QALY is reduced from $10,147 to being cost-saving if patient time costs are excluded.

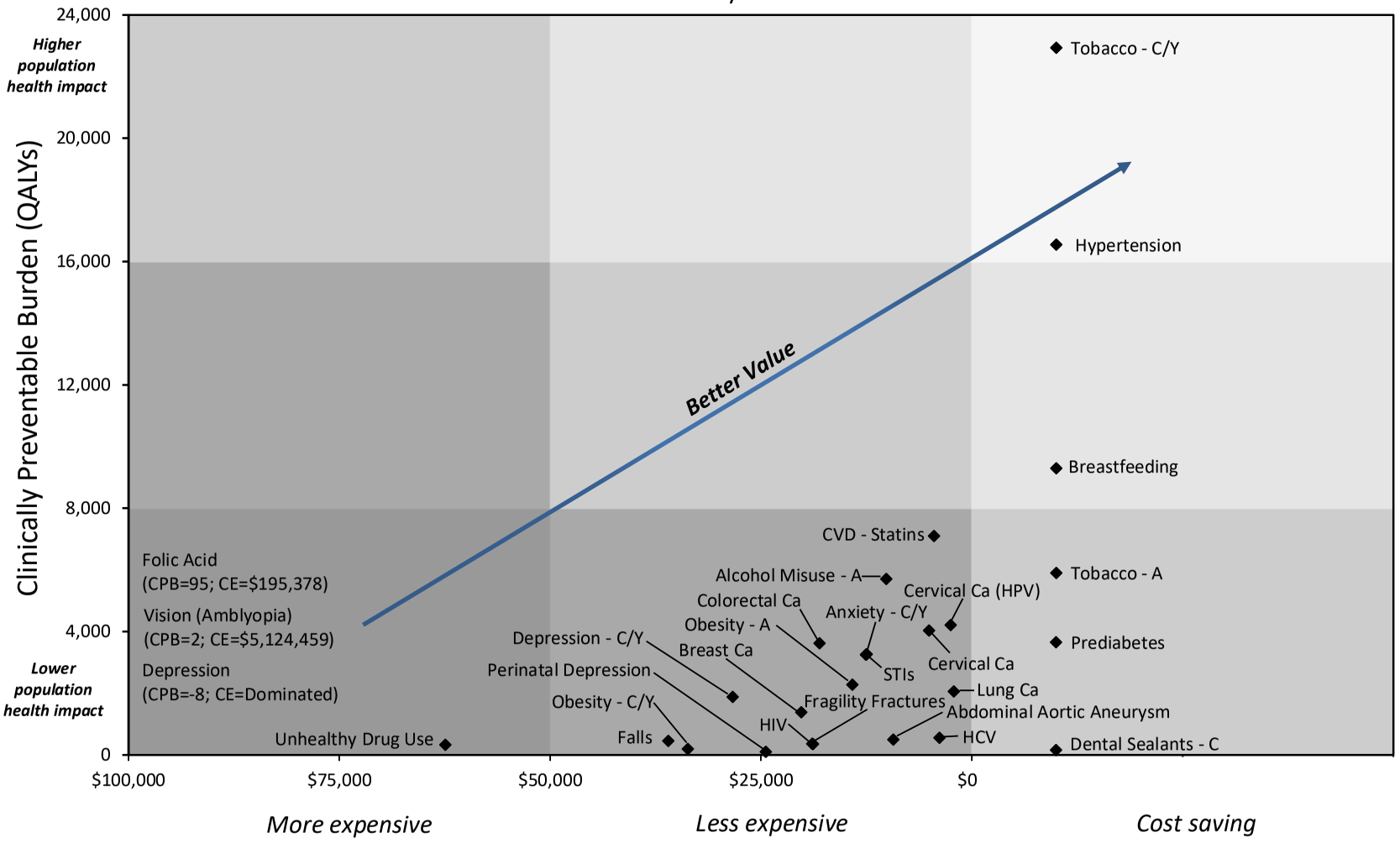
Combined Comparison Using CPB and CE

The results for CPB and CE are combined in Figure ES-3. CPB is on the vertical axis, ranging from 0 to 24,000 QALYs. CE is on the horizontal axis, ranging from $100,000/QALY at the intersection of the x- and y-axis to cost-saving at the right of the x-axis. By arranging CPB and CE in this manner, the most positive results are on the upper right of the chart and the least positive results are in the lower left of the chart. We also divided CPB into three equal segments as follows; 0 to 8,000 QALYs, 8,001 to 16,000 QALYs and 16,001 to 24,000 QALYs. CE was also divided into equal segments as follows: $100,000 to $50,000 per QALY, $50,000 to $0 per QALY and cost-saving.

The resulting nine segments are shown in Figure ES-3. Services in the upper right segment have the most favourable combination of CPB and CE while services in the lower left segment have the least favourable combination of CPB and CE.

Figure ES3: **Establishing Priorities Among Effective Clinical Prevention Services in BC**

Combining Clinically Preventable Burden and Cost-Effectiveness
Summary Results



List of Abbreviations

AAA – Abdominal Aortic Aneurysm

AABR – Automated Auditory Brainstem Response

ABR – Auditory Brainstem Response

ACC – American College of Cardiology

ACR - Albumin to Creatinine Ratio

AD – Anti-Depressant(s)

AD – Atopic Dermatitis

ADAM – Aneurysm Detection and Management

AHA – American Heart Association

AMI - Acute Myocardial Infarction

AOBP - Automated Office Blood Pressure

APC - Annual Percent Change

apoB – Apolipoprotein B

AQoLS – Alcohol Quality of Life Scale

ASA – Acetylsalicylic Acid

ASCVD – Atherosclerotic Cardiovascular Disease

ASIR - Age-standardized Incidence Rate

ASSIST - Alcohol, Smoking and Substance Involvement Screening Test

AOAE – Automated Otoacoustic Emissions

AUD – Australian Dollars

AUDIT - Alcohol Use Disorders Identification Test

AUGIB – Acute Upper Gastrointestinal Bleeding

BC – British Columbia

BCCSU – British Columbia Centre on Substance Use

BCEHP – British Columbia Early Hearing Program

BC-HTC – BC Hepatitis Testers Cohort

BD – Binge Drinking

BDI – Beck Depression Inventory

BiW – Best in the World

BFHI – Baby Friendly Hospital Initiative

BMD – Bone Mineral Density

BMI – Body Mass Index

BMT – Bone Marrow Transplant

CAD – Canadian Dollars

CAGE – Cut Down, Annoyed, Guilty, Eye-Opener

CANRISK - Canadian Diabetes Risk Assessment Questionnaire

CBT – Cognitive Behavioural Therapy

CCHD – Critical Coronary Heart Disease – also used for Critical Congenital Heart Defects

CCHS – Canadian Community Health Survey

CCS – Canadian Cardiovascular Society

CCSA – Canadian Centre on Substance Abuse (former name of Canadian Centre on Substance Use and Addiction)

CCSUA - Canadian Centre on Substance Use and Addiction

CISUR - Canadian Institute for Substance Use Research

CDC – Centers for Disease Control and Prevention

CE – Cost-Effectiveness

CGAS - Children's Global Assessment Scale

CHD – Coronary Heart Disease

CHEP - Canadian Hypertension Education Program

CI – Confidence Interval

CIN – Cervical Intraepithelial Neoplasia

CISUR – Canadian Institute for Substance Use Research

CKD - Chronic Kidney Disease

CLEM – Cardiovascular Life Expectancy Model

CMG – Case Mix Group

COF – Canadian Obesity Foundation

CPB – Clinically Preventable Burden

CPCSSN - Canadian Primary Care Sentinel Surveillance Network

CPS – Clinical Prevention Service

CRC – Colorectal Cancer

CSS – Canadian Cardiovascular Society

CSVS – Canadian Society for Vascular Surgery

CTADS – Canadian Tobacco, Alcohol and Drugs Survey

CTFPHC – Canadian Task Force on Preventive Health Care

CUD – Cannabis Use Disorder

CV – Cardiovascular

CVD – Cardiovascular Disease

DAA – Direct-acting antivirals

DAST-10 - 10 item Drug Abuse Screening Test

dB – Decibels

DPP - Diabetes Prevention Program

DSM - Diagnostic and Statistical Manual of Mental Disorders

DXA - Dual-Energy X-ray Absorptiometry

ECG – Electrocardiogram

eGFR - Estimated Glomerular Filtration Rate

ES – Executive Summary

ESRD - End-stage Renal Disease

ETS – Environmental Tobacco Smoke

EVAR – Endovascular Aneurysm Repair

FAEE – Fatty Acid Ethyl Esters

FAS – Fetal Alcohol Syndrome

FASD – Fetal Alcohol Spectrum Disorder

FDA – Food and Drug Administration (US)

FINDRISC - Finnish Diabetes Risk Score

FIN-D2D - Finland's National Diabetes Prevention Program

FIT – Fecal Immunochemical Test

FOBT – Fecal Occult Blood Test

FPG - Fasting Plasma Glucose

FRAX - Fracture Risk Assessment Tool

FRS – Framingham Heart Study Risk Score

FTE – Full Time Equivalent

gFOBT – Guaiac Fecal Occult Blood Test

GBD study – Global Burden of Disease study

GI – Gastrointestinal

GCBT - Group Cognitive Behavioural Therapy

GSMS - Great Smoky Mountains Study

GP – General Practitioner

HBV - Hepatitis B virus

HCC - Hepatocellular Carcinoma

HCV - Hepatitis C Virus

HCP – Health Care Provider

HDL-C – High-Density Lipoprotein Cholesterol

HEAPK – HealthLinkBC Eating and Activity Program for Kids

HIV - Human Immunodeficiency Virus

HMO – Health Maintenance Organization

HPV – Human Papillomavirus

hrHPV – High Risk Human Papillomavirus

HR – Hazard Ratio

ICD – International Classification of Diseases

ID – Intellectual Disability

ICBP - International Cancer Benchmarking Partnership

ICBT - Individual Cognitive Behavioural Therapy

IRR - Incidence Risk Ratio

IOTF – International Obesity Task Force

IR – Intermediate Risk

IQ – Intelligence Quotient

ISH – Intentional Self-Harm

LEEP – Loop Electrosurgical Excision Procedure

LDL – Low-Density Lipoprotein

LDL-C – Low-Density Lipoprotein Cholesterol

LHA – Local Health Areas

LRTI – Lower Respiratory Tract Infection

LPS – Lifetime Prevention Schedule

LPSEC – Lifetime Prevention Schedule Expert Committee

LYL – Life Years Lost

MASS – Multicentre Aneurysm Screening Study

MAST - Michigan Alcoholism Screening Test

MDD – Major Depressive Disorder

MEA – Middle Ear Analysis

MEND – Mind, Exercise, Nutrition, Do It!

MI - Myocardial Infarction

MPR - Medication Possession Ratio

mRS - Modified Rankin Scale

MSP – Medical Service Plan

NHANES – National Health and Nutrition Examination Survey

NICE – National Institute for Health and Clinical Excellence

NICU - Neonatal Intensive Care Unit

NSAID – Nonsteroidal Anti-Inflammatory Drug

NSDUH – National Survey on Drug Use and Health

NTD – Neural Tube Defect

NAT - Nucleic Acid Testing

OAE – Otoacoustic Emissions

OBPM - Office Blood Pressure Measurement

OM – Otitis Media

OME – Otitis Media with Effusion

OR – Odds Ratio

PCHI – Permanent Childhood Hearing Impairment

PCI – Percutaneous Coronary Intervention

PCP – Primary Care Provider

PDC – Proportion of Days Covered

PHQ-A – Patient Health Questionnaire for Adolescents

PHSA – Provincial Health Services Authority

POS – Pulse Oximetry Screening

PPV – Positive Predictive Value

PSBC – Perinatal Services British Columbia

PWID - Persons Who Inject Drugs

QALY – Quality-Adjusted Life-Year

QoL – Quality of life

RCT – Randomized Controlled Trial

RNA - Ribonucleic Acid

RR – Relative Risk

SAE - Serious adverse event

SAMHSA – US Substance Abuse and Mental Health Services Administration

SASQ – Single Alcohol Screening Question

SBIRT – Screening, Brief Intervention and Referral to Treatment

SCARED - Screen for Child Anxiety Related Disorders

SCID – Severe Combined Immune Deficiency

SF-36 – Short Form (Health Survey) with 36 items

SG – Standard Gamble

SIDS – Sudden Infant Death Syndrome

SPIN - Social Phobia Inventory

SUD – Substance Use Disorder

SVR – Sustained Virologic Response

T2DM – Type 2 Diabetes Mellitus

TC – Total Cholesterol

TEOAE –Transient Evoked Otoacoustic Emissions

TG – Triglycerides

TREC – T-cell Receptor Excision Circles

TTO – Time Trade-Off

UK – United Kingdom

UKPDS - UK Prospective Diabetes Study

UKSAT – United Kingdom Small Aneurysm Trial

UNHS – Universal Newborn Hearing Screening

US – United States

USD – United States Dollars

USPSTF – United States Preventive Services Task Force

WHO – World Health Organization

Screening for Asymptomatic Disease or Risk Factors

Vision Screening for Amblyopia

United States Preventive Service Task Force Recommendations (2017)

Among children younger than 6 years, 1% to 6% have amblyopia or its risk factors (strabismus, anisometropia, or both). Early identification of vision abnormalities could prevent the development of amblyopia.

The USPSTF recommends vision screening at least once in all children aged 3 to 5 years to detect amblyopia or its risk factors (B recommendation).

The USPSTF concludes that the current evidence is insufficient to assess the balance of benefits and harms of vision screening in children younger than 3 years (I statement).[4]

Canadian Task Force on Preventive Health Care Recommendations (1990)

In the 1990 publication on well-baby care in the first 2 years of life, the CTFPHC recommended that there was good evidence to include repeated examination of the eyes and hearing during the first year of life in the periodic health examination. This was given an 'A' recommendation.[5] Based on this information, vision screening was included in the BC Lifetime Prevention Schedule.[6]

Canadian Task Force on Preventive Health Care Recommendations (1994)

Once detected, simple refractive errors affecting visual acuity are readily treatable with eye glasses. However, evidence for the treatment of amblyopia is more controversial and inconclusive. It is widely held that for any potential benefit to be realized, amblyopia must be detected during the "sensitive" period, i.e. between birth and about the seventh year.

Systematic screening for visual deficits has been found to decrease prevalence later.

Fair evidence for inclusion in periodic health examination (B Recommendation).[7]

The Canadian Task Force website does state: "Guidelines and other material from the Canadian Task Force on the Periodic Health Examination (1979-2006) are presented for informational purposes only. The material has not been reviewed or approved by the

[4] Grossman DC, Curry SJ, Owens DK et al. Vision Screening in Children Aged 6 Months to 5 Years: US Preventive Services Task Force Recommendation Statement. *Journal of the American Medical Association.* 2017; 318(9): 836-44.
[5] Canadian Task Force on the Periodic Health Examination. Periodic health examination, 1990 update: 4. Well-baby care in the first 2 years of life. *Canadian Medical Association Journal*. 1990; 143(9): 867-72.
[6] Clinical Prevention Policy Review Committee. *A Lifetime of Prevention: A Report of the Clinical Prevention Policy Review Committee*. 2009. Available at http://www.health.gov.bc.ca/library/publications/year/2009/CPPR_Lifetime_of_Prevention_Report.pdf. Accessed August 2013.
[7] Feightner JW. *Canadian Guide to Clinical Preventive Health Care: Chapter 27: Routine Preschool Screening for Visual and Hearing Problems*. 1994. Available at http://canadiantaskforce.ca/wp-content/uploads/2013/03/Chapter27_preschool_visualhear94.pdf?0136ff. Accessed November 2013.

current Canadian Task Force on Preventive Health Care. It may not reflect current evidence or current standards of practice."[8]

In short, the Canadian Task Force on Preventive Health Care does not have a current recommendation on vision screening for children.

BC Early Childhood Vision Screening Program

In 2005, the BC Ministry of Health (MoH) announced its intention to screen all children in the province for vision disorders before they reached six years of age. This universal vision screening program was established with the goal of not only detecting amblyopia or its risk factors but also major refractive errors (e.g. myopia or nearsightedness, hyperopia or farsightedness and astigmatism).[9] The current model, based on evidence of effectiveness from the 2017 USPSTF review, only includes screening for amblyopia and its risk factors.

The Human Early Learning Partnership at UBC was asked to conduct an evaluation of the Vision Screening Program to track the program's effectiveness in achieving the provincial goal established by the Ministry of Health. The results of the evaluation were published in 2012, and form the basis for much of our modeling.[10]

What is Amblyopia

Amblyopia is a "functional reduction in visual acuity characterized by abnormal processing of visual images by the brain".[11] More simply, it is a condition in which the brain ceases to process normal visual inputs from (usually) one or (rarely) both eyes. It can result from several underlying conditions, such as misalignment of the eyes (strabismus) or unequal refractive power (anisometropia) that if untreated early in life (i.e. by 7 or 8 years old) eventually result in the visual processing center of the brain ignoring information (in whole or part) from the eye providing less useful visual information.

A primary reason behind early childhood screening for amblyopia is the assumption that there is a developmental 'critical period' during which the neural circuitry can potentially be reshaped by experience, with this critical period closing by about age seven. Current evidence suggests that neuroplasticity continues through later childhood and into adulthood and that the adult brain retains the capacity to re-wire, although perhaps in ways distinct from the brain prior to age seven. This suggests the possibility that treatment for amblyopia in adults as well as children may be effective.[12]

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[8] Canadian Task Force on Preventive Health Care. *The Red Brick: The Canadian Guide to Clinical Preventive Health Care (1994)*. 1994. Available at https://canadiantaskforce.ca/the-red-brick-the-canadian-guide-to-clinical-preventive-health-care-1994/. Accessed May 2019.

[9] Human Early Learning Partnership. Screening Research and Evaluation Unit. *BC Early Childhood Vision Screening Program. Final Evaluation Report.* 2012. Available at https://www2.gov.bc.ca/assets/gov/health/managing-your-health/women-children-maternal-health/bc-early-childhood-vision-screening-program.pdf. Accessed May 2019.

[10] Human Early Learning Partnership. Screening Research and Evaluation Unit. *BC Early Childhood Vision Screening Program. Final Evaluation Report.* 2012. Available at https://www2.gov.bc.ca/assets/gov/health/managing-your-health/women-children-maternal-health/bc-early-childhood-vision-screening-program.pdf. Accessed May 2019.

[11] Grossman DC, Curry SJ, Owens DK et al. Vision Screening in Children Aged 6 Months to 5 Years: US Preventive Services Task Force Recommendation Statement. *Journal of the American Medical Association.* 2017; 318(9): 836-44.

[12] The Lasker/IRRF Initiative for Innovation in Vision Science. *Amblyopia: Challenges and Opportunities*. 2017. Available online at http://www.laskerfoundation.org/new-noteworthy/articles/amblyopia-challenges/. Accessed January 2020.

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with screening children once in kindergarten, to detect the presence of amblyopia or its risk factors. We base our calculations on BC data reported in the evaluation of the BC Early Childhood Vision Screening Program.

In modelling CPB, we made the following assumptions:

- 99.56% of individuals in a birth cohort of 40,000 (or 39,831, Table 2, row *a*) would survive to age 5, based on data from the BC life tables for 2018 to 2020.
- Solebo et al. conducted a systematic review and found the prevalence of amblyopia in children under the age of 6 ranged from 1.0% to 3.8% depending on the criteria for amblyopia.[13]
- The USPSTF estimates the prevalence of strabismus, anisometropia (both risk factors for amblyopia) and amblyopia combined range from 1% to 6% among US children younger than 6 years.[14]
- For our model, we use the mid-point of the range for the USPSTF reported combined prevalence of amblyopia and its risk factors (3.50%) for the base case (Table 2, row *b*) and the range in sensitivity analysis.
- In the eight consecutive school years starting in 2007/08, 93.1% of BC kindergarten students completed vision screens (Table 2, row *d*). Completed screens ranged from a low of 79.2% of students in the Northern Health Authority in 2007/08 school year to a high of 96.6% in the Vancouver Island Health Authority the 2007/08 school year.[15,16] We use the range of completed screens in our sensitivity analysis.
- The BC Early Childhood Vision Screening Program (BCECVSP) uses two of three tests to screen kindergarten children, combining the Randot Preschool Stereotest (for stereopsis) with either the SureSight Vision Screener or the HOTV vision chart for detection of refractive errors.
- The Vision in Preschoolers study compared vision screening tests administered by professionals. At a specificity (rate of true negatives) of 90% the SureSight Vision Screener had a sensitivity (rate of true positives) of 89% to detect amblyopia. The HOTV vision chart had a sensitivity of 73% at a specificity of 89%. The Random Dot E stereotest had a sensitivity of 63% to detect amblyopia at a specificity of 90%.[17]
- Nishimura and colleagues tested vision screening tests / devices on children ages 4 and 5 in a Canadian school. The results of the vision screening tests / devices were compared with the results of an eye exam by a licensed optometrist. The sensitivity of each test / device individually was calculated along with all possible combination

[13] Solebo AL, Cumberland PM and Rahi JS. Whole-population vision screening in children aged 4–5 years to detect amblyopia. *The Lancet*. 2015; 385(9984): 2308-19.
[14] Jonas DE, Amick HR, Wallace IF et al. Vision screening in children aged 6 months to 5 years: evidence report and systematic review for the US Preventive Services Task Force. *Journal of the American Medical Association.* 2017; 318(9): 845-58.
[15] Human Early Learning Partnership. Screening Research and Evaluation Unit. *BC Early Childhood Vision Screening Program. Final Evaluation Report.* 2012. Available at https://www2.gov.bc.ca/assets/gov/health/managing-your-health/women-children-maternal-health/bc-early-childhood-vision-screening-program.pdf. Accessed May 2019.
[16] Keren Massey, Manager, Early Childhood Health, Public Health Services Branch, BC Ministry of Health. September 25, 2019. Personal communication.
[17] Vision in Preschoolers Study Group. Comparison of preschool vision screening tests as administered by licensed eye care professionals in the Vision in Preschoolers Study. *Ophthalmology*. 2004; 111(4): 637-50.

of devices. The results of the two photoscreeners (Plusoptix S12 and Spot) and an acuity test (Cambridge Crowded Acuity cards) in addition to the Randot Preschool Stereotest are shown in Table 1 below.[18]

Table 1: Sensitivity and Specificity of Screening Tool Combinations

Tools	Sensitivity	Specificity
Acuity and Randot	0.67 (0.60 - 0.72)	0.69 (0.64 - 0.72)
Plusoptix and Randot	0.72 (0.65 - 0.78)	0.80 (0.77 - 0.84)
Spot and Randot	0.68 (0.61 - 0.74)	0.85 (0.82 -0.88)

- Notwithstanding slight differences between individual photo screeners and between acuity tests, the sensitivity results for the tests combined with the Randot test appear to converge to a relatively narrow range.
- We model a sensitivity for testing in BC of 0.695 (midpoint of 0.67 and 0.72) using a combination of either the SureSight photo screener or the HOTV acuity test along with the Randot Preschool Stereotest. (Table 2, row *e*). We range this from 0.60 to 0.78 in our sensitivity analysis.
- In a study including 86 children diagnosed with amblyopia by age 5, Campbell and Charney found that 28 (32.6%) were diagnosed during routine eye exams by a primary care physician while the others were identified by a school screener, an ophthalmologist or an optometrist.[19] We assumed, therefore, that amblyopia would be diagnosed in 32.6% in the absence of an organized, universal screening program (Table 2, row *f*).
- Across the 2007/08 – 2009/10 school years, 54.2% of children who were referred from the Vision Screening Program in BC saw an eye doctor within one year of referral, with most of those visits within four months of referral (Table 2, row *h*).[20]
- A review of childhood amblyopia by Tailor et al. suggests that treatment adherence ranges from less than 50% for occlusion without educational intervention, to 80% for occlusion with educational intervention, to between 80.6 – 93% for binocular treatments, especially those involving computer games or videos.[21]

- We model a treatment adherence of 50% given that there does not appear to be any standard educational intervention in BC, and vary this between 50% and 80% in our sensitivity analysis (Table 2, row *j*).

[18] Nishimura M, Wong A, Cohen A et al. Choosing appropriate tools and referral criteria for vision screening of children aged 4–5 years in Canada: a quantitative analysis. *BMJ Open.* 2019; 9(9): e032138.
[19] Campbell LR and Charney E. Factors associated with delay in diagnosis of childhood amblyopia. *Pediatrics*. 1991; 87(2): 178-85.
[20] Human Early Learning Partnership. Screening Research and Evaluation Unit. *BC Early Childhood Vision Screening Program. Final Evaluation Report.* 2012. Available at https://www2.gov.bc.ca/assets/gov/health/managing-your-health/women-children-maternal-health/bc-early-childhood-vision-screening-program.pdf. Accessed May 2019.
[21] Tailor V, Bossi M, Greenwood JA et al. Childhood amblyopia: current management and new trends. *British Medical Bulletin.* 2016; 119(1): 75-86.

- The reported incidence of recurrence in successfully treated cases of amblyopia varies substantially.[22,23] McConachie and Gottlieb suggest a range in recurrence rates of between 13 – 24% for two or more logMAR lines at one year.[24]

- In keeping with considering two or more logMAR lines to be clinically significant, we model using a recurrence rate of 18.5% (midpoint of 13% and 24%, Table 2, row *l*), and use the upper and lower bounds in our sensitivity analysis.

- We assumed an average life expectancy for a 5 year-old of 77.7 years (Table 2, row *q*), based on data from the BC life tables for 2018 to 2020.

- Individuals with amblyopia rely on their non-amblyopic eye for visual information. Since the amblyopic eye does not contribute to vision, the loss of vision for any reason in the non-amblyopic eye is a significant event.

- The annual incidence of permanent visual impairment or blindness attributable to loss of vision in the non-amblyopic eye (for any reason) has been estimated at .00004 (.00001 to 0.00006) during the ages of 5 to 15 years, 0.00005 (0.00004 to 0.00007) for ages 16 to 64 and 0.00046 (0.00039 to 0.00052) for ages 65+[25] (Table 2, rows *r*, *s* and *t*).

- In screening a cohort of 40,000, we would expect to find and treat 165 five-year olds with amblyopia (Table 2, row *k*). Of these, approximately 134 (Table 2, row *m*) would retain the benefits of treatment. Without treatment, 1.6 would be expected to have permanent visual impairment or blindness attributable to loss of vision in the non-amblyopic eye. Most of this visual impairment / blindness (75%) would occur after age 65.

- In assessing the disability associated with vision impairment, the Global Burden of Disease (GBD) study found the following:[26]
    - mild vision impairment ("has some difficulty with distance vision, for example reading signs, but no other problems with eyesight") is associated with a disability weight of 0.003 (95% CI of 0.001 to 0.007)
    - monocular distance vision loss ("is blind in one eye and has difficulty judging distances") is associated with a disability weight of 0.017 (95% CI of 0.009 to 0.029)
    - moderate vision impairment ("has vision problems that make it difficult to recognize faces or objects across a room") is associated with a disability weight of 0.031 (95% CI of 0.019 to 0.049)
    - severe vision impairment ("has severe vision loss, which causes difficulty in daily activities, some emotional impact [for example worry], and some difficulty going outside the home without assistance") is associated with a disability weight of 0.184 (95% CI of 0.125 to 0.258)

[22] Saxena R, Puranik S, Singh D et al. Factors predicting recurrence in successfully treated cases of anisometropic amblyopia. *Indian Journal of Ophthalmology.* 2013; 61(11): 630.
[23] Gunton KB. Advances in amblyopia: what have we learned from PEDIG trials? *Pediatrics*. 2013; 131(3): 540-7.
[24] Maconachie GD and Gottlob I. The challenges of amblyopia treatment. *Biomedical Journal.* 2015; 38(6): 510-6.
[25] Carlton J, Karnon J, Czoski-Murray C et al. The clinical effectiveness and cost-effectiveness of screening programmes for amblyopia and strabismus in children up to the age of 4-5 years: a systematic review and economic evaluation. *Health Technology Assessment*. 2008; 12(25): xi-194.
[26] Institute for Health Metrics and Evaluation. *GBD 2016 sequelae, health states, health state lay descriptions, and disability weights*. Available online at http://ghdx.healthdata.org/record/global-burden-disease-study-2016-gbd-2016-disability-weights. Accessed December 2019.

- blindness is associated with a disability weight of 0.187 (95% CI of 0.124 to 0.260).

- We model a disability weight of 0.187 (Table 2, row *u*) if the non-amblyopic eye becomes blind.

- While blindness is associated with a reduced QoL, considerable debate exists about whether or not **living with amblyopia** reduces QoL.
- In a 2002 study assessing the cost-effectiveness of *treatment* for amblyopia, Membrano and colleagues assumed a reduction in QoL of 3.5% associated with living with amblyopia, based on their own assessment of 75 patients.[27]
- In 2004, Konig and Barry published the results of the long-term cost-effectiveness of a hypothetical screening program for untreated amblyopia in 3-year-old children in German kindergartens.[28] They assumed a reduction in QoL of 4.0% associated with living with amblyopia (yielding a cost per QALY of $14,323[29]) and then used a range of 0% to 8.0% in their univariate sensitivity analysis (yielding a cost per QALY of $3.67 million and $7,176, respectively).
- In 2008, Carlton and colleagues published an extensive systematic review and economic evaluation of the clinical effectiveness and cost-effectiveness of screening programmes for amblyopia and strabismus in children up to the age of 4-5 years.[30] Based on their review, they then developed their own model in which the base case included the assumption of no change in QoL associated with living with amblyopia due to the lack of "direct evidence of a utility effect". The resulting costs per QALY for screening at ages 3 or 4 ranged from $1.07 million to $1.62 million. In their sensitivity analysis they included a 2.0% reduction in QoL associated with living with amblyopia, resulting in the costs per QALY for screening at ages 3 or 4 being reduced to between $12,980 and $20,891.
- In 2011, Carlton and Kaltenthaler published a systematic review to identify the health-related quality of life (HRQoL) implications of amblyopia and/or its treatment.[31] Based on a review of 35 publications, they conclude that the HRQoL implications of amblyopia are "related specifically to amblyopia treatment, rather than to the condition itself. These included impact on family life, social interactions, difficulties in undertaking daily activities, as well as feelings and behaviour." They recommend that "further research is required to assess the immediate and long-term effects of amblyopia and/or its treatment on HRQoL".

[27] Membreno JH, Brown MM, Brown GC et al. A cost-utility analysis of therapy for amblyopia. *Ophthalmology*. 2002; 109(12): 2265-71.
[28] König H-H and Barry J-C. Cost-utility analysis of orthoptic screening in kindergarten: a Markov model based on data from Germany. *Pediatrics*. 2004; 113(2): e95-e108.
[29] All costs in the following sections have been converted to 2017 Canadian dollars.
[30] Carlton J, Karnon J, Czoski-Murray C et al. The clinical effectiveness and cost-effectiveness of screening programmes for amblyopia and strabismus in children up to the age of 4-5 years: a systematic review and economic evaluation. *Health Technology Assessment*. 2008; 12(25): xi-194.
[31] Carlton J and Kaltenthaler E. Amblyopia and quality of life: a systematic review. *Eye*. 2011; 25(4): 403.

- Research on the QoL implications of amblyopia and/or its treatment continues, with the focus seemingly remaining on the QoL implications associated with treatment rather than living with amblyopia.[32,33,34]

- Sufficient evidence exists to suggest a *disutility* associated with **treatment for amblyopia.** We model a 3.6% disutility (based on the midpoint of the reduction in QoL observed by Membrano et al[35] (3.5%) and van de Graaf et al[36] (3.7%)) for a period of six months for children receiving treatment (Table 2, rows *n* & *o*).

- We have found no convincing evidence of significant QoL reductions associated with **living with amblyopia** and therefore do not include these impacts in the base model. In our sensitivity analysis, we include a QoL reduction of 0.003 (ranging from 0.001 to 0.007), based on disability weights calculated by the Global Burden of Disease study for mild vision impairment.[37] In addition, we calculate what the threshold QoL reductions associated with living with amblyopia would be to achieve a cost per QALY of $50,000 and $25,000.

- Beyond correcting refractive errors, experts differ as to whether amblyopia should be treated at all (especially with occlusion therapy).[38]

- The effectiveness of interventions in improving amblyopia is fairly contentious. The USPSTF noted an average improvement of approximately one line on the logMAR chart among children treated with patching plus eyeglasses (without any pretreatment).[39] The other treatment methods reviewed resulted in an average of less than one line on the Snellen eye chart. A change of one line in the Snellen eye chart is not considered to be clinically significant.[40,41,42] Indeed, the most recent evidence review for the USPSTF concluded that "studies directly evaluating the effectiveness

[32] Chen Y, Chen X, Chen J et al. Longitudinal impact on quality of life for school-aged children with amblyopia treatment: perspective from children. *Current Eye Research.* 2016; 41(2): 208-14.
[33] Bokhary K. Impact of amblyopia treatment on vision-related quality of life. *Optometry: Open Access*. 2016; 1(2):
[34] Buckley CY, Whittle JC, Verity L et al. The effect of childhood eye disorders on social relationships during school years and psychological functioning as young adults. *British and Irish Orthoptic Journal*. 2018; 14(1): 35-44.
[35] Membreno JH, Brown MM, Brown GC et al. A cost-utility analysis of therapy for amblyopia. *Ophthalmology*. 2002; 109(12): 2265-71.
[36] van de Graaf ES, van Kempen-du Saar H, Looman CW et al. Utility analysis of disability caused by amblyopia and/or strabismus in a population-based, historic cohort. *Graefe's Archive for Clinical and Experimental Ophthalmology.* 2010; 248(12): 1803-7.
[37] Institute for Health Metrics and Evaluation. *GBD 2016 sequelae, health states, health state lay descriptions, and disability weights*. Available online at http://ghdx.healthdata.org/record/global-burden-disease-study-2016-gbd-2016-disability-weights. Accessed December 2019.
[38] Kulp MT, Cotter SA, Connor AJ et al. Should amblyopia be treated? *Ophthalmic and Physiological Optics*. 2014; 34(2): 226-32.
[39] Grossman DC, Curry SJ, Owens DK et al. Vision Screening in Children Aged 6 Months to 5 Years: US Preventive Services Task Force Recommendation Statement. *Journal of the American Medical Association.* 2017; 318(9): 836-44.
[40] Gibson R and Sanderson H. Observer variation in ophthalmology. *British Journal of Ophthalmology*. 1980; 64(6): 457-60.
[41] Laidlaw D, Abbott A and Rosser D. Development of a clinically feasible logMAR alternative to the Snellen chart: performance of the "compact reduced logMAR" visual acuity chart in amblyopic children. *British Journal of Ophthalmology.* 2003; 87(10): 1232-4.
[42] Beck RW, Moke PS, Turpin AH et al. A computerized method of visual acuity testing: adaptation of the early treatment of diabetic retinopathy study testing protocol. *American Journal of Ophthalmology.* 2003; 135(2): 194-205.

of screening were limited and do not establish whether vision screening in preschool children is better than no screening."[43]

- Other assumptions used in assessing the clinically preventable burden are detailed in the Reference Document.

Based on these assumptions, the CPB associated with screening for amblyopia in children ages 3 to 5 is 2.4 QALYs (Table 2, row *w*).

Table 2: CPB of Screening for Amblyopia in 5 Year-Olds in a Birth Cohort of 40,000 (B.C.)

Row Label	Variable	Base Case	Data Source
a	5 Year olds in cohort	39,831	BC Life Tables
b	Prevalence of amblyopia	3.50%	√
c	5 year-olds with amblyopia in birth cohort	1,394	= a * b
d	Rate of screening for kindergarten children	93.1%	√
e	Average sensitivity of refractive and stereo tests combined	69.5%	√
f	% of amblyopia that are undetected (asymptomatic)	67.4%	√
g	5 year-olds with amblyopia or risk factors detected through screening and referred to eye doctor	608	= c * d * e * f
h	Proportion of referrals that see eye doctor	54.2%	√
i	5 year-olds with amblyopia or risk factors detected through screening seeing physician for followup	330	= g * h
j	Treatment compliance	50.0%	√
k	Individuals with amblyopia who are treatment compliant	165	= i * j
l	Recurrence in those treated for amblyopia	18.5%	√
m	Individuals with lasting change due to screening and treatment	134	= k * (1- l)
n	Quality of Life reduction due to treatment	0.036	√
o	Length of Treatment, months	6	√
p	Estimated QALYs lost due to treatment	3.0	= k * n * (o / 12)
q	Average life expectancy of a 5 year old	77.7	BC Life Table
r	Incidence of permanent visual impairment or blindness - 5-15 yrs	0.00004	√
s	Incidence of permanent visual impairment or blindness - 16-64 yrs	0.00005	√
t	Incidence of permanent visual impairment or blindness - 65+ yrs	0.00046	√
u	Change in QoL associated with permanent visual impairment or blindness	0.187	√
v	Estimated QALYs gained due to avoided vision loss	5.3	Calculated
w	**Net QALYs gained through intervention, CPB**	**2.4**	= v - p

√ = Estimates from the literature

We also modified several major assumptions and recalculated the CPB as follows:

- Assume the disutility associated with living with amblyopia is changed from 0.0 to 0.001: CPB = 13.0
- Assume the disutility associated with living with amblyopia is changed from 0.0 to 0.003: CPB = 34.1

[43] Jonas DE, Amick HR, Wallace IF et al. Vision screening in children aged 6 months to 5 years: evidence report and systematic review for the US Preventive Services Task Force. *Journal of the American Medical Association.* 2017; 318(9): 845-58.

- Assume the disutility associated with living with amblyopia is changed from 0.0 to 0.007: **CPB = 76.4**

As expected, assumptions about the disutility associated with living with amblyopia dominate the sensitivity analysis. Moving from an assumption of no disutility to just 0.7% disutility changes the CPB from 2.4 (the base case) to 76.4. No other variable even comes close to influencing the results in such an important manner (see below).

- Assume the prevalence of amblyopia is reduced from 3.5% to 1.0% (Table 2, row b): CPB = 0.7
- Assume the prevalence of amblyopia is increased from 3.5% to 6.0% (Table 2, row b): CPB = 4.1
- Assume the screening rate decreases from 93.1% to 79.2% (Table 2, row d): CPB = 2.0
- Assume the screening rate increases from 93.1% to 96.6% (Table 2, row d): CPB = 2.5
- Assume joint testing sensitivity decreases from 69.5% to 60%. (Table 2, row e): CPB = 2.0
- Assume joint testing sensitivity increases from 69.5% to 78%. (Table 2, row e): CPB = 2.7
- Assume treatment compliance increases from 50% to 80% (Table 2, row j): CPB = 3.8
- Assume the recurrence of amblyopia decreases from 18.5% to 13.0% (Table 2, row l): CPB = 2.7
- Assume the recurrence of amblyopia increases from 18.5% to 24.0% (Table 2, row l): CPB = 2.0
- Assume the incidence of permanent visual impairment or blindness is at the low end of the range (Table 2, rows r, s, t): CPB = 1.0
- Assume the incidence of permanent visual impairment or blindness is at the high end of the range (Table 2, rows r, s, t): CPB = 4.1
- Assume the disutility associated with permanent visual impairment or blindness is reduced from -0.187 to -0.124 (Table 2, row u): **CPB = 0.6**
- Assume the disutility associated with permanent visual impairment or blindness is increased from -0.187 to -0.260 (Table 2, row u): CPB = 4.5

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with screening all children at least once between the ages of 3 and 5 years, to detect the presence of amblyopia or its risk factors.

In modelling CE, we made the following assumptions:

- In their 2008 analysis, Carlton and colleagues estimated a cost per screen of between £9.26 and £12.90, equivalent to between $20.51 and $28.57 in 2022 CAD.[44] They

[44] Carlton J, Karnon J, Czoski-Murray C et al. The clinical effectiveness and cost-effectiveness of screening programmes for amblyopia and strabismus in children up to the age of 4-5 years: a systematic review and economic evaluation. *Health Technology Assessment*. 2008; 12(25): xi-194.

included screening invitation, orthoptists time, equipment costs, room rental and data entry costs in their estimate.

- In fiscal 2017/18, BC health authorities spent an estimated $691,939 ($761,451 in 2022 CAD) to screen approximately 43,771 kindergarten age children.[45] This represents a cost of $17.40 per screen (Table 3, row *d*).
- Visits to the optometrist cost $47.08 for a full eye exam (Table 3, row i).[46]
- For patient time and travel costs, we estimated two hours of patient time required per physician visit.
- The estimated cost of interventions (Table 3, row *l*) are based on information in the economic evaluation by Carlton et al.[47] The cost of an intervention is estimated at £1,015 (95% CI of £907 to £1,122) in 2006 British Pounds Sterling or $2,370 (95% CI of $2,118 to $2,620) in 2022 CAD.
- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the CE associated with screening for amblyopia in children ages 3 to 5 is $5,169,538 per QALY (Table 3, row *r*).

[45] Khalilah Alwani, Policy Analyst, Women's, Maternal and Early Childhood Health, Public Health Services Branch, BC Ministry of Health. February 24, 2021. Personal Communication.
[46] BC Doctors of Optometry. *MSP and Your Eye Health.* 2023. Available at https://bc.doctorsofoptometry.ca/patients/medical-services-plan/#:~:text=MSP%20and%20Your%20Eye%20Health,19%20and%2065%20and%20older. Accessed March 2023.
[47] Carlton J, Karnon J, Czoski-Murray C et al. The clinical effectiveness and cost-effectiveness of screening programmes for amblyopia and strabismus in children up to the age of 4-5 years: a systematic review and economic evaluation. *Health Technology Assessment*. 2008; 12(25): xi-194.

Table 3: CE of Screening for Amblyopia in 3-5 Year-Olds in a Birth Cohort of 40,000 (B.C.)			
Row Label	**Variable**	**Base Case**	**Data Source**
a	5 Year olds in cohort	39,831	Table 1 row b
b	Screening rate	93%	Table 1, row d
c	# of screens	37,082	= a * b
	Costs of screening		
d	Screening cost per child in BC	$17.40	√
e	Cost of screening over lifetime of birth cohort	$645,235	= c * d
	Costs of follow-up visits to Optometrist		
f	Cases of amblyopia detected through screening and referred to optometrist	608	Table 1, row i
g	Proportion of referrals that see optometrist	54.2%	Table 1, row j
h	Number seeing optometrist	330	= f * g
i	Cost of full eye exam	$47.08	√
j	Value of patient time and travel for office visit	$74.32	Ref Doc
k	Costs of follow-up visits to Optometrist	$40,001	= h * (i + j)
	Costs of interventions		
l	Estimated intervention cost	$2,370	√
m	# of interventions	165	Table 1, row m
n	Total cost over lifetime of birth cohort	$390,458	= l * m
	CE calculation		
o	Lifetime cost of screening and interventions	$1,075,695	= e + k + n
p	QALYs saved (0% discount rate)	2.4	Table 1, row y
q	QALYs saved (1.5% discount rate)	0.2	Calculated
r	**CE ($/QALY saved)**	**$5,169,538**	= o / q

√ = Estimates from the literature

We also modified several major assumptions and recalculated the cost per QALY as follows:

- Assume the disutility associated with treating amblyopia is reduced from 0.036 to 0.0 (Table 2, row n): CE = $338,952
- Assume the disutility associated with living with amblyopia is changed from 0.0 to 0.001: CE = $166,031
- Assume the disutility associated with living with amblyopia is changed from 0.0 to 0.003: CE = $56,555
- Assume the disutility associated with living with amblyopia is changed from 0.0 to 0.007: **CE = $24,390**
- Threshold disutility for living with amblyopia required to produce a CE of $50,000 / QALY: 0.0034
- Threshold disutility for living with amblyopia required to produce a CE of $25,000 / QALY: 0.0068
- Assume the disutility associated with treating amblyopia is reduced from 0.036 to 0.0 (Table 2, *row p*) ***and*** assume the disutility associated with living with amblyopia is changed from 0.0 to 0.007: CE = $22,854

Any assumption about the disutility associated with **living with amblyopia** dramatically reduces the cost / QALY. Adding just a 0.1% disutility changes the cost / QALY from $5.2 million to $0.17 million. If the disutility is changed to 0.68%, the cost / QALY would be $25,000.

- Assume the prevalence of amblyopia is reduced from 3.5% to 1.0% (Table 2, row b): **CE = $12,921,661**
- Assume the prevalence of amblyopia is increased from 3.5% to 6.0% (Table 2, row b): CE = $3,877,517
- Assume joint testing sensitivity decreases from 69.5% to 60%. (Table 2, row e): CE = $5,660,506
- Assume joint testing sensitivity increases from 69.5% to 78%. (Table 2, row e): CE = $4,831,625
- Assume treatment compliance increases from 50% to 80% (Table 2, row j): CE = $3,934,630
- Assume the recurrence of amblyopia decreases from 18.5% to 13.0% (Table 2, row l): CE = $2,547,519
- Assume the recurrence of amblyopia increases from 18.5% to 24.0% (Table 2, row l): CE = n/a (intervention is harmful [1.5% discount])
- Assume the incidence of permanent visual impairment or blindness is at the low end of the range (Table 2, rows r, s, t): CE = n/a (intervention is harmful [1.5% discount])
- Assume the incidence of permanent visual impairment or blindness is at the high end of the range (Table 2, rows r, s, t): CE = $793,704
- Assume the disutility associated with permanent visual impairment or blindness is reduced from -0.187 to -0.124 (Table 2, row u): CE = n/a (intervention is harmful [1.5% discount])
- Assume the disutility associated with permanent visual impairment or blindness is increased from -0.187 to -0.260 (Table 2, row u): CE = $743,411
- Assume the cost per intervention is reduced from $2,370 to $2,118 (Table 3, row l): CE = $4,970,016
- Assume the cost per intervention is increased from $2,370 to $2,620 (Table 3, row l): CE = $5,367,476

Summary

The clinically preventable burden (CPB) associated with screening all children at least once between the ages of 3 and 5 years, to detect the presence of amblyopia or its risk factors, is 2.4 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated at $5,169,538 per QALY (see Table 4).

Table 4: Screening for Amblyopia in 3-5 Year-Olds in a Birth Cohort of 40,000

Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume No Current Service			
1.5% Discount Rate	**0.2**	-0.9	44.1
3% Discount Rate	-0.8	-1.6	28.3
0% Discount Rate	2.4	0.6	76.4
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$5,169,538**	$24,390	$12,921,661
3% Discount Rate	-*	$38,053	-*
0% Discount Rate	$453,110	$14,075	$1,132,584
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$5,051,852	$23,835	$12,803,975
3% Discount Rate	-*	$37,186	-*
0% Discount Rate	$442,795	$13,755	$1,122,269

* Intervention resulted in a loss of QALYs. Therefore CE was dominated.

Whether or not the screening of all children at least once between the ages of 3 and 5 years to detect the presence of amblyopia or its risk factors is cost-effective depends largely on assumptions made regarding QoL reductions associated with **living with amblyopia**. The uncertainty associated with this single parameter is so large that reasonable assumptions could result in a range of values indicating that screening is clearly **not cost-effective** to it being **highly cost-effective**. As noted by Karnon et al, the "existing evidence is so weak that it is difficult to even assign a probability of disutility, let alone an expected disutility value."[48] Nevertheless, the lack of research evidence does not necessarily mean the lack of an effect. Models such as the one above can help clarify "the decision-making process by explicitly identifying the key factors underlying the uncertainty in the cost-effectiveness estimates. Decision makers can then consider the likely value of these specific parameters…or they may choose to focus on other decision factors" [49] when choosing to implement, enhance or disinvest / de-adopt a specific program.

In summary, the cost-effectiveness of screening all children in BC at least once between the ages of 3 and 5 years to detect the presence of amblyopia or its risk factors is highly sensitive to assumptions about the disutility associated with living with amblyopia. If we assume no disutility (the base case), then the cost per QALY is $5.2 million. However, adding just a 0.1% disutility changes the cost / QALY from $5.2 million to $0.17 million. If the disutility is changed to 0.7%, the cost / QALY would be $24,390.

[48] Karnon J, Carlton J, Czoski-Murray C et al. Informing disinvestment through cost-effectiveness modelling. *Applied Health Economics and Health Policy.* 2009; 7(1): 1-9.
[49] Karnon J, Carlton J, Czoski-Murray C et al. Informing disinvestment through cost-effectiveness modelling. *Applied Health Economics and Health Policy.* 2009; 7(1): 1-9.

United States Preventive Services Task Force Recommendations[50]

This recommendation applies to children and adolescents aged 18 years or younger who do not have a diagnosis of MDD [major depressive disorder].

The USPSTF recommends screening for MDD in adolescents aged 12 to 18 years. Screening should be implemented with adequate systems in place to ensure accurate diagnosis, effective treatment, and appropriate follow-up. (B recommendation)

The USPSTF concludes that the current evidence is insufficient to assess the balance of benefits and harms of screening for MDD in children aged 11 years or younger. (I statement)

Canadian Task Force on Preventive Health Care Recommendations

The CTFPHC does not have a specific recommendation on depression screening for children or adolescents.[51]

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with screening for MDD in adolescents ages 12 to 18.

In modelling CPB, we made the following assumptions:

- The USPSTF "found no evidence on appropriate or recommended screening intervals, and the optimal interval is unknown…opportunistic screening may be appropriate for adolescents, who may have infrequent health care visits."[52] For adolescents with risk factors for MDD, "repeated screening may be most productive."[53]
- Rand and colleagues evaluated primary care visits by US adolescents and found that many did not have any primary care visits during a 12-month period.[54] Averaging the data presented for the relevant 12 – 18 year old group, 56.9% had a primary care visit during the last 12-month period.
- Skehar and colleagues found that adolescents 12 – 14 years old who were continuously enrolled in private insurance in the US made an average of 0.58 well-care visits per year.[55]

[50] Siu AL. Screening for depression in children and adolescents: US Preventive Services Task Force recommendation statement. *Annals of Internal Medicine.* 2016; 164(5): 360-6.
[51] Joffres M, Jaramillo A, Dickinson J et al. Recommendations on screening for depression in adults. *Canadian Medical Association Journal*. 2013; 185(9): 775-82.
[52] Siu AL. Screening for depression in children and adolescents: US Preventive Services Task Force recommendation statement. *Annals of Internal Medicine.* 2016; 164(5): 360-6.
[53] Siu AL. Screening for depression in children and adolescents: US Preventive Services Task Force recommendation statement. *Annals of Internal Medicine.* 2016; 164(5): 360-6.
[54] Rand CM and Goldstein NP. Patterns of primary care physician visits for US adolescents in 2014: implications for vaccination. *Academic Pediatrics.* 2018; 18(2): S72-S8.
[55] Sekhar DL, Ba DM, Liu G et al. Major depressive disorder screening remains low even among privately insured adolescents. *Journal of Pediatrics*. 2018: Available at https://www-sciencedirect-com.ezproxy.library.ubc.ca/science/article/pii/S0022347618310850. Accessed December 2018.

- Using data provided by the BC Ministry of Health, Health Sector Information, Analysis and Reporting Division[56] we were able to generate BC-specific rates of primary care visits and average visits per year for the fiscal years ending in 2012/13 to 2016/17, in total and by sex, as shown in Table 1 below.
- For the five years considered, the average proportion of adolescents ages 10-19 visiting a GP is 70%, and the average number of GP visits per adolescent is 2.07 per year. The proportion of males visiting a GP was 65.4% and for females it was 75.0%. The average number of visits per male in the population was 1.75 and for females was 2.42.

Table 1: General Practitioner Visits by Adolescents
British Columbia, 2012/13 to 2016/17

Age Group	2012/13	2013/14	2014/15	2015/16	2016/17	Total
	Population in Each Age Group					
10 - 14	234,780	231,544	230,178	230,177	232,010	1,158,689
15 - 19	284,482	282,214	279,997	276,909	272,677	1,396,279
Total	519,262	513,758	510,175	507,086	504,687	2,554,968
	Number of Unique Individuals with GP Visit					
10 - 14	163,332	160,912	158,653	160,260	159,826	802,983
15 - 19	205,821	200,410	196,629	192,566	189,547	984,973
Total	369,153	361,322	355,282	352,826	349,373	1,787,956
	Proportion of Individuals with a GP Visit					
10 - 14	69.6%	69.5%	68.9%	69.6%	68.9%	69.3%
15 - 19	72.3%	71.0%	70.2%	69.5%	69.5%	70.5%
Total	71.1%	70.3%	69.6%	69.6%	69.2%	70.0%
	Number of GP Visits					
10 - 14	429,881	422,188	412,182	413,411	407,442	2,085,104
15 - 19	681,806	659,038	641,316	619,790	601,925	3,203,875
Total	1,111,687	1,081,226	1,053,498	1,033,201	1,009,367	5,288,979
	GP Visits per Individual in Total Population					
10 - 14	1.83	1.82	1.79	1.80	1.76	1.80
15 - 19	2.40	2.34	2.29	2.24	2.21	2.29
Total	2.14	2.10	2.06	2.04	2.00	2.07

[56] Aciemme (Sam) Ospan, Senior Manager, Lifetime Prevention Schedule, Healthy Living and Health Promotion Branch, BC Ministry of Health. January 30, 2019. Personal communication.

Table 1: General Practitioner Visits by Adolescents

British Columbia, 2012/13 to 2016/17

Males

Age Group	2012/13	2013/14	2014/15	2015/16	2016/17	Total
	Population in Each Age Group					
10 - 14	121,031	119,378	118,720	118,572	119,586	597,287
15 - 19	149,279	147,563	145,417	143,117	140,451	725,827
Total	270,310	266,941	264,137	261,689	260,037	1,323,114
	Number of Unique Males with GP Visit					
10 - 14	82,970	81,960	80,756	81,067	80,862	407,615
15 - 19	95,992	93,224	91,170	89,118	87,596	457,100
Total	178,962	175,184	171,926	170,185	168,458	864,715
	Proportion of Males with a GP Visit					
10 - 14	68.6%	68.7%	68.0%	68.4%	67.6%	68.2%
15 - 19	64.3%	63.2%	62.7%	62.3%	62.4%	63.0%
Total	66.2%	65.6%	65.1%	65.0%	64.8%	65.4%
	Number of GP Visits					
10 - 14	215,841	211,444	206,909	206,013	202,386	1,042,593
15 - 19	270,303	259,637	253,874	244,381	238,257	1,266,452
Total	486,144	471,081	460,783	450,394	440,643	2,309,045
	GP Visits per Male in Total Population					
10 - 14	1.78	1.77	1.74	1.74	1.69	1.75
15 - 19	1.81	1.76	1.75	1.71	1.70	1.74
Total	1.80	1.76	1.74	1.72	1.69	1.75

Table 1: General Practitioner Visits by Adolescents

British Columbia, 2012/13 to 2016/17

Females

Age Group	2012/13	2013/14	2014/15	2015/16	2016/17	Total
	Population in Each Age Group					
10 - 14	113,749	112,166	111,458	111,605	112,424	561,402
15 - 19	135,203	134,651	134,580	133,792	132,226	670,452
Total	248,952	246,817	246,038	245,397	244,650	1,231,854
	Number of Unique Females with GP Visit					
10 - 14	80,381	78,955	77,909	79,202	78,985	395,432
15 - 19	109,865	107,210	105,496	103,488	101,995	528,054
Total	190,246	186,165	183,405	182,690	180,980	923,486
	Proportion of Females with a GP Visit					
10 - 14	70.7%	70.4%	69.9%	71.0%	70.3%	70.4%
15 - 19	81.3%	79.6%	78.4%	77.3%	77.1%	78.8%
Total	76.4%	75.4%	74.5%	74.4%	74.0%	75.0%
	Number of GP Visits					
10 - 14	214,033	210,738	205,270	207,393	205,052	1,042,486
15 - 19	411,487	399,386	387,411	375,393	363,660	1,937,337
Total	625,520	610,124	592,681	582,786	568,712	2,979,823
	GP Visits per Female in Total Population					
10 - 14	1.88	1.88	1.84	1.86	1.82	1.86
15 - 19	3.04	2.97	2.88	2.81	2.75	2.89
Total	2.51	2.47	2.41	2.37	2.32	2.42

Source: BC Ministry of Health, Health Sector Information, Analysis and Reporting Division

Calculations by H. Krueger & Associates, Inc.

- In our model, we assume a maximum (best in the world) adolescent depression screening rate of 57.0% (81.5%[57] times 70.0%) and that screening for this 57.0% of adolescents (Table 6, row *ah*) is completed at each well-care visit, or 2.07 times per year (Table 6, row *ag)*,[58] during the seven years of an adolescent's life between 12 and 18 years of age.
- In our model for **males**, we assume a maximum (best in the world) depression screening rate of 53.3% (81.5%[59] times 65.4%) and that screening for this 53.3% of male adolescents (Table 6a, row *ah*) is completed at each well-care visit, or 1.75 times per year (Table 6a, row *ag)*,[60] during the seven years of an adolescent's life between 12 and 18 years of age.
- In our model for **females**, we assume a maximum (best in the world) depression screening rate of 61.1% (81.5%[61] times 75.0%) and that screening for this 61.1% of female adolescents (Table 6b, row *ah*) is completed at each well-care visit, or 2.42 times per year (Table 6b, row *ag)*,[62] during the seven years of an adolescent's life between 12 and 18 years of age.

- Patten et al. estimate that for the Canadian population aged 15-25 the annual prevalence of MDD was 5.0% (95% CI 4.2% - 5.7%) and the lifetime prevalence was 8.8% (95% CI 7.9% - 9.7%).[63]
- Avenevoli et al. report that the annual and lifetime prevalence of MDD in 13-18 year olds in the US is 7.5% and 11.0% respectively.[64]
- Using data from the US National Survey on Drug Use and Health (NSDUH) Mojtabai and colleagues found that the annual prevalence of MDD in the US has increased from 5.6% in 2005 to 7.2% in 2014 for 12-13year olds, 9.1% to 11.8% in 14-15 year olds and 11.2% to 14.7% in 16-17 year olds.[65]
- Vasiliadis and colleagues found that there was no significant difference between Canadian and US rates of depression and subsequent use of mental health services.[66]
- Using the detailed data tables publicly available from the US NSDUH, we calculated the aggregate rates of 12-month major depressive episodes for the years 2014 (the

[57] Davis M, Jones J, So A et al. Adolescent depression screening in primary care: Who is screened and who is at risk? *Journal of Affective Disorders*. 2022; 299: 318-25.
[58] Sekhar DL, Ba DM, Liu G et al. Major depressive disorder screening remains low even among privately insured adolescents. *Journal of Pediatrics*. 2018: Available at https://www-sciencedirect-com.ezproxy.library.ubc.ca/science/article/pii/S0022347618310850. Accessed December 2018.
[59] Davis M, Jones J, So A et al. Adolescent depression screening in primary care: Who is screened and who is at risk? *Journal of Affective Disorders*. 2022; 299: 318-25.
[60] Sekhar DL, Ba DM, Liu G et al. Major depressive disorder screening remains low even among privately insured adolescents. *Journal of Pediatrics*. 2018: Available at https://www-sciencedirect-com.ezproxy.library.ubc.ca/science/article/pii/S0022347618310850. Accessed December 2018.
[61] Davis M, Jones J, So A et al. Adolescent depression screening in primary care: Who is screened and who is at risk? *Journal of Affective Disorders*. 2022; 299: 318-25.
[62] Sekhar DL, Ba DM, Liu G et al. Major depressive disorder screening remains low even among privately insured adolescents. *Journal of Pediatrics*. 2018: Available at https://www-sciencedirect-com.ezproxy.library.ubc.ca/science/article/pii/S0022347618310850. Accessed December 2018.
[63] Patten SB, Wang JL, Williams JV et al. Descriptive epidemiology of major depression in Canada. *The Canadian Journal of Psychiatry*. 2006; 51(2): 84-90.
[64] Avenevoli S, Swendsen J, He J-P et al. Major depression in the National Comorbidity Survey–Adolescent Supplement: prevalence, correlates, and treatment. *Journal of the American Academy of Child & Adolescent Psychiatry*. 2015; 54(1): 37-44.
[65] Mojtabai R, Olfson M and Han B. National trends in the prevalence and treatment of depression in adolescents and young adults. *Pediatrics*. 2016; 138(6): e20161878.
[66] Vasiliadis H-M, Lesage A, Adair C et al. Do Canada and the United States differ in prevalence of depression and utilization of services? *Psychiatric Services*. 2007; 58(1): 63-71.

end of Mojtabai and colleague's data) through 2017, using the tables from 2015[67] (containing data for 2014 and 2015) and 2017[68] (containing data for 2016 and 2017), splitting the results by age and sex. The results, shown in Table 2, indicate a substantial difference in major depressive episodes between the sexes, with the annual prevalence of MDE being consistently lower in males than females.

- Similar overall data to the US NSDUH has been reported in the McCreary Centre's *Balance and Connection in BC* report summarizing the results of the 2018 BC adolescent Health Survey. Adolescents in grades 7 through 12 were surveyed and 10% of males reported "mental health conditions", while 20% of females reported the same.[69]

[67] Substance Abuse and Mental Health Services Administration. *Reports and Detailed Tables from the 2015 National Survey on Drug Use and Health (NSDUH)*. 2015. Available at https://www.samhsa.gov/data/nsduh/reports-detailed-tables-2015-NSDUH. Accessed February 2019.
[68] Substance Abuse and Mental Health Services Administration. *Reports and Detailed Tables from the 2017 National Survey on Drug Use and Health (NSDUH)*. 2017. Available at https://www.samhsa.gov/data/nsduh/reports-detailed-tables-2017-NSDUH. Accessed February 2019.
[69] McCreary Centre Society. *Balance and Connection in BC: The Health and Well-Being of our Youth. Results of the 2018 BC Adolescent Health Survey.* 2019. Available at https://www.mcs.bc.ca/pdf/balance_and_connection.pdf. Accessed May 2019.

Table 2: (US) National Survey on Drug Use and Health

12-Month MDE Events, By Age and Sex

2014 - 2017 Results

12 Year Olds

	Male			Female			Calculated Total		
Year	Sample Size	MDE %	MDE (n)	Sample Size	MDE %	MDE (n)	Sample Size	MDE %	MDE (n)
2014	1,347	2.8%	38	1,293	8.9%	115	2,640	5.8%	153
2015	1,346	2.2%	30	1,307	8.7%	114	2,653	5.4%	143
2016	1,323	3.1%	41	1,291	6.9%	89	2,614	5.0%	130
2017	1,329	2.7%	36	1,269	7.0%	89	2,598	4.8%	125
Total	**5,345**	**2.7%**	**144**	**5,160**	**7.9%**	**407**	**10,505**	**5.2%**	**551**

13 Year Olds

	Male			Female			Calculated Total		
	Sample Size	MDE %	MDE (n)	Sample Size	MDE %	MDE (n)	Sample Size	MDE %	MDE (n)
2014	1,433	3.9%	56	1,388	13.8%	192	2,821	8.8%	247
2015	1,428	3.9%	56	1,394	16.8%	234	2,822	10.3%	290
2016	1,479	3.8%	56	1,414	15.3%	216	2,893	9.4%	273
2017	1,507	3.6%	54	1,423	14.5%	206	2,930	8.9%	261
Total	**5,847**	**3.8%**	**222**	**5,619**	**15.1%**	**848**	**11,466**	**9.3%**	**1,070**

14 Year Olds

	Male			Female			Calculated Total		
	Sample Size	MDE %	MDE (n)	Sample Size	MDE %	MDE (n)	Sample Size	MDE %	MDE (n)
2014	1,491	4.6%	69	1,443	17.1%	247	2,934	10.7%	315
2015	1,491	4.1%	61	1,411	19.0%	268	2,902	11.3%	329
2016	1,484	5.2%	77	1,432	20.5%	294	2,916	12.7%	371
2017	1,492	5.2%	78	1,385	19.0%	263	2,877	11.8%	341
Total	**5,958**	**4.8%**	**284**	**5,671**	**18.9%**	**1,072**	**11,629**	**11.7%**	**1,356**

15 Year Olds

	Male			Female			Calculated Total		
Year	Sample Size	MDE %	MDE (n)	Sample Size	MDE %	MDE (n)	Sample Size	MDE %	MDE (n)
2014	1,483	5.5%	82	1,451	20.7%	300	2,934	13.0%	382
2015	1,438	5.3%	76	1,486	26.7%	397	2,924	16.2%	473
2016	1,512	6.5%	98	1,498	21.0%	315	3,010	13.7%	413
2017	1,460	7.4%	108	1,427	27.2%	388	2,887	17.2%	496
Total	**5,893**	**6.2%**	**364**	**5,862**	**23.9%**	**1,400**	**11,755**	**15.0%**	**1,764**

16 Year Olds

	Male			Female			Calculated Total		
	Sample Size	MDE %	MDE (n)	Sample Size	MDE %	MDE (n)	Sample Size	MDE %	MDE (n)
2014	1,467	7.5%	110	1,469	20.7%	304	2,936	14.1%	414
2015	1,459	9.9%	144	1,384	22.3%	309	2,843	15.9%	453
2016	1,487	9.4%	140	1,409	25.8%	364	2,896	17.4%	503
2017	1,508	9.8%	148	1,389	24.1%	335	2,897	16.7%	483
Total	**5,921**	**9.2%**	**542**	**5,651**	**23.2%**	**1,311**	**11,572**	**16.0%**	**1,853**

17 Year Olds

	Male			Female			Calculated Total		
	Sample Size	MDE %	MDE (n)	Sample Size	MDE %	MDE (n)	Sample Size	MDE %	MDE (n)
2014	1,392	9.7%	135	1,350	21.0%	284	2,742	15.3%	419
2015	1,434	9.1%	130	1,333	21.5%	287	2,767	15.1%	417
2016	1,415	9.7%	137	1,337	24.7%	330	2,752	17.0%	467
2017	1,419	11.6%	165	1,418	25.5%	362	2,837	18.5%	526
Total	**5,660**	**10.0%**	**567**	**5,438**	**23.2%**	**1,262**	**11,098**	**16.5%**	**1,829**

Source for Sample Size and MDE %: National Survey on Drug Use and Health, 2014 - 2017

Calculations by H. Krueger & Associates, Inc.

- Based on the data in Table 2, we assume an annual prevalence of MDD of 5.2% in 12 year olds (Table 6, row *b*), 7.9% in 12 year old females (Table 6b, row *b*) and 2.7% in 12 year old males (Table 6a, row *b*).
- We assume an annual prevalence of MDD of 9.3% in 13 year olds (Table 6, row *f*), 15.1% in 13 year old females (Table 6b, row *f*) and 3.8% in 13 year old males (Table 6a, row *f*).
- We assume an annual prevalence of MDD of 11.7% in 14 year olds (Table 6, row *j*), 18.9% in 14 year old females (Table 6b, row *j*) and 4.8% in 14 year old males (Table 6a, row *j*).
- We assume an annual prevalence of MDD of 15.0% in 15 year olds (Table 6, row *n*), 23.9% in 15 year old females (Table 6b row *n*) and 6.2% in 15 year old males (Table 6a, row *n*).
- We assume an annual prevalence of MDD of 16.0% in 16 year olds (Table 6, row *r*), 23.2% in 16 year old females (Table 6b row *r*) and 9.2% in 16 year old males (Table 6a, row *r*).
- We assume an annual prevalence of MDD of 16.5% in 17 and 18 year olds (Table 6, row *v*), 23.2% in 17 and 18 year old females (Table 6b row *v*) and 10.0% in 17 and 18 year old males (Table 6a, row *v*).

- In 2017, 17.2% of US high school students had seriously considered attempting suicide during the previous 12 months, 13.6% had made a plan about how they would attempt suicide, 7.4% had actually attempted suicide and 2.4% had made a suicide attempt resulting in an injury, poisoning or overdose that had to be treated by a doctor or nurse.[70]
- In BC in 2013, 12.2% of students in grades 7 - 12 had seriously considered attempting suicide during the previous 12 months and 6.2% had actually attempted suicide.[71]
- Suicide mortality among youth ages 15 – 19 in BC between 2011 and 2013 is 4.7 / 100,000 population.[72]
- The ratio of attempted suicides to completed suicides among adolescents is estimated to be 50:1 to 100:1.[73]
- Rohde and colleagues report that 19% (95% CI of 14.4% - 22.9%) of adolescents with MDD had at least one suicide attempt by age 30, compared with 3% (95% CI of 1.6% and 5.1%) of adolescents without MDD.[74]

[70] Kann L, McManus T, Harris WA et al. Youth risk behavior surveillance—United States, 2017. *MMWR Surveillance Summaries*. 2018; 67(8): 1.
[71] BC Office of the Provincial Health Officer. *Is "Good", Good Enough? A Report on the Health & Well-Being of Children & Youth in BC*. Available online at http://www.childhealthindicatorsbc.ca/findings/mental-emotional-health-well-being/suicidality. Accessed December 2018.
[72] BC Office of the Provincial Health Officer. *Is "Good", Good Enough? A Report on the Health & Well-Being of Children & Youth in BC*. Available online athttp://www.childhealthindicatorsbc.ca/findings/mental-emotional-health-well-being/suicidality. Accessed December 2018.
[73] Shain BN. Suicide and suicide attempts in adolescents. *Pediatrics*. 2007; 120(3): 669-76.
[74] Rohde P, Lewinsohn PM, Klein DN et al. Key characteristics of major depressive disorder occurring in childhood, adolescence, emerging adulthood, and adulthood. *Clinical Psychological Science*. 2013; 1(1): 41-53.

- A 2018 systematic review by Johnson et al found that adolescent depression increased the risk of adult depression by 2.78 times (OR of 2.78; 95% CI of 1.97 – 3.93).[75]

- Based on the evidence from Rohde et al [76] and Johnson et al[77] noted above, we have assumed that the effect of adolescent depression on suicide would continue until age 34.

- Based on data from the 2013[78], 2014[79] and 2015[80] BC Vital Statistics annual reports, 24.3% of deaths in males and 15.5% of deaths in females ages 15-19 are due to intentional self-harm (see Table 3).

Table 3: Total Deaths and Deaths Attributable to Intentional Self-Harm (ISH)
British Columbia, 2013 to 2015

Males

Age Group	2013 All Deaths	2013 Deaths Attributable to ISH	2013 % of Deaths Attributable to ISH	2014 All Deaths	2014 Deaths Attributable to ISH	2014 % of Deaths Attributable to ISH	2015 All Deaths	2015 Deaths Attributable to ISH	2015 % of Deaths Attributable to ISH	2013 - 2015 Combined All Deaths	2013 - 2015 Combined Deaths Attributable to ISH	2013 - 2015 Combined % of Deaths Attributable to ISH
10-14	10	1	10.0%	12	2	16.7%	12	1	8.3%	34	4	11.8%
15-19	58	5	8.6%	64	24	37.5%	59	15	25.4%	181	44	24.3%
20-24	119	16	13.4%	99	22	22.2%	110	22	20.0%	328	60	18.3%
25-44	650	107	16.5%	669	119	17.8%	757	89	11.8%	2,076	315	15.2%
	837	**129**	**15.4%**	**844**	**167**	**19.8%**	**938**	**127**	**13.5%**	**2,619**	**423**	**16.2%**

Females

Age Group	2013 All Deaths	2013 Deaths Attributable to ISH	2013 % of Deaths Attributable to ISH	2014 All Deaths	2014 Deaths Attributable to ISH	2014 % of Deaths Attributable to ISH	2015 All Deaths	2015 Deaths Attributable to ISH	2015 % of Deaths Attributable to ISH	2013 - 2015 Combined All Deaths	2013 - 2015 Combined Deaths Attributable to ISH	2013 - 2015 Combined % of Deaths Attributable to ISH
10-14	11	0	0.0%	3	0	0.0%	5	0	0.0%	19	0	0.0%
15-19	29	6	20.7%	26	3	11.5%	29	4	13.8%	84	13	15.5%
20-24	55	15	27.3%	37	9	24.3%	43	9	20.9%	135	33	24.4%
25-44	368	42	11.4%	392	44	11.2%	337	25	7.4%	1,097	111	10.1%
	463	**63**	**13.6%**	**458**	**56**	**12.2%**	**414**	**38**	**9.2%**	**1,335**	**157**	**11.8%**

- Tables 4 and 5 provide data on the expected number of deaths in a BC birth cohort of 20,000 males (see Table 4) and 20,000 females (see Table 5) and how many of those deaths would be attributable to intentional self-harm (see Table 3). Total deaths and deaths attributable to intentional self-harm (ISH) from age 12 to 34 are considered.

- In the birth cohort of 20,000 males, 66 of the 398 (16.6%) deaths between the ages of 12 and 34 are due to ISH, resulting in 3,240 life-years lost due to ISH (see Table 4).

[75] Johnson D, Dupuis G, Piche J et al. Adult mental health outcomes of adolescent depression: a systematic review. *Depression and Anxiety.* 2018; 35: 700-16.
[76] Rohde P, Lewinsohn PM, Klein DN et al. Key characteristics of major depressive disorder occurring in childhood, adolescence, emerging adulthood, and adulthood. *Clinical Psychological Science*. 2013; 1(1): 41-53.
[77] Johnson D, Dupuis G, Piche J et al. Adult mental health outcomes of adolescent depression: a systematic review. *Depression and Anxiety.* 2018; 35: 700-16.
[78] BC Vital Statistics Agency. *Annual Report 2013. Selected Vital Statistics and Health Status Indicators.* 2015. Available at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2013/pdf/annual-report-2013.pdf. Accessed December 2018.
[79] BC Vital Statistics Agency. *Annual Report 2014. Selected Vital Statistics and Health Status Indicators.* 2015. Available at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2014/pdf/annual-report-2014.pdf. Accessed December 2018.
[80] BC Vital Statistics Agency. *Annual Report 2015. Selected Vital Statistics and Health Status Indicators.* 2015. Available at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2015/pdf/annual-report-2015.pdf. Accessed December 2018.

In the birth cohort of 20,000 females, 24 of 165 (14.4%) deaths between the ages of 12 and 34 are due to ISH, resulting in 1,263 life-years lost due to ISH (see Table 5).

Table 4: Deaths and Life Years Lost Attributable to Intentional Self-Harm (ISH)

Males in a British Columbia Male Birth Cohort of 20,000

Age Group	Males in Birth Cohort	Deaths	% of Deaths due to ISH	# of Deaths due to ISH	Average Life Years Lived	Life Years Lost due to ISH
11	19,903					
12	19,902	1	11.8%	0.1	68.6	10
13	19,900	2	11.8%	0.2	67.6	13
14	19,898	2	11.8%	0.2	66.6	16
15	19,896	3	24.3%	0.7	65.7	45
16	19,891	4	24.3%	1.1	64.7	69
17	19,885	6	24.3%	1.6	63.7	99
18	19,876	9	24.3%	2.2	62.7	137
19	19,864	11	24.3%	2.8	61.7	171
20	19,851	14	18.3%	2.5	60.8	151
21	19,835	16	18.3%	2.9	59.8	175
22	19,817	18	18.3%	3.3	58.9	194
23	19,796	20	18.3%	3.7	57.9	216
24	19,775	22	18.3%	4.0	57.0	227
25	19,751	23	15.2%	3.6	56.0	199
26	19,727	24	15.2%	3.7	55.1	202
27	19,702	25	15.2%	3.8	54.1	207
28	19,676	26	15.2%	3.9	53.1	209
29	19,649	27	15.2%	4.1	52.2	212
30	19,621	28	15.2%	4.2	51.2	214
31	19,593	28	15.2%	4.3	50.2	215
32	19,564	29	15.2%	4.4	49.3	215
33	19,535	29	15.2%	4.5	48.3	215
34	19,505	30	15.2%	4.6	47.4	216
Total		**398**	**16.6%**	**66**		**3,240**

Table 5: Deaths and Life Years Lost Attributable to Intentional Self-Harm (ISH)
in a British Columbia Female Birth Cohort of 20,000

Age Group	Individuals in Birth Cohort	Deaths	% of Deaths due to ISH	# of Deaths due to ISH	Average Life Years Lived	Life Years Lost due to ISH
11	19,914					
12	19,913	1	0.0%	0.0	72.6	0
13	19,911	2	0.0%	0.0	71.6	0
14	19,910	2	0.0%	0.0	70.6	0
15	19,907	2	15.5%	0.3	69.6	24
16	19,904	3	15.5%	0.5	68.6	36
17	19,900	4	15.5%	0.7	67.6	46
18	19,894	6	15.5%	0.9	66.6	58
19	19,888	6	15.5%	1.0	65.7	63
20	19,881	7	24.4%	1.6	64.7	104
21	19,874	7	24.4%	1.7	63.7	106
22	19,867	7	24.4%	1.8	62.7	113
23	19,859	8	24.4%	1.9	61.7	118
24	19,851	8	24.4%	2.0	60.8	119
25	19,843	8	24.4%	2.0	59.8	120
26	19,834	9	10.1%	0.9	58.8	52
27	19,825	9	10.1%	0.9	57.8	53
28	19,816	9	10.1%	1.0	56.8	54
29	19,806	10	10.1%	1.0	55.9	55
30	19,796	10	10.1%	1.0	54.9	57
31	19,785	11	10.1%	1.1	53.9	60
32	19,773	11	10.1%	1.2	52.9	61
33	19,761	12	10.1%	1.2	51.9	63
34	19,749	13	10.1%	1.3	51.0	65
Total		**165**	**14.4%**	**24**		**1,263**

- Depression has an important influence on a person's QoL. Studies have also shown that individuals with current or treated depression report lower preference scores for depression health states than the general population.[81,82] Pyne and colleagues suggest that "public stigma may result in the general population being less sympathetic to the suffering of individuals with depression and less willing to validate the impact of depression symptoms."[83] Revicki and Wood, based on input from patients with depression who had completed at least eight weeks of anti-depressant (AD) medication, identified the following health state utilities: severe depression = 0.30, moderate depression = 0.55 to 0.63, mild depression = 0.64 to 0.73 and

[81] Pyne JM, Fortney JC, Tripathi S et al. How bad is depression? Preference score estimates from depressed patients and the general population. *Health Services Research*. 2009; 44(4): 1406-23.
[82] Gerhards SA, Evers SM, Sabel PW et al. Discrepancy in rating health-related quality of life of depression between patient and general population. *Quality of Life Research*. 2011; 20(2): 273-9.
[83] Pyne JM, Fortney JC, Tripathi S et al. How bad is depression? Preference score estimates from depressed patients and the general population. *Health Services Research*. 2009; 44(4): 1406-23.

antidepressant maintenance therapy = 0.72 to 0.83.[84] Whiteford and colleagues[85] suggest the following health utilities:

- Severe depression 0.35 (95% CI of 0.18-0.53)
- Moderate depression 0.59 (95% CI of 0.45-0.72)
- Mild depression 0.84 (95% CI of 0.78-0.89)

- For modelling purposes we assumed an equal proportion of individuals with mild, moderate and severe depression and used the average quality of life provided by Whiteford and colleagues of 0.59 (95% CI of 0.47 to 0.72). Based on a general population QoL of 0.85 (see Reference Document), depression results in a reduction in QoL of 31% (0.85-0.59 / 0.85) (95% CI of 15% to 45%) (see Table 6, row *z*).

- When a longitudinal perspective is taken, 30% of adult patients with depression remain undetected at 1 year and only 14% at the end of 3 years, or approximately one out of seven patients with treatable depression.[86,87,88]
- Applying the adult rate of undiagnosed treatable depression to adolescents may result in understating the number of adolescents with undetected depression in BC as adolescents are more likely than adults to seek advice from peers rather than seek professional help.[89]

- For modelling purposes, we assumed that 25% of adolescent major depressive disorder is undiagnosed treatable depression and varied this between 15% and 35% in the sensitivity analysis (Table 6, row *ae*).

- The USPSTF only found two screening methods that it deemed adequate for use with adolescents, the Patient Health Questionnaire for Adolescents (PHQ-A) and the Beck Depression Inventory (BDI). The sensitivity of a screening instrument refers to the number of people with the illness, in this case, depression correctly identified by the test. The specificity of the test is the number of people without the illness that are correctly identified by the test.
- For the PHQ-A, Johnson et al. found a sensitivity of 73% and a specificity of 94%.[90] They report a positive predictive value (probability that the disease is present when the test is positive) of 56% for MDD and a negative predictive value of 97%. The PHQ-A has been validated compared to a structured clinical interview.

[84] Revicki DA and Wood M. Patient-assigned health state utilities for depression-related outcomes: differences by depression severity and antidepressant medications. *Journal of Affective Disorders*. 1998; 48(1): 25-36.
[85] Whiteford HA, Degenhardt L, Rehm J et al. Global burden of disease attributable to mental and substance use disorders: findings from the Global Burden of Disease Study 2010. *The Lancet*. 2013; 382(9904): 1575-86.
[86] Kessler D, Heath I, Lloyd K et al. Cross sectional study of symptom attribution and recognition of depression and anxiety in primary care. *BMJ*. 1999; 318(7181): 436-40.
[87] Kessler D, Bennewith O, Lewis G et al. Detection of depression and anxiety in primary care: follow up study. *BMJ*. 2002; 325(7371): 1016-7.
[88] Tylee A and Walters P. Underrecognition of anxiety and mood disorders in primary care: why does the problem exist and what can be done? *The Journal of Clinical Psychiatry.* 2006; 68(2): 27-30.
[89] Dr. Jana Davidson, Psychiatrist-in-Chief, Children's & Women's Mental Health Programs, Children's and Women's Health Centre of BC. May 6, 2019. Personal communication.
[90] Johnson JG, Harris ES, Spitzer RL et al. The patient health questionnaire for adolescents: validation of an instrument for the assessment of mental disorders among adolescent primary care patients. *Journal of Adolescent Health*. 2002; 30(3): 196-204.

- In their analysis of the BDI, Canals et al. found for a cut-off score of 11 (i.e. 11 and higher = depressed) the sensitivity of BDI was 90%, the specificity was 86% and the positive predictive value was 20%.[91]
- Roberts et al. found sensitivity of BDI at 83.7%, specificity at 80.9% and positive predictive value at 10.2% when referenced against DSM III clinical diagnosis.[92]

- The USPSTF considers the PHQ-A to be the best test to use in assessing adolescent depression. We will therefore assume use of the PHQ-A in our base model (with a sensitivity of 73% and a specificity of 94%) (Table 6, rows *ai & aj*). We will assume use of the BDI in our sensitivity analysis, taking the average of the Canals and Roberts studies for sensitivity (86.9%) and specificity (83.5%) of the BDI. Because of the potential harms of misdiagnosis, it is useful to apply a second test if individuals test positive with the PHQ-A. When this is modelled we begin with the PHQ-A and then apply the BDI. In the base model, the second test sensitivity is set to 100% and the specificity to 0% in order to correctly carry through the all first tests results to the rest of the model (Table 6, rows *am & an*).

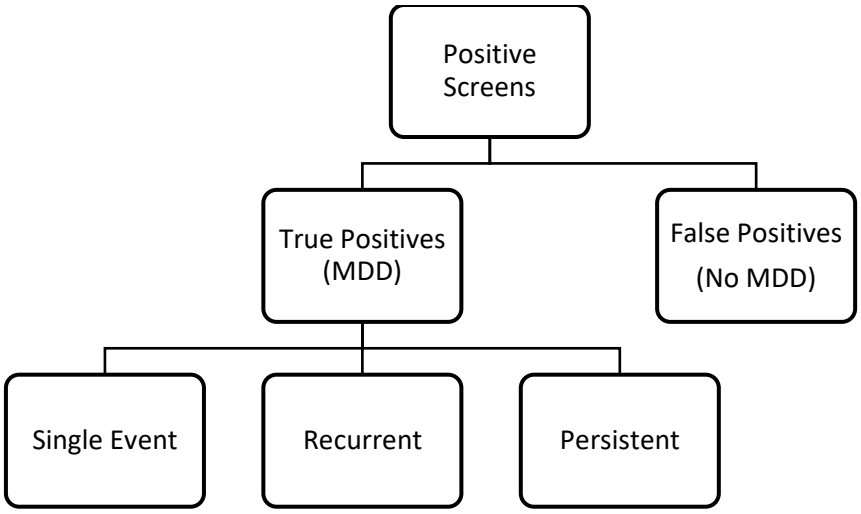
- Merikangas and colleagues found that 40.9% of female and 36.5% of male adolescents in the US aged 13-17 years with major depressive disorder received mental health services for their illness.[93]
- Mojtabai and colleagues found a similar overall rate in 2005, reporting that 36.4% of adolescents 12 -17 sought treatment. This rate increased modestly to 42.0% in 2014 in US adolescents aged 12-17.[94]
- On the other hand, research by Ghandour et al based on 2016 survey results in the US found that 79.0% (95% CI of 74.4% to 83.0%) of adolescents aged 12-17 with diagnosed depression received mental health treatment or counselling.[95] In females 3 – 17 years old (the only sex breakdown available), the number was 80.7% (95% CI of 76.2 to 84.5%) and in males 3 – 17 years old it was 75.2% (95% CI of 67.9 to 81.3%). Unfortunately, the study by Ghandour et al does not provide information on the extent of that treatment or the type of treatment.
- Updating Mojtabai and colleague's numbers using the 2016 and 2017 data from the NSDUH shows that a total of 40.3% of individuals with a 12-month major depressive episode either saw or talked to a health professional or used prescription medication. Averaging the rates for the two years, the number is 31.8% for males and 43.3% for females.[96]
- Mojtabai and colleagues found that of those US adolescents aged 12-17 seeking treatment for their MDD, 20.0% reported use of prescription medication while 50.7%

[91] Canals J, Blade J, Carbajo G et al. The Beck Depression Inventory: Psychometric characteristics and usefulness in nonclinical adolescents. *European Journal of Psychological Assessment*. 2001; 17(1): 63.
[92] Roberts RE, Lewinsohn PM and Seeley JR. Screening for adolescent depression: A comparison of depression scales. *Journal of the American Academy of Child & Adolescent Psychiatry*. 1991; 30(1): 58-66.
[93] Merikangas KR, He J-p, Burstein M et al. Service utilization for lifetime mental disorders in US adolescents: results of the National Comorbidity Survey–Adolescent Supplement (NCS-A). *Journal of the American Academy of Child & Adolescent Psychiatry*. 2011; 50(1): 32-45.
[94] Mojtabai R, Olfson M and Han B. National trends in the prevalence and treatment of depression in adolescents and young adults. *Pediatrics*. 2016; 138(6): e20161878.
[95] Ghandour RM, Sherman LJ, Vladutiu CJ et al. Prevalence and treatment of depression, anxiety, and conduct problems in US children. *The Journal of Pediatrics.* 2018:
[96] Substance Abuse and Mental Health Services Administration. *Reports and Detailed Tables from the 2017 National Survey on Drug Use and Health (NSDUH)*. 2017. Available at https://www.samhsa.gov/data/nsduh/reports-detailed-tables-2017-NSDUH. Accessed February 2019.

reported receiving counselling or therapy.[97] No sex breakdown of counselling or therapy rates was available. NSDUH data for 2016 and 2017 show medication rates of 17.3% for males and 21.7% for females.[98]

- The Mental Health Parity and Addiction Equity Act in the US "generally prevents group health plans and health insurance issuers that provide mental health or substance use disorder (MH/SUD) benefits from imposing less favorable benefit limitations on those benefits than on medical/surgical benefits."[99] The lack of similar legislation in BC may result in treatment seeking rates being lower in BC than are reflected in the US data, especially for non-pharmacological interventions (e.g. counselling).[100]
- In our model, we reduce the US treatment rate(s) by an absolute value of 10% to account for possibly lower treatment rates in BC.
- Data provided by the BC Ministry of Health indicate that for fiscal years 2011/12 through 2015/16 (5 years), 15.7% of BC adolescents (12 -18) diagnosed with major depression had a prescription for fluoxetine filled within one month of diagnosis, 19.7% within three months of diagnosis (i.e. an additional 4%) and 22.2% within six months of diagnosis (i.e. an additional 2.5% since the three-month point). These rates are 14.1%, 17.5% and 19.5%, respectively, for males and 16.6%, 20.9% and 23.6%, respectively, for females.[101]
- It is not uncommon to see wait times of 2 – 6 months for non-pharmacological depression interventions (e.g. cognitive behavioural therapy or individual counselling) in BC.[102]
- We consider four distinct groups in our model, that branch from the group of individuals who received a positive screen for major depressive disorder as follows:

[97] Mojtabai R, Olfson M and Han B. National trends in the prevalence and treatment of depression in adolescents and young adults. *Pediatrics*. 2016; 138(6): e20161878.
[98] Substance Abuse and Mental Health Services Administration. *Reports and Detailed Tables from the 2017 National Survey on Drug Use and Health (NSDUH)*. 2017. Available at https://www.samhsa.gov/data/nsduh/reports-detailed-tables-2017-NSDUH. Accessed February 2019.
[99] Centers for Medicare & Medicaid Services. *The Mental Health Parity and Addiction Equity Act (MHPAEA).* 2019. Available at https://www.cms.gov/cciio/programs-and-initiatives/other-insurance-protections/mhpaea_factsheet.html. Accessed May 2019.
[100] Dr. Jana Davidson, Psychiatrist-in-Chief, Children's & Women's Mental Health Programs, Children's and Women's Health Centre of BC. May 6, 2019. Personal communication.
[101] Aciemme (Sam) Ospan, Senior Manager, Lifetime Prevention Schedule, Healthy Living and Health Promotion Branch, BC Ministry of Health. April 18, 2019. Personal communication.
[102] Dr. Jana Davidson, Psychiatrist-in-Chief, Children's & Women's Mental Health Programs, Children's and Women's Health Centre of BC. May 6, 2019. Personal communication.



- We model each group over different time horizons:
    - False Positives (no MDD) are modelled as being treated for six months after which time we assume that it becomes clear that this group has been incorrectly screened positive and treatments cease for this group.
    - The group with correctly diagnosed MDD that ends up being single event MDD, is also modelled as receiving treatment for six months after which time we assume that no further treatments are undertaken or necessary.
    - The group with correctly diagnosed MDD that ends up being recurrent is modelled as receiving treatment for one year after the index event. We model that this group receives treatment for seven subsequent events during their lifetime, each lasting one year.
    - The group with correctly diagnosed MDD that ends up being persistent is modelled as receiving treatment for twenty years after the index event. We model that this group continues to use anti-depressants throughout this time.

- For modelling purposes, we assume that 50.5% (60.5% - 10%) of adolescents with MDD seek treatment (60.5% is the mid-point of 42%[103] and 79%[104]) and vary this from 32% to 69% in our sensitivity analysis (Table 6, rows *be, bu & co*).
- Of those seeking treatment, 50.7% receive counselling or therapy (Table 6, rows *bf, bv & cp*).
- In modelling for males, we assume that 43.5% (53.5% - 10%) of male adolescents with MDD seek treatment (53.5% is the mid-point of 31.8%[105] and 75.2%[106]) and vary this from 21.8% to 65.2% in our sensitivity analysis (Table 6a, rows *be, bu & co*).

[103] Mojtabai R, Olfson M and Han B. National trends in the prevalence and treatment of depression in adolescents and young adults. *Pediatrics*. 2016; 138(6): e20161878.
[104] Ghandour RM, Sherman LJ, Vladutiu CJ et al. Prevalence and treatment of depression, anxiety, and conduct problems in US children. *The Journal of Pediatrics.* 2018:
[105] Substance Abuse and Mental Health Services Administration. *Reports and Detailed Tables from the 2017 National Survey on Drug Use and Health (NSDUH)*. 2017. Available at https://www.samhsa.gov/data/nsduh/reports-detailed-tables-2017-NSDUH. Accessed February 2019.
[106] Ghandour RM, Sherman LJ, Vladutiu CJ et al. Prevalence and treatment of depression, anxiety, and conduct problems in US children. *The Journal of Pediatrics.* 2018:

- In modelling for females, we assume that 52.0% (62.0% - 10%) of female adolescents with MDD seek treatment (62.0% is the mid-point of 43.3%[107] and 80.7%[108]) and vary this from 33.3% to 70.7% in our sensitivity analysis (Table 6b, rows *be, bu & co*).
- In our model, we assume that 19.7% (Table 6, row *ap*) of ***all individuals*** screened positive for depression will fill anti-depressant prescriptions during the first three months of treatment and that this increases to 22.2% during months 4 – 6 after a positive screen (Table 6, row *ar*).
- In our model for males, we assume that 17.5% (Table 6a, row *ap*) of ***all males*** screened positive for depression will fill anti-depressant prescriptions during the first three months of treatment and that this increases to 19.5% during months 4 – 6 after a positive screen (Table 6a, row *ar*).
- In our model for females, we assume that 20.9% (Table 6b, row *ap*) of ***all females*** screened positive for depression will fill anti-depressant prescriptions during the first three months of treatment and that this increases to 23.6% during months 4 – 6 after a positive screen (Table 6b, row *ar*).
- We model anti-depressant use among recurrent MDD cases and the first year of persistent MDD at 22.2% (Table 6, row *bo*) and assume that after the first year, ***all*** of the persistent MDD cases are taking anti-depressant medication (Table 6, row *cj*)
- In males, we model anti-depressant use among recurrent MDD cases and the first year of persistent MDD at 19.5% (Table 6a, row *bo*) and assume that after the first year, ***all*** of the persistent MDD cases are taking anti-depressant medication (Table 6a, row *cj*)
- In females, we model anti-depressant use among recurrent MDD cases and the first year of persistent MDD at 23.6% (Table 6b, row *bo*) and assume that after the first year, ***all*** of the persistent MDD cases are taking anti-depressant medication (Table 6b, row *cj*)

- Cognitive behavioural therapy (CBT) is considered to be a "well-established intervention" for depression in adolescents.[109]
- The systematic review prepared by Forman-Hoffman and colleagues for the USPSTF estimated that CBT leads to a clinical improvement in MDD for 12.1% (Table 6, row *bi*) of adolescents receiving this therapy compared to a placebo.[110]

[107] Substance Abuse and Mental Health Services Administration. *Reports and Detailed Tables from the 2017 National Survey on Drug Use and Health (NSDUH)*. 2017. Available at https://www.samhsa.gov/data/nsduh/reports-detailed-tables-2017-NSDUH. Accessed February 2019.
[108] Ghandour RM, Sherman LJ, Vladutiu CJ et al. Prevalence and treatment of depression, anxiety, and conduct problems in US children. *The Journal of Pediatrics.* 2018:
[109] Weersing VR, Jeffreys M, Do M-CT et al. Evidence base update of psychosocial treatments for child and adolescent depression. *Journal of Clinical Child & Adolescent Psychology*. 2017; 46(1): 11-43.
[110] Forman-Hoffman V, McClure E, McKeeman J et al. Screening for Major Depressive Disorder in children and adolescents: a systematic review for the US Preventive Services Task Force. *Annals of Internal Medicine.* 2016; 164(5): 342-9.

- Cipriani and colleagues conducted a meta-analysis on efficacy and tolerability of antidepressants in adolescents with major depressive disorder and concluded that "only fluoxetine was statistically significantly more effective than placebo."[111]
- In the clinical guideline for the USPSTF, Siu only identifies one type of selective serotonin reuptake inhibitor (SSRI) with a "good" quality study supporting its use in treating MDD in adolescents: fluoxetine.[112]
- The systematic review prepared by Forman-Hoffman and colleagues for the USPSTF estimated that fluoxetine alone leads to a clinical improvement in MDD for 25.7% (95% CI of 16.2% to 35.2%) of adolescents taking it (Table 6, row *bb*, *bq* & *cl*).
- The systematic review prepared by Forman-Hoffman and colleagues for the USPSTF estimated that when fluoxetine is combined with CBT, the clinical improvement in MDD increases to 36.2% (95% CI of 27.2% to 45.2%).
- The Canadian Network for Mood and Anxiety Treatments (CANMAT) 2016 Clinical Guidelines recommend two treatment phases for depression:[113]
    - an acute phase, lasting 8 to 12 weeks, targeting symptom remission and restoration of functioning
    - a maintenance phase, lasting 6 to 24 months, targeting prevention of recurrence and return to full functioning and quality of life
- Depression is a highly recurrent disorder.[114] On average, half of individuals experiencing at least one MDE during their lifetime will experience between 5-9 recurrent episodes during their lifetime.[115,116,117]
- In a follow-up of individuals using anti-depressants, Colman and colleagues reported that 24% of patients were still using anti-depressants 10-years later.[118]

- In our model, we assume that 50% of the MDD cases are single events and the remainder will be recurrent or persistent MDD (Table 6, row *ax*).
- We model that 5.3% of the MDD cases are persistent (22.2% 6-month anti-depressant use in BC adolescents x 24% still using anti-depressants 10 years later = 5.3% of MDD) (Table 6, row *cc*), which leaves 44.7% of the initial MDD cases that recur multiple times in an individual's lifetime (100% - 50% - 5.3% = 44.7%) (Table 6, row *bm*).

[111] Cipriani A, Zhou X, Del Giovane C et al. Comparative efficacy and tolerability of antidepressants for major depressive disorder in children and adolescents: a network meta-analysis. *The Lancet*. 2016; 388(10047): 881-90.
[112] Siu AL. Screening for depression in children and adolescents: US Preventive Services Task Force recommendation statement. *Annals of Internal Medicine.* 2016; 164(5): 360-6.
[113] Lam RW, McIntosh D, Wang J et al. Canadian Network for Mood and Anxiety Treatments (CANMAT) 2016 clinical guidelines for the management of adults with major depressive disorder: section 1. Disease burden and principles of care. *The Canadian Journal of Psychiatry*. 2016; 61(9): 510-23.
[114] Burcusa SL and Iacono WG. Risk for recurrence in depression. *Clinical Psychology Review*. 2007; 27(8): 959-85.
[115] Kessler RC, Zhao S, Blazer DG et al. Prevalence, correlates, and course of minor depression and major depression in the National Comorbidity Survey. *Journal of Affective Disorders*. 1997; 45(1): 19-30.
[116] Kessler RC and Walters EE. Epidemiology of DSM-III-R major depression and minor depression among adolescents and young adults in the national comorbidity survey. *Depression and Anxiety*. 1998; 7(1): 3-14.
[117] Colman I, Naicker K, Zeng Y et al. Predictors of long-term prognosis of depression. *Canadian Medical Association Journal*. 2011; 183(17): 1969-76.
[118] Colman I, Croudace TJ, Wadsworth ME et al. Psychiatric outcomes 10 years after treatment with antidepressants or anxiolytics. *The British Journal of Psychiatry*. 2008; 193(4): 327-31.

- For males, we model that 4.7% of the MDD cases are persistent (19.5% 6-month anti-depressant use in BC adolescents x 24% still using anti-depressants 10 years later = 4.7% of MDD) (Table 6a, row *cc*), which leaves 45.3% of the initial MDD cases that recur multiple times in an individual's lifetime (100% - 50% - 4.7% = 45.3%) (Table 6a, row *bm*).
- For females, we model that 5.7% of the MDD cases are persistent (23.6% 6-month anti-depressant use in BC adolescents x 24% still using anti-depressants 10 years later = 5.7% of MDD) (Table 6b, row *cc*), which leaves 44.3% of the initial MDD cases that recur multiple times in an individual's lifetime (100% - 50% - 5.7% = 44.3%) (Table 6b, row *bm*).
- We have modelled an additional 7 episodes after the index MDD episode for a total of eight (8) MDD events for recurrent MDD (Table 6, row *bs*). For discounting purposes, we model these as occurring eight years apart throughout the lifetime of the affected individuals.

- Approximately 60% of patients stay on anti-depressant medication for at least 3 months and 45% for at least 6 months.[119,120] For those diagnosed with depression and taking medication, an average of 71% of days in a 180-day period had anti-depressant use and 62% of days in a 365-day period had anti-depressant use.[121] On average, anti-depressants are taken on 226 days each year.[122]
- The average length of an adolescent depressive episode has been reported to range between 24.4 and 27 weeks.[123,124]
- Van der Voort and colleagues report that single episodes of MDD recover within six months of onset and that individuals with syndromal (recurrent) MDD take up to twelve months to recover fully.[125]

- Following van der Voort and colleagues, we model single episodes of MDD as recovering within 6 months (Table 6, row *bc*) and recurrent episodes as recovering within one year (Table 6, row *br*). We model persistent MDD as requiring treatment throughout the lifetime (Table 6, row *ct*). We model persistent treatment for the 20 years from 15 years old (mid-point of the 12 -18 year old cohort) to 34 years of age, consistent with Tables 4 & 5.

[119] Solberg LI, Trangle MA and Wineman AP. Follow-up and follow-through of depressed patients in primary care: the critical missing components of quality care. *The Journal of the American Board of Family Practice*. 2005; 18(6): 520-7.
[120] Cantrell CR, Eaddy MT, Shah MB et al. Methods for evaluating patient adherence to antidepressant therapy: a real-world comparison of adherence and economic outcomes. *Medical Care*. 2006; 44(4): 300-3.
[121] Puyat JH, Kazanjian A, Wong H et al. Comorbid chronic general health conditions and depression care: a population-based analysis. *Psychiatric Services.* 2017; 68(9): 907-15.
[122] Puyat JH, Kazanjian A, Wong H et al. Comorbid chronic general health conditions and depression care: a population-based analysis. *Psychiatric Services.* 2017; 68(9): 907-15.
[123] Rohde P, Lewinsohn PM, Klein DN et al. Key characteristics of major depressive disorder occurring in childhood, adolescence, emerging adulthood, and adulthood. *Clinical Psychological Science*. 2013; 1(1): 41-53.
[124] Avenevoli S, Swendsen J, He J-P et al. Major depression in the National Comorbidity Survey–Adolescent Supplement: prevalence, correlates, and treatment. *Journal of the American Academy of Child & Adolescent Psychiatry*. 2015; 54(1): 37-44.
[125] van der Voort T, Seldenrijk A, van Meijel B et al. Functional versus syndromal recovery in patients with major depressive disorder and bipolar disorder. *Journal of Clinical Psychiatry*. 2015; 76: e809-e14.

- Several recent meta-analyses suggest that internet-based cognitive behavioural therapy may be effective in treating general depression in adults.[126,127] The evidence that is currently available is insufficient to justify modelling this approach for adolescents with MDD.
- We model treatment for those with a positive MDD screen by time period as follows:
    - 0 – 3 months after screening: 19.7% of positive screened adolescents (17.5% males, 20.9% females) are taking anti-depressants.
    - 4 – 6 months after screening: 22.2% of positive screen adolescents are taking anti-depressants and 25.6% are in counselling or therapy (Table 6 rows *bg, bw & cq*), with half of the therapy group in individual sessions and half in group sessions. The 25.6% is based on 50.5% seeking treatment multiplied by 50.7% of those seeking treatment attending therapy / counselling.
        - For males the counselling rate is 22.1% (43.5% treatment seeking x 50.7% counselling rate among treatment seekers) (Table 6a rows *bg, bw & cq*).
        - For females the counselling rate is 26.4% (52.0% treatment seeking x 50.7% counselling rate among treatment seekers) (Table 6b rows *bg, bw & cq*).
    - 7 – 12 months after screening: 22.2% of **correctly diagnosed** adolescents with **recurrent or persistent MDD** are on anti-depressants and 25.6% are in counselling or therapy, with half of the therapy group in individual sessions and half in group sessions.
    - 13+ months after screening: all of the **correctly diagnosed** adolescents with **persistent MDD** are on anti-depressants. We assume that the 25.6% in counselling or therapy receive four (4) individual sessions annually.
    - Recurrent MDD: for each year of recurrent MDD, 22.2% of individuals with recurrent MDD take anti-depressants and 25.6% receive therapy (5 sessions).

[126] Karyotaki E, Riper H, Twisk J et al. Efficacy of self-guided internet-based cognitive behavioral therapy in the treatment of depressive symptoms: a meta-analysis of individual participant data. *JAMA Psychiatry.* 2017; 74(4): 351-9.

[127] Twomey C and O'Reilly G. Effectiveness of a freely available computerised cognitive behavioural therapy programme (MoodGYM) for depression: meta-analysis. *Australian & New Zealand Journal of Psychiatry*. 2017; 51(3): 260-9.

<table>
<tr><th colspan="6">Treatment Modeling for Positive MDD Screens</th></tr>
<tr><td colspan="2" rowspan="2"></td><td colspan="3">True Positive Screens</td><td rowspan="2">False Positive Screens</td></tr>
<tr><td>Single Event</td><td>Recurrent</td><td>Persistent</td></tr>
<tr><td rowspan="2">0 - 3 Months</td><td>Pharmacological</td><td colspan="4">19.7% anti-depressant rate</td></tr>
<tr><td>Therapeutic</td><td colspan="4">None</td></tr>
<tr><td rowspan="2">4 - 6 Months</td><td>Pharmacological</td><td colspan="4">22.2% anti-depressant rate</td></tr>
<tr><td>Therapeutic</td><td colspan="4">25.6% receiving therapy</td></tr>
<tr><td rowspan="2">7 -12 Months</td><td>Pharmacological</td><td rowspan="4">No treatment</td><td colspan="2">22.2% anti-depressant rate</td><td rowspan="4">No treatment</td></tr>
<tr><td>Therapeutic</td><td colspan="2">25.6% receiving therapy</td></tr>
<tr><td rowspan="2">13+ Months</td><td>Pharmacological</td><td rowspan="2">No Treatment</td><td>100% anti-depressant rate</td></tr>
<tr><td>Therapeutic</td><td>25.6% receiving therapy</td></tr>
</table>

- Revicki and Wood found that antidepressant maintenance therapy resulted in a weighted average QoL of 0.78 (95% CI of 0.63 to 0.93).[128] Based on a general population QoL of 0.85 (see Reference Document), antidepressant maintenance therapy results in a reduction in QoL of 8% (0.85-0.78 / 0.85) (95% CI of 26% to no reduction) (Table 6, row *au*).

[128] Revicki DA and Wood M. Patient-assigned health state utilities for depression-related outcomes: differences by depression severity and antidepressant medications. *Journal of Affective Disorders*. 1998; 48(1): 25-36.

CPB for Both Sexes

Based on these assumptions, the CPB associated with screening for major depressive disorder in adolescents (both sexes) ages 12 to 18 is 1,880 QALYs (see Table 6, row *da*).

Table 6: CPB of Screening for MDD in Adolescents Ages 12 - 18
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
a	Number of life years, 12 year olds	39,814	BC Life Table
b	Annual rate of MDD, 12 year olds	5.2%	√
c	Life years with MDD, 12 year olds	2,070	= a * b
d	Life years without MDD, 12 year olds	37,743	= a - c
e	Number of life years, 13 year olds	39,810	BC Life Table
f	Annual rate of MDD, 13 year olds	9.3%	√
g	Life years with MDD, 13 year olds	3,702	= e * f
h	Life years without MDD, 13 year olds	36,108	= e - g
i	Number of life years, 14 year olds	39,806	BC Life Table
j	Annual rate of MDD, 14 year olds	11.7%	√
k	Life years with MDD, 14 year olds	4,657	= i * j
l	Life years without MDD, 14 year olds	35,149	= i - k
m	Number of life years, 15 year olds	39,801	BC Life Table
n	Annual rate of MDD, 15 year olds	15.0%	√
o	Life years with MDD, 15 year olds	5,970	= m * n
p	Life years without MDD, 15 year olds	33,831	= m - o
q	Number of life years, 16 year olds	39,793	BC Life Table
r	Annual rate of MDD, 16 year olds	16.0%	√
s	Life years with MDD, 16 year olds	6,367	= q * r
t	Life years without MDD, 16 year olds	33,426	= q - s
u	Number of life years, 17 and 18 year olds	79,550	BC Life Table
v	Annual rate of MDD, 17 and 18 year olds	16.5%	√
w	Life years with MDD, 17 and 18 year olds	13,126	= u * v
x	Life years without MDD, 17 and 18 year olds	66,424	= u - w
y	**Life years with MDD between 12 and 18**	**35,893**	= c + g + k + o + s + w
z	QoL decrement due to depression	0.31	√
aa	QALYs lost during adolescence due to depression	11,127	= y * z
ab	Deaths attributable to ISH between the ages of 12 and 34	90	Tables 4 & 5
ac	QALYS lost due to deaths attributable to ISH between the ages of 12 and 34	4,504	Tables 4 & 5
ad	**Total QALYs lost due to depression in adolescence**	**15,630**	= aa + ac
ae	% MDD undetected in lifetime	25.0%	√
af	Life years with undetected MDD in cohort between 12 - 18 years of age	8,973	= y * ae
ag	Number of well care visits per year	2.07	√
ah	Depression screening rate	57.0%	√
ai	Sensitivity (rate of true positives), initial test	73.0%	√
aj	Specificity (rate of true negatives), initial test	94.0%	√
ak	Number of MDD cases correctly identified, initial test	7,729	= af * ag * ah * ai
al	Number of MDD cases diagnosed incorrectly, initial test	17,180	= (d + h + l + p + t + x) * ag * ah * (1 - aj)
am	Sensitivity (rate of true positives), 2nd test	100.0%	No second test in base model
an	Specificity (rate of true negatives), 2nd test	0.0%	No second test in base model
	Incorrectly Diagnosed MDD Cases		
ao	Number of MDD cases diagnosed incorrectly, overall	17,180	= al * (1 - an)
ap	Rate of anti-depressants, months 0 - 3	19.7%	√
aq	Number taking anti-depressants months 0 - 3	3,385	= ao * ap
ar	Rate of anti-depressants, months 4 - 6	22.2%	√
as	Number taking anti-depressants months 4 - 6	3,814	= ao * ar
at	Life years on anti-depressants	1,800	= (aq * 0.25) + (as * 0.25)
au	QoL decrement due to anti-depressant therapy	0.08	√
av	**QALYs Gained (or Lost), Incorrectly Diagnosed MDD**	**-144.0**	= - (at * au)

Table 6 (continued): CPB of Screening for MDD in Adolescents Ages 12 - 18 In a BC Birth Cohort of 40,000			
	Correctly Diagnosed MDD Cases		
	Single Event MDD		
aw	Number of MDD cases correctly identified, overall	7,729	= ak * am
ax	Rate of single event MDD in correct diagnoses	50.0%	√
ay	Number of single event MDD cases	3,864	= aw * ax
az	Rate of 6-month anti-depressant use	22.2%	√
ba	Number on anti-depressants	858	= ay * az
bb	Clinical improvement rate due to anti-depressants	25.7%	√
bc	Length of single event MDD, years	0.5	√
bd	**Depression-free life years gained due to anti-depressants**	**110.2**	= ab * bb * bc
be	Treatment seeking rate	50.5%	√
bf	Rate counselling among treatment seekers	50.7%	√
bg	Overall counselling rate	25.6%	= be * bf
bh	Number in counselling	989	= ay * bg
bi	Clinical improvement rate due to counselling	12.1%	√
bj	Length of single event MDD counselling, years	0.25	√
bk	**Depression-free life years gained due to counselling**	**29.9**	= bh * bi * bj
	Recurrent MDD		
bl	Number of MDD cases correctly identified, overall	7,729	= ak * am
bm	Rate of recurrent MDD in correct diagnoses	44.7%	√
bn	Number of recurrent MDD cases	3,453	= bl * bm
bo	Rate of 12-month anti-depressant use	22.2%	√
bp	Number on anti-depressants	766	= bn * bo
bq	Clinical improvement rate due to anti-depressants	25.7%	√
br	Length of recurrent MDD event, years	1.0	√
bs	Number of recurrent episodes, lifetime	8.0	√
bt	**Depression-free life years gained due to anti-depressants**	**1,576**	= bp * bq * br * bs
bu	Treatment seeking rate	50.5%	√
bv	Rate counselling among treatment seekers	50.7%	√
bw	Overall counselling rate	25.6%	= bu * bv
bx	Number in counselling	884	= bn * bw
by	Clinical improvement rate due to counselling	12.1%	√
bz	Length of recurrent MDD counselling, years	0.75	√
ca	**Depression-free life years gained due to counselling**	**642**	= bx * by * bz *bs
	Persistent MDD		
cb	Number of MDD cases correctly identified, overall	7,729	= ak * am
cc	Rate of persistent MDD in correct diagnoses	5.3%	√
cd	Number of persistent MDD cases	412	= cb * cc
ce	Rate of first year anti-depressant use	22.2%	√
cf	Number on anti-depressants	91	= cd * ce
cg	Clinical improvement rate due to anti-depressants	25.7%	√
ch	Length of treatment	1.0	√
ci	**Depression-free life years gained due to anti-depressants, year 1**	**23.5**	= cf * cg * ch
cj	Rate of anti-depressant use years 2 - 20	100.0%	√
ck	Number on anti-depressants	412	= cd * cj
cl	Clinical improvement rate due to anti-depressants	25.7%	√
cm	Length of treatment	19.0	√
cn	**Depression-free life years gained due to anti-depressants, years 2 - 20**	**2,011**	= ck * cl * cm
co	Treatment seeking rate	50.5%	√
cp	Rate counselling among treatment seekers	50.7%	√
cq	Overall counselling rate	25.6%	= co * cp
cr	Number in counselling	105	= cd * cq
cs	Clinical improvement rate due to counselling	12.1%	√
ct	Length of effect persistent event MDD counselling, years	20.0	√
cu	**Depression-free life years gained due to counselling**	**255**	= cr * cs * ct
	Summary of QALYs Gained with Screening		
cv	Individuals with MDD helped by treatment	680	= aw * ((az * bb) + (bg * bi))
cw	Depression free life years due to screening, correctly diagnosed MDD	4,647	= (bd + bk) + (bt + ca) + (ci + cn + cu)
cx	Reduction in % of total life years with MDD due to screening	12.95%	= cw / y
cy	QALYs gained due to screening, correctly diagnosed MDD	2,024	= cx * ad
cz	QALYs due to treating incorrectly diagnosed MDD	-144	= av
da	**Net QALYs as a result of screening (CPB)**	**1,880**	= cy + cz

√ = Estimates from the literature

For the sensitivity analysis of the base model (both sexes), we modified a number of major assumptions and recalculated the CPB as follows:

- Assume the rate of undetected MDD decreases from 25% to 15% (Table 6, row *ae*): CPB = 1,070
- Assume the rate of undetected MDD increases from 25% to 35% (Table 6, row *ae*): **CPB = 2,689**
- Assume a second round of screening (with BDI) is introduced, with a sensitivity of 86.9% and a specificity of 83.5% (Table 6, rows *am & an*): CPB = 1,735
- Assume the rate of treatment seeking increases from 50.5% to 69% (Table 6, row *be*): CPB = 2,028
- Assume the rate of treatment seeking decreases from 50.5% to 32% (Table 6, row *be*): CPB = 1,732
- Assume the QoL decrement for depression is reduced from 31% to 15% (Table 6, row *z*) and the QoL decrement for anti-depressant maintenance therapy is reduced from 8% to 0% (i.e. no decrement) (Table 6, row *au*): CPB = 1,280
- Assume the QoL decrement for depression is increased from 31% to 45% (Table 6, row *z*) and the QoL decrement for anti-depressant maintenance therapy is increased from 8% to 26% (Table 6, row *au*): CPB = 2,206
- Assume that the screening rate is only applied to one visit per year per patient, rather than 2.07 (Table 6, row *ag*): **CPB = 908**

CPB for Males

Based on the above assumptions for males, the CPB associated with screening for major depressive disorder in male adolescents' ages 12 to 18 is 739 QALYs (see Table 6a, row *da*).

Table 6a: CPB of Screening for MDD in Male Adolescents Ages 12 - 18
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
a	Number of life years, 12 year olds	19,902	BC Life Table
b	Annual rate of MDD, 12 year olds	5.2%	√
c	Life years with MDD, 12 year olds	1,035	= a * b
d	Life years without MDD, 12 year olds	18,867	= a - c
e	Number of life years, 13 year olds	19,900	BC Life Table
f	Annual rate of MDD, 13 year olds	9.3%	√
g	Life years with MDD, 13 year olds	1,851	= e * f
h	Life years without MDD, 13 year olds	18,050	= e - g
i	Number of life years, 14 year olds	19,898	BC Life Table
j	Annual rate of MDD, 14 year olds	11.7%	√
k	Life years with MDD, 14 year olds	2,328	= i * j
l	Life years without MDD, 14 year olds	17,570	= i - k
m	Number of life years, 15 year olds	19,896	BC Life Table
n	Annual rate of MDD, 15 year olds	15.0%	√
o	Life years with MDD, 15 year olds	2,984	= m * n
p	Life years without MDD, 15 year olds	16,911	= m - o
q	Number of life years, 16 year olds	19,891	BC Life Table
r	Annual rate of MDD, 16 year olds	16.0%	√
s	Life years with MDD, 16 year olds	3,183	= q * r
t	Life years without MDD, 16 year olds	16,709	= q - s
u	Number of life years, 17 and 18 year olds	39,761	BC Life Table
v	Annual rate of MDD, 17 and 18 year olds	16.5%	√
w	Life years with MDD, 17 and 18 year olds	6,560	= u * v
x	Life years without MDD, 17 and 18 year olds	33,200	= u - w
y	**Life years with MDD between 12 and 18**	**17,941**	= c + g + k + o + s + w
z	QoL decrement due to depression	0.31	√
aa	QALYs lost during adolescence due to depression	5,562	= y * z
ab	Deaths attributable to ISH between the ages of 12 and 34	66	Table 4
ac	QALYS lost due to deaths attributable to ISH between the ages of 12 and 34	3,240	Table 4
ad	**Total QALYs lost due to depression in adolescence**	**8,802**	= aa + ac
ae	% MDD undetected in lifetime	25.0%	√
af	Life years with undetected MDD in cohort between 12 - 18 years of age	4,485	= y * ae
ag	Number of well care visits per year	1.75	√
ah	Depression screening rate	53.3%	√
ai	Sensitivity (rate of true positives), initial test	73.0%	√
aj	Specificity (rate of true negatives), initial test	94.0%	√
ak	Number of MDD cases correctly identified, initial test	3,054	= af * ag * ah * ai
al	Number of MDD cases diagnosed incorrectly, initial test	6,789	= (d + h + l + p + t + x) * ag * ah * (1 - aj)
am	Sensitivity (rate of true positives), 2nd test	100.0%	No second test in base model
an	Specificity (rate of true negatives), 2nd test	0.0%	No second test in base model
	Incorrectly Diagnosed MDD cases		
ao	Number of MDD cases diagnosed incorrectly, overall	6,789	= al * (1 - an)
ap	Rate of anti-depressants, months 0 - 3	17.5%	√
aq	Number taking anti-depressants months 0 - 3	1,188	= ao * ap
ar	Rate of anti-depressants, months 4 - 6	19.5%	√
as	Number taking anti-depressants months 4 - 6	1,324	= ao * ar
at	Life years on anti-depressants	628	= (aq * 0.25) + (as * 0.25)
au	QoL decrement due to antidepressant therapy	0.08	√
av	**QALYs Gained (or Lost), Incorrectly Diagnosed MDD**	**-50.2**	= - (at * au)

Table 6a (continued): CPB of Screening for MDD in Male Adolescents Ages 12 - 18 In a BC Birth Cohort of 40,000			
	Correctly Diagnosed MDD cases		
	Single Event MDD		
aw	Number of MDD cases correctly identified, overall	3,054	= ak * am
ax	Rate of single event MDD in correct diagnoses	50.0%	√
ay	Number of single event MDD cases	1527	= aw * ax
az	Rate of 6-month anti-depressant use	19.5%	√
ba	Number on anti-depressants	298	= ay * az
bb	Clinical improvement rate due to anti-depressants	25.7%	√
bc	Length of single event MDD, years	0.5	√
bd	**Depression-free life years gained due to anti-depressants**	**38.3**	= ab * bb * bc
be	Treatment seeking rate	43.5%	√
bf	Rate counselling among treatment seekers	50.7%	√
bg	Overall counselling rate	22.1%	= be * bf
bh	Number in counselling	337	= ay * bg
bi	Clinical improvement rate due to counselling	12.1%	√
bj	Length of single event MDD counselling, years	0.25	√
bk	**Depression-free life years gained due to counselling**	**10.2**	= bh * bi * bj
	Recurrent MDD		
bl	Number of MDD cases correctly identified, overall	3,054	= ak * am
bm	Rate of recurrent MDD in correct diagnoses	45.3%	√
bn	Number of recurrent MDD cases	1383	= bl * bm
bo	Rate of 12-month anti-depressant use	19.5%	√
bp	Number on anti-depressants	270	= bn * bo
bq	Clinical improvement rate due to anti-depressants	25.7%	√
br	Length of recurrent MDD event, years	1.0	√
bs	Number of recurrent episodes, lifetime	8.0	√
bt	**Depression-free life years gained due to anti-depressants**	**555**	= bp * bq * br * bs
bu	Treatment seeking rate	43.5%	√
bv	Rate counselling among treatment seekers	50.7%	√
bw	Overall counselling rate	22.1%	= bu * bv
bx	Number in counselling	305	= bn * bw
by	Clinical improvement rate due to counselling	12.1%	√
bz	Length of recurrent MDD counselling, years	0.75	√
ca	**Depression-free life years gained due to counselling**	**222**	= bx * by * bz *bs
	Persistent MDD		
cb	Number of MDD cases correctly identified, overall	3,054	= ak * am
cc	Rate of persistent MDD in correct diagnoses	4.7%	√
cd	Number of persistent MDD cases	144	= cb * cc
ce	Rate of first year anti-depressant use	19.5%	√
cf	Number on anti-depressants	28	= cd * ce
cg	Clinical improvement rate due to anti-depressants	25.7%	√
ch	Length of treatment	1.0	√
ci	**Depression-free life years gained due to anti-depressants, year 1**	**7.2**	= cf * cg * ch
cj	Rate of anti-depressant use years 2 - 20	100.0%	√
ck	Number on anti-depressants	144	= cd * cj
cl	Clinical improvement rate due to anti-depressants	25.7%	√
cm	Length of treatment	19.0	√
cn	**Depression-free life years gained due to anti-depressants, years 2 - 20**	**701**	= ck * cl * cm
co	Treatment seeking rate	43.5%	√
cp	Rate counselling among treatment seekers	50.7%	√
cq	Overall counselling rate	22.1%	= co * cp
cr	Number in counselling	32	= cd * cq
cs	Clinical improvement rate due to counselling	12.1%	√
ct	Length of effect persistent event MDD counselling, years	20.0	√
cu	**Depression-free life years gained due to counselling**	**77**	= cr * cs * ct
	Summary of QALYs Gained with Screening		
cv	Individuals with MDD helped by treatment	235	= aw * ((az * bb) + (bg * bi))
cw	Depression free life years due to screening, correctly diagnosed MDD	1609	= (bd + bk) + (bt + ca) + (ci + cn + cu)
cx	Reduction in % of total life years with MDD due to screening	8.97%	= cw / y
cy	QALYs gained due to screening, correctly diagnosed MDD	790	= cx * ad
cz	QALYs due to treating incorrectly diagnosed MDD	-50	= av
da	**Net QALYs as a result of screening (CPB)**	**739**	= cy + cz

√ = Estimates from the literature

For the sensitivity analysis of the base model for males, we modified a number of major assumptions and recalculated the CPB as follows:

- Assume the rate of undetected MDD decreases from 25% to 15% (Table 6a, row *ae*): CPB = 423
- Assume the rate of undetected MDD increases from 25% to 35% (Table 6a, row *ae*): **CPB = 1,055**
- Assume a second round of screening (with BDI) is introduced, with a sensitivity of 86.9% and a specificity of 83.5% (Table 6a, rows *am & an*): CPB = 678
- Assume the rate of treatment seeking increases from 43.5% to 65.2% (Table 6a, row *be*): CPB = 815
- Assume the rate of treatment seeking decreases from 43.5% to 21.8% (Table 6a, row *be*): CPB = 664
- Assume the QoL decrement for depression is reduced from 31% to 15% (Table 6a, row *z*) and the QoL decrement for anti-depressant maintenance therapy is reduced from 8% to 0% (i.e. no decrement) (Table 6a, row *au*): CPB = 532
- Assume the QoL decrement for depression is increased from 31% to 45% (Table 6a, row *z*) and the QoL decrement for anti-depressant maintenance therapy is increased from 8% to 26% (Table 6a, row *au*): CPB = 852
- Assume that the screening rate is only applied to one visit per year per patient, rather than 1.75 (Table 6a, row *ag*): **CPB = 422**

CPB for Females

Based on the above assumptions for females, the CPB associated with screening for major depressive disorder in female adolescents' ages 12 to 18 is 1,078 QALYs (see Table 6b, row *da*).

Table 6b: CPB of Screening for MDD in Female Adolescents Ages 12 - 18
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
a	Number of life years, 12 year olds	19,913	BC Life Table
b	Annual rate of MDD, 12 year olds	5.2%	√
c	Life years with MDD, 12 year olds	1,035	= a * b
d	Life years without MDD, 12 year olds	18,878	= a - c
e	Number of life years, 13 year olds	19,911	BC Life Table
f	Annual rate of MDD, 13 year olds	9.3%	√
g	Life years with MDD, 13 year olds	1,852	= e * f
h	Life years without MDD, 13 year olds	18,060	= e - g
i	Number of life years, 14 year olds	19,910	BC Life Table
j	Annual rate of MDD, 14 year olds	11.7%	√
k	Life years with MDD, 14 year olds	2,329	= i * j
l	Life years without MDD, 14 year olds	17,580	= i - k
m	Number of life years, 15 year olds	19,907	BC Life Table
n	Annual rate of MDD, 15 year olds	15.0%	√
o	Life years with MDD, 15 year olds	2,986	= m * n
p	Life years without MDD, 15 year olds	16,921	= m - o
q	Number of life years, 16 year olds	19,904	BC Life Table
r	Annual rate of MDD, 16 year olds	16.0%	√
s	Life years with MDD, 16 year olds	3,185	= q * r
t	Life years without MDD, 16 year olds	16,719	= q - s
u	Number of life years, 17 and 18 year olds	39,794	BC Life Table
v	Annual rate of MDD, 17 and 18 year olds	16.5%	√
w	Life years with MDD, 17 and 18 year olds	6,566	= u * v
x	Life years without MDD, 17 and 18 year olds	33,228	= u - w
y	**Life years with MDD between 12 and 18**	**17,953**	= c + g + k + o + s + w
z	QoL decrement due to depression	0.31	√
aa	QALYs lost during adolescence due to depression	5,566	= y * z
ab	Deaths attributable to ISH between the ages of 12 and 34	24	Table 5
ac	QALYS lost due to deaths attributable to ISH between the ages of 12 and 34	1,263	Table 5
ad	**Total QALYs lost due to depression in adolescence**	**6,829**	= aa + ac
ae	% MDD undetected in lifetime	25.0%	√
af	Life years with undetected MDD in cohort between 12 - 18 years of age	4,488	= y * ae
ag	Number of well care visits per year	2.42	√
ah	Depression screening rate	61.1%	√
ai	Sensitivity (rate of true positives), initial test	73.0%	√
aj	Specificity (rate of true negatives), initial test	94.0%	√
ak	Number of MDD cases correctly identified, initial test	4,845	= af * ag * ah * ai
al	Number of MDD cases diagnosed incorrectly, initial test	10,769	= (d + h + l + p + t + x) * ag * ah * (1 - aj)
am	Sensitivity (rate of true positives), 2nd test	100.0%	No second test in base model
an	Specificity (rate of true negatives), 2nd test	0.0%	No second test in base model
	Incorrectly Diagnosed MDD cases		
ao	Number of MDD cases diagnosed incorrectly, overall	10,769	= al * (1 - an)
ap	Rate of anti-depressants, months 0 - 3	20.9%	√
aq	Number taking anti-depressants months 0 - 3	2,251	= ao * ap
ar	Rate of anti-depressants, months 4 - 6	23.6%	√
as	Number taking anti-depressants months 4 - 6	2,541	= ao * ar
at	Life years on anti-depressants	1,198	= (aq * 0.25) + (as * 0.25)
au	QoL decrement due to antidepressant therapy	0.08	√
av	**QALYs Gained (or Lost), Incorrectly Diagnosed MDD**	**-95.8**	= - (at * au)

Table 6b (continued): CPB of Screening for MDD in Female Adolescents Ages 12 - 18 In a BC Birth Cohort of 40,000			
	Correctly Diagnosed MDD cases		
	Single Event MDD		
aw	Number of MDD cases correctly identified, overall	4,845	= ak * am
ax	Rate of single event MDD in correct diagnoses	50.0%	√
ay	Number of single event MDD cases	2422	= aw * ax
az	Rate of 6-month anti-depressant use	23.6%	√
ba	Number on anti-depressants	572	= ay * az
bb	Clinical improvement rate due to anti-depressants	25.7%	√
bc	Length of single event MDD, years	0.5	√
bd	**Depression-free life years gained due to anti-depressants**	**73.5**	= ab * bb * bc
be	Treatment seeking rate	52.0%	√
bf	Rate counselling among treatment seekers	50.7%	√
bg	Overall counselling rate	26.4%	= be * bf
bh	Number in counselling	639	= ay * bg
bi	Clinical improvement rate due to counselling	12.1%	√
bj	Length of single event MDD counselling, years	0.25	√
bk	**Depression-free life years gained due to counselling**	**19.3**	= bh * bi * bj
	Recurrent MDD		
bl	Number of MDD cases correctly identified, overall	4,845	= ak * am
bm	Rate of recurrent MDD in correct diagnoses	44.3%	√
bn	Number of recurrent MDD cases	2146	= bl * bm
bo	Rate of 12-month anti-depressant use	23.6%	√
bp	Number on anti-depressants	507	= bn * bo
bq	Clinical improvement rate due to anti-depressants	25.7%	√
br	Length of recurrent MDD event, years	1.0	√
bs	Number of recurrent episodes, lifetime	8.0	√
bt	**Depression-free life years gained due to anti-depressants**	**1,041**	= bp * bq * br * bs
bu	Treatment seeking rate	52.0%	√
bv	Rate counselling among treatment seekers	50.7%	√
bw	Overall counselling rate	26.4%	= bu * bv
bx	Number in counselling	566	= bn * bw
by	Clinical improvement rate due to counselling	12.1%	√
bz	Length of recurrent MDD counselling, years	0.75	√
ca	**Depression-free life years gained due to counselling**	**411**	= bx * by * bz *bs
	Persistent MDD		
cb	Number of MDD cases correctly identified, overall	4,845	= ak * am
cc	Rate of persistent MDD in correct diagnoses	5.7%	√
cd	Number of persistent MDD cases	276	= cb * cc
ce	Rate of first year anti-depressant use	23.6%	√
cf	Number on anti-depressants	65	= cd * ce
cg	Clinical improvement rate due to anti-depressants	25.7%	√
ch	Length of treatment	1.0	√
ci	**Depression-free life years gained due to anti-depressants, year 1**	**16.7**	= cf * cg * ch
cj	Rate of anti-depressant use years 2 - 20	100.0%	√
ck	Number on anti-depressants	276	= cd * cj
cl	Clinical improvement rate due to anti-depressants	25.7%	√
cm	Length of treatment	19.0	√
cn	**Depression-free life years gained due to anti-depressants, years 2 - 20**	**1,348**	= ck * cl * cm
co	Treatment seeking rate	52.0%	√
cp	Rate counselling among treatment seekers	50.7%	√
cq	Overall counselling rate	26.4%	= co * cp
cr	Number in counselling	73	= cd * cq
cs	Clinical improvement rate due to counselling	12.1%	√
ct	Length of effect persistent event MDD counselling, years	20.0	√
cu	**Depression-free life years gained due to counselling**	**176**	= cr * cs * ct
	Summary of QALYs Gained with Screening		
cv	Individuals with MDD helped by treatment	448	= aw * ((az * bb) + (bg * bi))
cw	Depression free life years due to screening, correctly diagnosed MDD	3,086	= (bd + bk) + (bt + ca) + (ci + cn + cu)
cx	Reduction in % of total life years with MDD due to screening	17.19%	= cw / y
cy	QALYs gained due to screening, correctly diagnosed MDD	1,174	= cx * ad
cz	QALYs due to treating incorrectly diagnosed MDD	-96	= av
da	**Net QALYs as a result of screening (CPB)**	**1,078**	= cy + cz

√ = Estimates from the literature

For the sensitivity analysis of the base model for females, we modified a number of major assumptions and recalculated the CPB as follows:

- Assume the rate of undetected MDD decreases from 25% to 15% (Table 6b, row *ae*): CPB = 609
- Assume the rate of undetected MDD increases from 25% to 35% (Table 6b, row *ae*): **CPB = 1,548**
- Assume a second round of screening (with BDI) is introduced, with a sensitivity of 86.9% and a specificity of 83.5% (Table 6b, rows *am & an*): CPB = 1,004
- Assume the rate of treatment seeking increases from 52.0% to 70.7% (Table 6b, row *be*): CPB = 1,161
- Assume the rate of treatment seeking decreases from 52.0% to 33.3% (Table 6b, row *be*): CPB = 995
- Assume the QoL decrement for depression is reduced from 31% to 15% (Table 6b, row *z*) and the QoL decrement for anti-depressant maintenance therapy is reduced from 8% to 0% (i.e. no decrement) (Table 6b, row *au*): CPB = 680
- Assume the QoL decrement for depression is increased from 31% to 45% (Table 6b, row *z*) and the QoL decrement for anti-depressant maintenance therapy is increased from 8% to 26% (Table 6b, row *au*): CPB = 1,295
- Assume that the screening rate is only applied to one visit per year per patient, rather than 2.42 (Table 6b, row *ag*): **CPB = 445**

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with screening for major depressive disorder in adolescents.

In modelling CE, we made the following assumptions:

- An adolescent depression screening rate of 7.4% (Table 7, row *c*), completed at each well-care visit, or 2.07 times per year (Table 7, row *b)*,[129] during the seven years of an adolescent's life between 12 and 18 years of age. We model the number available for screening as the sum of adolescents of each age in the cohort (Table 7, row *a)*.
- The cost of each 10 minute primary care provider office visit is $35.97 (see Reference Document) (Table 7, row *e)*.
- The value of patient time for each visit to a primary care office is $74.32 (see Reference Document) (Table 7, row *f)*.
- The proportion of each office visit attributable to screening is 50% (see Reference Document) (Table 7, row *g)*.
- If a second screening is applied (Table 7, row *k*), then all individuals with a positive screen on the first test make another visit to their primary care provider for the second screen. 50% of the office visit time is assumed to be used for the second screen (Table 7, row *g)*.
- Both the PHQ-A[130] and BDI are available online. The PHQ-A is free, but the BDI is copyright (though unlicensed copies exist online) and therefore each use of the BDI is considered to occur through properly licensed channels and cost $5.05 per use (Table 7, row *n*).[131]
- We have assumed that each positive depression diagnosis results in one (1) follow-up visit to the primary care provider. It is assumed that the entire visit is devoted to the depression diagnosis (100% of office visit cost and patient cost) (Table 7, row *r).*
- We have assumed that each depression diagnosis resulting in a course of anti-depressant medication results in two (2) additional visits to a primary care provider to monitor prescription effectiveness (Table 7, row *ab*).
- We model treatment for those with a positive MDD screen by time period as follows:
    - 0 – 3 months after screening: 19.7% of positive screened adolescents are taking anti-depressants (Table 7, row *t*).
        - For males this rate is 17.5% (Table 7a, row *t*)
        - For females this rate is 20.9% (Table 7b, row *t*)
    - 4 – 6 months after screening: 22.2% of positive screen adolescents are taking anti-depressants and 25.6% are in counselling or therapy (Table 7 row *ad*),

[129] Sekhar DL, Ba DM, Liu G et al. Major depressive disorder screening remains low even among privately insured adolescents. *Journal of Pediatrics*. 2018: Available at https://www-sciencedirect-com.ezproxy.library.ubc.ca/science/article/pii/S0022347618310850. Accessed December 2018.
[130] PHQ-9 modified for Adolescents (PHQ-A) Available at http://www.uacap.org/uploads/3/2/5/0/3250432/phq-a.pdf. Accessed November 2018.
[131] Pearson Clinical Assessment Canada. *Beck Depression Inventory®—II.* 2018. Available at https://www.pearsonclinical.ca/store/caassessments/en/Store/Professional-Assessments/Personality-%26-Biopsychosocial/Brief/Beck-Depression-Inventory-II/p/P100008037.html. Accessed March 2023.

with half of the therapy group in individual sessions and half in group sessions.

- For males the counselling rate is 22.1% (Table 7a row *ad*).
- For females the counselling rate is 26.4% (Table 7b row *ad*).

- 7 – 12 months after screening: 22.2% of **correctly diagnosed** adolescents with **recurrent or persistent MDD** are on anti-depressants and 25.6% are in counselling or therapy, with half of the therapy group in individual sessions and half in group sessions (To avoid double-counting, counselling for these individuals is modelled in the 4 – 6 month time period).
- 13+ months after screening: all of the **correctly diagnosed** adolescents with **persistent MDD** are on anti-depressants. We assume that the 25.6% in counselling or therapy receive four (4) individual sessions annually (Table 7 row *bk*).
  - For males the counselling rate is 22.1% (Table 7a row *bk*).
  - For females the counselling rate is 26.4% (Table 7b row *bk*).
- Recurrent MDD: for each year of recurrent MDD, 22.2% of individuals with recurrent MDD take anti-depressants and 25.6% receive therapy (Table 7 row *cc*).
  - For males the counselling rate is 22.1% (Table 7a row *cc*).
  - For females the counselling rate is 26.4% (Table 7b row *cc*).

<table>
<tr><th colspan="5">Treatment Modeling for Positive MDD Screens</th></tr>
<tr><td colspan="2" rowspan="2"></td><td colspan="3">True Positive Screens</td><td rowspan="2">False Positive Screens</td></tr>
<tr><td>Single Event</td><td>Recurrent</td><td>Persistent</td></tr>
<tr><td rowspan="2">0 - 3 Months</td><td>Pharmacological</td><td colspan="3">19.7% anti-depressant rate</td><td rowspan="2"></td></tr>
<tr><td>Therapeutic</td><td colspan="3">None</td></tr>
<tr><td rowspan="2">4 - 6 Months</td><td>Pharmacological</td><td colspan="3">22.2% anti-depressant rate</td><td rowspan="2"></td></tr>
<tr><td>Therapeutic</td><td colspan="3">25.6% receiving therapy</td></tr>
<tr><td rowspan="2">7 -12 Months</td><td>Pharmacological</td><td rowspan="4">No treatment</td><td colspan="2">22.2% anti-depressant rate</td><td rowspan="4">No treatment</td></tr>
<tr><td>Therapeutic</td><td colspan="2">25.6% receiving therapy</td></tr>
<tr><td rowspan="2">13+ Months</td><td>Pharmacological</td><td rowspan="2">No Treatment</td><td>100% anti-depressant rate</td></tr>
<tr><td>Therapeutic</td><td>25.6% receiving therapy</td></tr>
</table>

- 50% of the MDD cases are single events and 50% will be recurrent (Table 7, row *ax*), split into 5.3% (Table 7, row *bf*) of the total that are persistent (i.e. requiring continuing treatment) and 44.7% of the total that occur on a recurrent basis (Table 7, row *bu*).
- For males, 50% of MDD cases will be recurrent (Table 7a, row *ax*), split into 4.7% (Table 7a, row *bf*) of the total that are persistent (i.e. requiring continuing treatment) and 45.3% of the total that occur on a recurrent basis (Table 7a, row *bu*).

- For females, 50% of MDD cases will be recurrent (Table 7, row *ax*), split into 5.7% (Table 7, row *bf*) of the total that are persistent (i.e. requiring continuing treatment) and 44.3% of the total that occur on a recurrent basis (Table 7, row *bu*).
- Each patient with persistent MDD visits their primary care provider an additional 2 times each year for mental health related matters.[132,133] (Table 7, row *bs*)
- Treatment length for persistent MDD is modelled at 20 years, in keeping with Tables 4 & 5.
- For recurrent cases, there are an additional 7 episodes after the index MDD episode (Table 7, row *bw*). For discounting purposes, we model these as occurring eight years apart throughout the lifetime of the affected individuals.
- When group CBT is given, it is typically provided in a group setting of 10 individuals and lasts between 10 – 15 sessions. Each session is approximately 1.5 hours long (Table 7, row *an*).[134]
- We assume one hour of total travel time per patient to attend each CBT session (Table 7, row *ao*).
- We assume that each session is provided by a grade III clinical social worker, Level 13 with 6 years of experience. We assume 25% benefits and 40% non-worked hours and a wage rate of $48.01 / hr[135] for a total cost per *worked* hour of $79.22 ($48.01 + ($48.01 * 0.25) + ($48.01 * 0.40)).
- We assume that each of 12 group CBT sessions lasts 1.5 hours and that the preparation time is also 1.5 hours, for a total cost of $237.66 (3 hours * $79.22) per session for the clinical social worker (Table 7, row *ai, bm & ch*).
- We model that half (50%) of adolescents receiving counselling interventions receive 12 group CBT sessions (Table 7, rows *aq*) lasting 1.5 hours in groups of 10 (Table 7, rows *ar*) for their initial sessions. Subsequent CBT requirements as a result of recurring MDD are reduced to 5 sessions each time (Table 7, row *cp*).
- We model that the other half (50%) of adolescents receiving counselling interventions receive 12 individual counselling sessions with a clinical social worker (Table 7, rows *ah*). These sessions also last 1.5 hours.
- Individuals with persistent MDD receive four sessions of individual counselling each year (Table 7, row *bl*).
- March and colleagues' report, upon which the USPSTF recommendation was based, started the treatment at 10mg of fluoxetine daily, increased to 20mg/day after one week and, if necessary, up to a maximum of 40mg/day by week eight of the twelve week trial.[136]

[132] Wong ST, Manca D, Barber D et al. The diagnosis of depression and its treatment in Canadian primary care practices: an epidemiological study. *Canadian Medical Association Journal Open*. 2014; 2(4): e337-42.
[133] Valenstein M, Vijan S, Zeber JE et al. The cost–utility of screening for depression in primary care. *Annals of Internal Medicine.* 2001; 134(5): 345-60.
[134] Dr. Kelly Price, Senior Psychologist, Child and Youth Mental Health Branch, B.C. Ministry of Children and Families. January 8, 2019. Personal communication.
[135] Health Employers Association of BC. *Provincial Agreement between the Health Science Professionals Bargaining Association and Health Employers Association of BC April 1, 2019 – March 31, 2022.* Available at https://www.heabc.bc.ca/public/CAs/HSP/HSP2019-2022.pdf. Accessed March 2023.
[136] March J, Silva S, Petrycki S et al. Fluoxetine, cognitive-behavioral therapy, and their combination for adolescents with depression: Treatment for Adolescents With Depression Study (TADS) randomized controlled trial. *Journal of the American Medical Association*. 2004; 292(7): 807-20.

- Fluoxetine is available in 10mg and 20mg doses.[137] We model daily treatment with 20mg fluoxetine (or generic equivalent). The cost ranges between $0.37 – 0.52 per 20mg pill for the "BC, Canada" geography. The dispensing fee ranges from $10.00 – 10.95.[138] Using the mid-point of the above ranges and assuming a 30-day dose is dispensed each time, the modelled annual cost of treatment is $288 (($0.445 * 365) + (12 * $10.48)) (Table 7, row *aj*). Using the high and low numbers of the ranges above, we use a high of $321 and low of $255 / year in our sensitivity analysis.
- Clayton and Barcelo estimated the direct costs associated with death by suicide in the province of New Brunswick to be $5,693 (in 1996 CAD) or $9,153 in 2022 CAD, including ambulance, hospital, physician, autopsy, and funeral services plus the cost of police investigations.[139]
- Kinchin and Doran estimated the direct costs per youth suicide in Australia to be $9,721 (in 2014 AUD) or $9,356 in 2022 CAD.[140]
- Shepard et al estimated that the direct costs per nonfatal suicide attempt are 10% higher than the direct costs per completed suicide in the US.[141]
- For modelling purposes, we have assumed the direct costs per death by suicide in BC to be $9,255 ($9,153 + $9,356 / 2) (Table 7, row *db*) and the direct cost per suicide attempt to be $10,180 ($9,255 * 1.1) (Table 7, row *dc*).
- The ratio of attempted suicides to death by suicide among adolescents is estimated to be 50:1 to 100:1.[142] One-third (33%) of suicide attempts in adolescents require medical attention.[143] For modelling purposes, we assumed that there would be 25 attempted suicides requiring medical attention per death by suicide (Table 7, row *df*) (based on the midpoint between 50 and 100 times 33%) and varied this from 17 to 33 in the sensitivity analysis.
- In a US study by Wright and colleagues, adolescents ages 13-17 who screened negative for depression utilized $2,357 (in 2013 USD) in health care services in the 12-month period following the screening. By comparison, adolescents who screened positive for moderate to severe depression utilized $8,173 in health care services in the 12-month period following the screening.[144] We assumed that the difference of $5,816 ($8,173 - $2,357) would be avoided in those adolescents for whom treatment for MDD was effective. This comes to $5,853 (2022 CAD) (Table 7, row *di*).

[137] Pacific Blue Cross. *Pharmacy Compass*. 2023. Available at https://www.pac.bluecross.ca/pharmacycompass. Accessed March 2023.
[138] Pacific Blue Cross. *Pharmacy Compass*. 2023. Available at https://www.pac.bluecross.ca/pharmacycompass. Accessed March 2023.
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CE for Both Sexes

Based on these assumptions, the CE associated with screening for major depressive disorder in adolescents ages 12 to 18 is $28,359 / QALY (Table 7, row *dp*).

Table 7: CE of Screening for MDD in Adolescents Ages 12 - 18
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Source
a	Life years, 12 to 18 year olds	278,575	Table 6, rows a + e + l + m + q + u
b	Number of well care visits per year	2.07	√
c	Depression screening rate	57.0%	√
d	Number of screens conducted, cohort total	328,690	= a * b * c
e	Cost of 10 minute office visit	$35.97	Ref Doc
f	Value of patient time and travel for office visit	$74.32	Ref Doc
g	Portion of 10-minute visit for screening	50%	Ref Doc
h	Initial screening cost	$18,125,632	= d * (e + f) * g
i	Number of MDD cases correctly identified, initial test	7,729	Table 6, row ak
j	Number of MDD cases diagnosed incorrectly, initial test	17,180	Table 6, row al
k	Second screen applied	NO	Table 6, row am
l	Number to be re-screened	0	= i + j (if applicable)
m	Cost of second screening test, each	$5.05	√
n	Cost of second screening	$0	= l * (((e + f) * g) + m)
o	Number of MDD cases correctly identified, overall	7,729	Table 6, row ao
p	Number of MDD cases diagnosed incorrectly, overall	17,180	Table 6, row ap
q	Total number of MDD cases diagnosed	24,909	= o + p
r	Follow up visits, each diagnosed depression	1	Assumed
s	Follow up visit cost	$2,747,247	= q * (e + f) * r
	Treatment 0 - 3 months post diagnosis (All positive screens)		
t	Anti-depressant rate, 0 - 3 months	19.7%	√
u	Number on anti-depressants	4,907	= q * t
v	Cost of medication, per year	$288	√
w	Cost of medication, 0 - 3 months	$353,313	= u * v * 0.25
	Treatment 4 - 6 months post diagnosis (All positive screens)		
x	Anti-depressant rate, 4 - 6 months	22.2%	√
y	Number on anti-depressants	5,530	= q * x
z	Cost of medication, per year	$288	√
aa	Cost of medication, 4 - 6 months	$398,150	= y * z * 0.25
ab	Follow up visits for medication review, per patient	1	√
ac	Cost of medication follow-up	$609,889	= y * ab * (e + f)
ad	Counselling rate	25.6%	Table 6
ae	Number receiving counselling	6,378	= q * ad
af	Rate of individual counselling	50.0%	√
ag	Number receiving individual counselling	3,189	= ae * af
ah	Number of CBT sessions	12	√
ai	Cost of clinical social worker per session	$237.66	√
aj	Cost of offering individual CBT (social worker)	$9,094,277	= ag * ah * ai
ak	Session length, in hours	1.5	√
al	Travel time, in hours	1.0	√
am	Patient time, cost per hour	$37.16	Ref Doc
an	Patient time cost, individual CBT treatment sessions	$3,554,903	= ag * ah * (ak + al) * am
ao	Rate of group counselling	50.0%	√
ap	Number receiving individual counselling	3,189	= ae * ao
aq	Number of CBT sessions	12	√
ar	Number of individuals in each session	10	√
as	Cost of offering group CBT (social worker)	$909,428	= (ap / ar) * aq * ai
at	Session length, in hours	1.5	√
au	Travel time, in hours	1.0	√
av	Patient time cost per hour	$37.16	Ref Doc
aw	Patient time cost, group CBT treatment sessions	$3,554,903	= ap *aq * (at + au) * av
	Treatment 7 - 12 months post diagnosis (recurrent and persistent MDD only)		
ax	Rate of recurrent and persistent MDD, correctly diagnosed	50.0%	√
ay	Anti-depressant rate, 7 - 12 months	22.2%	√
az	Number on anti-depressants	858	= o * ax * ay
ba	Cost of medication, per year	$288	√
bb	Cost of medication, 7 - 12 months	$123,538	= az * ba * 0.5
bc	Counselling costs	$0	Included in 4 - 6 month counselling costs

Table 7 (continued): CE of Screening for MDD in Adolescents Ages 12 - 18 In a BC Birth Cohort of 40,000			
	Treatment 13+ months post diagnosis (persistent MDD only)		
be	Anti-depressant rate, 13+ months	100.0%	√
bf	Rate of persistent MDD, correctly diagnosed	5.3%	√
bg	Number on anti-depressants	412	= o * be * bf
bh	Cost of medication, per year	$288	√
bi	Additional years of medication	19	√
bj	Cost of medication, 2 - 20 years	$2,253,339	= bg * bh * bi
bk	Counselling rate, for persistent MDD	25.6%	√
bl	Number of CBT sessions, per year	4	√
bm	Cost of clinical social worker per session	$237.66	√
bn	Cost of offering individual CBT (social worker), years 2 - 20	$1,904,362	= bg * bi * bl * bk * bm
bo	Session length, in hours	1.5	√
bp	Travel time, in hours	1.0	√
bq	Patient time cost per hour	$37.16	Ref Doc
br	Patient time cost, first CBT treatment sessions	$2,907,433	= bg * bi * bl * (bo + bp) * bq
bs	Additional physician visits due to anti-depressant medication, each year	2	√
bt	Cost of additional physician visits, persistent MDD	$1,725,838	= bg * bi * bs * (e + f)
	Treatment for Recurrent MDD (after index event)		
bu	Rate of recurrent MDD, correctly diagnosed	44.7%	√
bv	Number of individuals with recurrent MDD	3453	= o * bu
bw	Number of additional recurrent MDD events after index event	7	√
bx	Length of each recurrent MDD event, years	1	√
by	Anti-depressant rate, recurrent MDD	22.2%	√
bz	Number on anti-depressants	766	= bv * by
ca	Cost of medication, per year	$288	√
cb	Cost of medication, recurrent MDD	$1,545,237	= bz * ca * bw * bx
cc	Counselling rate, for recurrent MDD	25.6%	√
cd	Number individuals in therapy, per recurrent MDD event	884	= bv * cc
ce	Rate of individual counselling	50.0%	√
cf	Number receiving individual counselling	442	= cd * ce
cg	Number of CBT sessions	5	√
ch	Cost of clinical social worker per session	$237.66	√
ci	Cost of offering individual CBT (social worker)	$3,676,589	= cf * cg * ch * bw
cj	Session length, in hours	1.5	√
ck	Travel time, in hours	1.0	√
cl	Patient time cost per hour	$37.16	Ref Doc
cm	Patient time cost, individual CBT sessions, recurrent MDD	$1,437,159	= cf * cg * (cj + ck) * cl * bw
cn	Rate of group counselling	50.0%	√
co	Number receiving group counselling	442	= cd * cn
cp	Number of CBT sessions	5	√
cq	Number of individuals in each session	10	√
cr	Cost of offering group CBT (social worker)	$367,659	= (co / cq) * cp * ch * bw
cs	Session length, in hours	1.5	√
ct	Travel time, in hours	1.0	√
cu	Patient time cost per hour	$37.16	Ref Doc
cv	Patient time cost, group CBT, recurrent MDD	$1,437,159	= co * cp * (cs + ct) * cu * bw
cw	Sub-total, Screening & Screening Follow-up Cost	$20,872,879	= h + n + s
cx	Sub-total, Medication and Medication Follow-up Cost	$7,009,305	= w + aa + ac + bb + bj + bt + cb
cy	Sub-total, Individual Counselling Cost	$22,574,723	= aj + an + bn + br + ci + cm
cz	Sub-total, Group Counselling Cost	$6,269,149	= as + aw + cr + cv
da	**Total Cost of Intervention**	**$56,726,055**	= cw + cx + cy + cz
	Potential Costs Avoided		
db	Direct costs per completed suicide	$9,255	√
dc	Direct cost per attempted suicide	$10,180	√
dd	Completed suicides avoided due to screening	11.66	Table 6, row ab * Table 6, row cx
de	Costs avoided due to suicides avoided	$107,872	= db * dd
df	Attempted suicides requiring medical attention per completed suicide	25	√
dg	Costs avoided due to suicide attempts avoided	$2,966,347	= dc * dd * df
dh	Number of people for whom treatment is effective	680.4	Table 6, row cv
di	Health care cost avoided in first 12 months after screening due to effective treatment	$5,853	√
dj	Health care cost avoided, total	$3,982,413	= dh * di
dk	**Net Costs of Intervention**	**$49,669,423**	= da - de - dg - dj
dl	Net QALYs Gained	1,880	Table 6, row da
dm	Cost Effectiveness (CE) of Intervention, $/QALY	$26,423	= dk / dl
dn	Net Cost of Intervention (1.5% Discount)	$44,357,141	Calculated
do	Net QALYs Gained (1.5% Discount)	1,564	Calculated
dp	Cost Effectiveness (CE) of Intervention, $/QALY (1.5% Discount)	**$28,359**	= dn /do

√ = Estimates from the literature

For the sensitivity analysis, we modified a number of major assumptions and recalculated the CE as follows:

- Assume the rate of undetected MDD decreases from 25% to 15% (Table 6, row *ae*): **CE = $44,688**
- Assume the rate of undetected MDD increases from 25% to 35% (Table 6, row *ae*): CE = $21,958
- Assume a second round of screening (with BDI) is introduced, with a sensitivity of 86.9% and a specificity of 83.5% (Table 6, rows *am & am*): **CE = $21,922**
- Assume the rate of treatment seeking increases from 50.5% to 69% (Table 6, row *aq*): CE = $30,785
- Assume the rate of treatment seeking decreases from 50.5% to 32% (Table 6, row *aq*): CE = $25,512
- Assume the QoL decrement for depression is reduced from 31% to 15% (Table 6, row *z*) and the QoL decrement for anti-depressant maintenance therapy is reduced from 8% to 0% (i.e. no decrement) (Table 6, row *bg*): CE = $44,504
- Assume QoL decrement for depression is increased from 31% to 45% (Table 6, row *z*) and the QoL decrement for anti-depressant maintenance therapy is increased from 8% to 26% (Table 6, row *bg*): CE = $23,814
- Assume number of visits after depression diagnosis increases from 1 to 2 (Table 7, row *r*): CE = $30,039
- Assume the cost of medication increases from $288/year to $321/year (Table 7, rows *v, z, ba, bh & ca*): CE = $28,625
- Assume the cost of medication decreases from $288/year to $255/year (Table 7, rows *v, z, ba, bh & ca*): CE = $28,093
- Assume the number of suicide attempts per completed suicide is increased from 25 to 33 (Table 7, row *df*): CE = $27,853
- Assume the number of suicide attempts per completed suicide is reduced from 25 to 17 (Table 7, row *df*): CE = $28,865
- Assume the direct cost of completed suicide doubles from $9,255 to $18,150 (Table 7, row *db*) and the direct cost of attempted suicide doubles from $10,180 to $20,360 (Table 7, row *dc*): CE = $26,721
- Assume that the screening rate is only applied to one visit per year per patient, rather than 2.07 (Table 6, row *ag*): CE = $28,359

CE for Males

Based on the above assumptions for males, the CE associated with screening for major depressive disorder in male adolescents' ages 12 to 18 is $26,659 (see Table 7a, row *dp*).

Table 7a: CE of Screening for MDD in Male Adolescents Ages 12 - 18
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Source
a	Life years, 12 to 18 year olds	139,248	Table 6, rows a + e + l + m + q + u
b	Number of well care visits per year	1.75	√
c	Depression screening rate	53.3%	√
d	Number of screens conducted, cohort total	129,884	= a * b * c
e	Cost of 10 minute office visit	$35.97	Ref Doc
f	Value of patient time and travel for office visit	$74.32	Ref Doc
g	Portion of 10-minute visit for screening	50%	Ref Doc
h	Initial screening cost	$7,162,440	= d * (e + f) * g
i	Number of MDD cases correctly identified, initial test	3,054	Table 6, row ak
j	Number of MDD cases diagnosed incorrectly, initial test	6,789	Table 6, row al
k	Second screen applied	NO	Table 6, row am
l	Number to be re-screened	0	= i + j (if applicable)
m	Cost of second screening test, each	$5.05	√
n	Cost of second screening	$0	= l * (((e + f) * g) + m)
o	Number of MDD cases correctly identified, overall	3,054	Table 6, row ao
p	Number of MDD cases diagnosed incorrectly, overall	6,789	Table 6, row ap
q	Total number of MDD cases diagnosed	9,843	= o + p
r	Follow up visits, each diagnosed depression	1	Assumed
s	Follow up visit cost	$1,085,587	= q * (e + f) * r
	Treatment 0 - 3 months post diagnosis (All positive screens)		
t	Anti-depressant rate, 0 - 3 months	17.5%	√
u	Number on anti-depressants	1,723	= q * t
v	Cost of medication, per year	$288	√
w	Cost of medication, 0 - 3 months	$124,022	= u * v * 0.25
	Treatment 4 - 6 months post diagnosis (All positive screens)		
x	Anti-depressant rate, 4 - 6 months	19.5%	√
y	Number on anti-depressants	1,919	= q * x
z	Cost of medication, per year	$288	√
aa	Cost of medication, 4 - 6 months	$138,196	= y * z * 0.25
ab	Follow up visits for medication review, per patient	1	√
ac	Cost of medication follow-up	$211,689	= y * ab * (e + f)
ad	Counselling rate	22.1%	Table 6
ae	Number receiving counselling	2171	= q * ad
af	Rate of individual counselling	50.0%	√
ag	Number receiving individual counselling	1,085	= ae * af
ah	Number of CBT sessions	12	√
ai	Cost of clinical social worker per session	$237.66	√
aj	Cost of offering individual CBT (social worker)	$3,095,515	= ag * ah * ai
ak	Session length, in hours	1.5	√
al	Travel time, in hours	1.0	√
am	Patient time, cost per hour	$37.16	Ref Doc
an	Patient time cost, individual CBT treatment sessions	$1,210,020	= ag * ah * (ak + al) * am
ao	Rate of group counselling	50.0%	√
ap	Number receiving individual counselling	1,085	= ae * ao
aq	Number of CBT sessions	12	√
ar	Number of individuals in each session	10	√
as	Cost of offering group CBT (social worker)	$309,551	= (ap / ar) * aq * ai
at	Session length, in hours	1.5	√
au	Travel time, in hours	1.0	√
av	Patient time cost per hour	$37.16	Ref Doc
aw	Patient time cost, group CBT treatment sessions	$1,210,020	= ap *aq * (at + au) * av
	Treatment 7 - 12 months post diagnosis (recurrent and persistent MDD only)		
ax	Rate of recurrent and persistent MDD, correctly diagnosed	50.0%	√
ay	Anti-depressant rate, 7 - 12 months	19.5%	√
az	Number on anti-depressants	298	= o * ax * ay
ba	Cost of medication, per year	$288	√
bb	Cost of medication, 7 - 12 months	$42,879	= az * ba * 0.5
bc	Counselling costs	$0	Included in 4 - 6 month counselling costs

Table 7a (continued): CE of Screening for MDD in Male Adolescents Ages 12 - 18 In a BC Birth Cohort of 40,000			
	Treatment 13+ months post diagnosis (persistent MDD only)		
be	Anti-depressant rate, 13+ months	100.0%	√
bf	Rate of persistent MDD, correctly diagnosed	4.7%	√
bg	Number on anti-depressants	144	= o * be * bf
bh	Cost of medication, per year	$288	√
bi	Additional years of medication	19	√
bj	Cost of medication, 2 - 20 years	$785,458	= bg * bh * bi
bk	Counselling rate, for persistent MDD	22.1%	√
bl	Number of CBT sessions, per year	4	√
bm	Cost of clinical social worker per session	$237.66	√
bn	Cost of offering individual CBT (social worker), years 2 - 20	$571,800	= bg * bi * bl * bk * bm
bo	Session length, in hours	1.5	√
bp	Travel time, in hours	1.0	√
bq	Patient time cost per hour	$37.16	Ref Doc
br	Patient time cost, first CBT treatment sessions	$1,013,460	= bg * bi * bl * (bo + bp) * bq
bs	Additional physician visits due to anti-depressant medication, each year	2	√
bt	Cost of additional physician visits, persistent MDD	$601,585	= bg * bi * bs * (e + f)
	Treatment for Recurrent MDD (after index event)		
bu	Rate of recurrent MDD, correctly diagnosed	45.3%	√
bv	Number of individuals with recurrent MDD	1,383	= o * bu
bw	Number of additional recurrent MDD events after index event	7	√
bx	Length of each recurrent MDD event, years	1	√
by	Anti-depressant rate, recurrent MDD	19.5%	√
bz	Number on anti-depressants	270	= bv * by
ca	Cost of medication, per year	$288	√
cb	Cost of medication, recurrent MDD	$543,879	= bz * ca * bw * bx
cc	Counselling rate, for recurrent MDD	22.1%	√
cd	Number individuals in therapy, per recurrent MDD event	305	= bv * cc
ce	Rate of individual counselling	50.0%	√
cf	Number receiving individual counselling	153	= cd * ce
cg	Number of CBT sessions	5	√
ch	Cost of clinical social worker per session	$237.66	√
ci	Cost of offering individual CBT (social worker)	$1,269,021	= cf * cg * ch * bw
cj	Session length, in hours	1.5	√
ck	Travel time, in hours	1.0	√
cl	Patient time cost per hour	$37.16	Ref Doc
cm	Patient time cost, individual CBT sessions, recurrent MDD	$496,053	= cf * cg * (cj + ck) * cl * bw
cn	Rate of group counselling	50.0%	√
co	Number receiving group counselling	153	= cd * cn
cp	Number of CBT sessions	5	√
cq	Number of individuals in each session	10	√
cr	Cost of offering group CBT (social worker)	$126,902	= (co / cq) * cp * ch * bw
cs	Session length, in hours	1.5	√
ct	Travel time, in hours	1.0	√
cu	Patient time cost per hour	$37.16	Ref Doc
cv	Patient time cost, group CBT, recurrent MDD	$496,053	= co * cp * (cs + ct) * cu * bw
cw	Sub-total, Screening & Screening Follow-up Cost	$8,248,026	= h + n + s
cx	Sub-total, Medication and Medication Follow-up Cost	$2,447,709	= w + aa + ac + bb + bj + bt + cb
cy	Sub-total, Individual Counselling Cost	$7,655,868	= aj + an + bn + br + ci + cm
cz	Sub-total, Group Counselling Cost	$2,142,527	= as + aw + cr + cv
da	**Total Cost of Intervention**	**$20,494,131**	= cw + cx + cy + cz
	Potential Costs Avoided		
db	Direct costs per completed suicide	$9,255	√
dc	Direct cost per attempted suicide	$10,180	√
dd	Completed suicides avoided due to screening	5.94	Table 6, row ab * Table 6, row cx
de	Costs avoided due to suicides avoided	$54,929	= db * dd
df	Attempted suicides requiring medical attention per completed suicide	25	√
dg	Costs avoided due to suicide attempts avoided	$1,510,472	= dc * dd * df
dh	Number of people for whom treatment is effective	234.6	Table 6, row cv
di	Health care cost avoided in first 12 months after screening due to effective treatment	$5,853	√
dj	Health care cost avoided, total	$1,372,854	= dh * di
dk	**Net Costs of Intervention**	**$17,555,876**	= da - de - dg - dj
dl	Net QALYs Gained	739	Table 6, row da
dm	Cost Effectiveness (CE) of Intervention, $/QALY	$23,746	= dk / dl
dn	Net Cost of Intervention (1.5% Discount)	$15,767,461	Calculated
do	Net QALYs Gained (1.5% Discount)	591	Calculated
dp	Cost Effectiveness (CE) of Intervention, $/QALY (1.5% Discount)	**$26,659**	= dn /do

√ = Estimates from the literature

For the sensitivity analysis of the base model for males, we modified a number of major assumptions and recalculated the CE as follows:

- Assume the rate of undetected MDD decreases from 25% to 15% (Table 6a, row *ae*): **CE = $42,486**
- Assume the rate of undetected MDD increases from 25% to 35% (Table 6a, row *ae*): **CE = $20,411**
- Assume a second round of screening (with BDI) is introduced, with a sensitivity of 86.9% and a specificity of 83.5% (Table 6a, rows *am & am*): CE = $21,131
- Assume the rate of treatment seeking increases from 43.5% to 65.2% (Table 6a, row *aq*): CE = $29,485
- Assume the rate of treatment seeking decreases from 43.5% to 21.8% (Table 6a, row *aq*): CE = $23,178
- Assume the QoL decrement for depression is reduced from 31% to 15% (Table 6a, row *z*) and the QoL decrement for anti-depressant maintenance therapy is reduced from 8% to 0% (i.e. no decrement) (Table 6a, row *bg*): CE = $39,883
- Assume QoL decrement for depression is increased from 31% to 45% (Table 6a, row *z*) and the QoL decrement for anti-depressant maintenance therapy is increased from 8% to 26% (Table 6a, row *bg*): CE = $22,720
- Assume number of visits after depression diagnosis increases from 1 to 2 (Table 7a, row *r*): CE = $28,415
- Assume the cost of medication increases from $288/year to $321/year (Table 7a, rows *v, z, ba, bh & ca*): CE = $26,905
- Assume the cost of medication decreases from $288/year to $255/year (Table 7a, rows *v, z, ba, bh & ca*): CE = $26,413
- Assume the number of suicide attempts per completed suicide is increased from 25 to 33 (Table 7a, row *df*): CE = $25,978
- Assume the number of suicide attempts per completed suicide is reduced from 25 to 17 (Table 7a, row *df*): CE = $27,339
- Assume the direct cost of completed suicide doubles from $9,255 to $18,150 (Table 7a, row *db*) and the direct cost of attempted suicide doubles from $10,180 to $20,360 (Table 7a, row *dc*): CE = $24,543
- Assume that the screening rate is only applied to one visit per year per patient, rather than 1.75 (Table 6a, row *ag*): CE = $26,659

CE for Females

Based on the above assumptions for males, the CE associated with screening for major depressive disorder in female adolescents' ages 12 to 18 is $30,982 (see Table 7b, row *dp*).

Table 7b: CE of Screening for MDD in Female Adolescents Ages 12 - 18
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Source
a	Life years, 12 to 18 year olds	139,339	Table 6, rows a + e + l + m + q + u
b	Number of well care visits per year	2.42	√
c	Depression screening rate	61.1%	√
d	Number of screens conducted, cohort total	206,029	= a * b * c
e	Cost of 10 minute office visit	$35.97	Ref Doc
f	Value of patient time and travel for office visit	$74.32	Ref Doc
g	Portion of 10-minute visit for screening	50%	Ref Doc
h	Initial screening cost	$11,361,493	= d * (e + f) * g
i	Number of MDD cases correctly identified, initial test	4,845	Table 6, row ak
j	Number of MDD cases diagnosed incorrectly, initial test	10,769	Table 6, row al
k	Second screen applied	NO	Table 6, row am
l	Number to be re-screened	0	= i + j (if applicable)
m	Cost of second screening test, each	$5.05	√
n	Cost of second screening	$0	= l * (((e + f) * g) + m)
o	Number of MDD cases correctly identified, overall	4,845	Table 6, row ao
p	Number of MDD cases diagnosed incorrectly, overall	10,769	Table 6, row ap
q	Total number of MDD cases diagnosed	15,614	= o + p
r	Follow up visits, each diagnosed depression	1	Assumed
s	Follow up visit cost	$1,722,032	= q * (e + f) * r
	Treatment 0 - 3 months post diagnosis (All positive screens)		
t	Anti-depressant rate, 0 - 3 months	20.9%	√
u	Number on anti-depressants	3,263	= q * t
v	Cost of medication, per year	$288	√
w	Cost of medication, 0 - 3 months	$234,955	= u * v * 0.25
	Treatment 4 - 6 months post diagnosis (All positive screens)		
x	Anti-depressant rate, 4 - 6 months	23.6%	√
y	Number on anti-depressants	3,685	= q * x
z	Cost of medication, per year	$288	√
aa	Cost of medication, 4 - 6 months	$265,308	= y * z * 0.25
ab	Follow up visits for medication review, per patient	1	√
ac	Cost of medication follow-up	$406,400	= y * ab * (e + f)
ad	Counselling rate	26.4%	Table 6
ae	Number receiving counselling	4,116	= q * ad
af	Rate of individual counselling	50.0%	√
ag	Number receiving individual counselling	2,058	= ae * af
ah	Number of CBT sessions	12	√
ai	Cost of clinical social worker per session	$237.66	√
aj	Cost of offering individual CBT (social worker)	$5,869,806	= ag * ah * ai
ak	Session length, in hours	1.5	√
al	Travel time, in hours	1.0	√
am	Patient time, cost per hour	$37.16	Ref Doc
an	Patient time cost, individual CBT treatment sessions	$2,294,475	= ag * ah * (ak + al) * am
ao	Rate of group counselling	50.0%	√
ap	Number receiving individual counselling	2,058	= ae * ao
aq	Number of CBT sessions	12	√
ar	Number of individuals in each session	10	√
as	Cost of offering group CBT (social worker)	$586,981	= (ap / ar) * aq * ai
at	Session length, in hours	1.5	√
au	Travel time, in hours	1.0	√
av	Patient time cost per hour	$37.16	Ref Doc
aw	Patient time cost, group CBT treatment sessions	$2,294,475	= ap *aq * (at + au) * av
	Treatment 7 - 12 months post diagnosis (recurrent and persistent MDD only)		
ax	Rate of recurrent and persistent MDD, correctly diagnosed	50.0%	√
ay	Anti-depressant rate, 7 - 12 months	23.6%	√
az	Number on anti-depressants	572	= o * ax * ay
ba	Cost of medication, per year	$288	√
bb	Cost of medication, 7 - 12 months	$82,321	= az * ba * 0.5
bc	Counselling costs	$0	Included in 4 - 6 month counselling costs

Table 7b (continued): CE of Screening for MDD in Female Adolescents Ages 12 - 18 In a BC Birth Cohort of 40,000			
	Treatment 13+ months post diagnosis (persistent MDD only)		
be	Anti-depressant rate, 13+ months	100.0%	√
bf	Rate of persistent MDD, correctly diagnosed	5.7%	√
bg	Number on anti-depressants	276	= o * be * bf
bh	Cost of medication, per year	$288	√
bi	Additional years of medication	19	√
bj	Cost of medication, 2 - 20 years	$1,511,075	= bg * bh * bi
bk	Counselling rate, for persistent MDD	26.4%	√
bl	Number of CBT sessions, per year	4	√
bm	Cost of clinical social worker per session	$237.66	√
bn	Cost of offering individual CBT (social worker), years 2 - 20	$1,314,985	= bg * bi * bl * bk * bm
bo	Session length, in hours	1.5	√
bp	Travel time, in hours	1.0	√
bq	Patient time cost per hour	$37.16	Ref Doc
br	Patient time cost, first CBT treatment sessions	$1,949,706	= bg * bi * bl * (bo + bp) * bq
bs	Additional physician visits due to anti-depressant medication, each year	2	√
bt	Cost of additional physician visits, persistent MDD	$1,157,336	= bg * bi * bs * (e + f)
	Treatment for Recurrent MDD (after index event)		
bu	Rate of recurrent MDD, correctly diagnosed	44.3%	√
bv	Number of individuals with recurrent MDD	2,146	= o * bu
bw	Number of additional recurrent MDD events after index event	7	√
bx	Length of each recurrent MDD event, years	1	√
by	Anti-depressant rate, recurrent MDD	23.6%	√
bz	Number on anti-depressants	507	= bv * by
ca	Cost of medication, per year	$288	√
cb	Cost of medication, recurrent MDD	$1,021,107	= bz * ca * bw * bx
cc	Counselling rate, for recurrent MDD	26.4%	√
cd	Number individuals in therapy, per recurrent MDD event	566	= bv * cc
ce	Rate of individual counselling	50.0%	√
cf	Number receiving individual counselling	283	= cd * ce
cg	Number of CBT sessions	5	√
ch	Cost of clinical social worker per session	$237.66	√
ci	Cost of offering individual CBT (social worker)	$2,353,283	= cf * cg * ch * bw
cj	Session length, in hours	1.5	√
ck	Travel time, in hours	1.0	√
cl	Patient time cost per hour	$37.16	Ref Doc
cm	Patient time cost, individual CBT sessions, recurrent MDD	$919,886	= cf * cg * (cj + ck) * cl * bw
cn	Rate of group counselling	50.0%	√
co	Number receiving group counselling	283	= cd * cn
cp	Number of CBT sessions	5	√
cq	Number of individuals in each session	10	√
cr	Cost of offering group CBT (social worker)	$235,328	= (co / cq) * cp * ch * bw
cs	Session length, in hours	1.5	√
ct	Travel time, in hours	1.0	√
cu	Patient time cost per hour	$37.16	Ref Doc
cv	Patient time cost, group CBT, recurrent MDD	$919,886	= co * cp * (cs + ct) * cu * bw
cw	Sub-total, Screening & Screening Follow-up Cost	$13,083,525	= h + n + s
cx	Sub-total, Medication and Medication Follow-up Cost	$4,678,501	= w + aa + ac + bb + bj + bt + cb
cy	Sub-total, Individual Counselling Cost	$14,702,142	= aj + an + bn + br + ci + cm
cz	Sub-total, Group Counselling Cost	$4,036,670	= as + aw + cr + cv
da	**Total Cost of Intervention**	**$36,500,837**	= cw + cx + cy + cz
	Potential Costs Avoided		
db	Direct costs per completed suicide	$9,255	√
dc	Direct cost per attempted suicide	$10,180	√
dd	Completed suicides avoided due to screening	4.10	Table 6, row ab * Table 6, row cx
de	Costs avoided due to suicides avoided	$37,956	= db * dd
df	Attempted suicides requiring medical attention per completed suicide	25	√
dg	Costs avoided due to suicide attempts avoided	$1,043,726	= dc * dd * df
dh	Number of people for whom treatment is effective	448.4	Table 6, row cv
di	Health care cost avoided in first 12 months after screening due to effective treatment	$5,853	√
dj	Health care cost avoided, total	$2,624,408	= dh * di
dk	**Net Costs of Intervention**	**$32,794,747**	= da - de - dg - dj
dl	Net QALYs Gained	1,078	Table 6, row da
dm	Cost Effectiveness (CE) of Intervention, $/QALY	$30,420	= dk / dl
dn	Net Cost of Intervention (1.5% Discount)	$29,195,113	Calculated
do	Net QALYs Gained (1.5% Discount)	942	Calculated
dp	Cost Effectiveness (CE) of Intervention, $/QALY (1.5% Discount)	**$30,982**	= dn /do

√ = Estimates from the literature

For the sensitivity analysis of the base model for females, we modified a number of major assumptions and recalculated the CE as follows:

- Assume the rate of undetected MDD decreases from 25% to 15% (Table 6b, row *ae*): CE = $48,594
- Assume the rate of undetected MDD increases from 25% to 35% (Table 6b, row *ae*): CE = $24,144
- Assume a second round of screening (with BDI) is introduced, with a sensitivity of 86.9% and a specificity of 83.5% (Table 6b, rows *am* & *am*): **CE = $23,804**
- Assume the rate of treatment seeking increases from 52.0% to 70.7% (Table 6b, row *aq*): CE = $33,580
- Assume the rate of treatment seeking decreases from 52.0% to 33.3% (Table 6b, row *aq*): CE = $27,944
- Assume the QoL decrement for depression is reduced from 31% to 15% (Table 6b, row *z*) and the QoL decrement for anti-depressant maintenance therapy is reduced from 8% to 0% (i.e. no decrement) (Table 6b, row *bg*): **CE = $51,606**
- Assume QoL decrement for depression is increased from 31% to 45% (Table 6b, row *z*) and the QoL decrement for anti-depressant maintenance therapy is increased from 8% to 26% (Table 6b, row *bg*): CE = $25,608
- Assume number of visits after depression diagnosis increases from 1 to 2 (Table 7b, row *r*): CE = $32,730
- Assume the cost of medication increases from $288/year to $321/year (Table 7b, row *aj*): CE = $31,276
- Assume the cost of medication decreases from $288/year to $255/year (Table 7b, row *aj*): CE = $30,687
- Assume the number of suicide attempts per completed suicide is increased from 25 to 33 (Table 7b, row *df*): CE = $30,686
- Assume the number of suicide attempts per completed suicide is reduced from 25 to 17 (Table 7b, row *df*): CE = $31,277
- Assume the direct cost of completed suicide doubles from $9,255 to $18,150 (Table 7b, row *db*) and the direct cost of attempted suicide doubles from $10,180 to $20,360 (Table 7b, row *dc*): CE = $30,025
- Assume that the screening rate is only applied to one visit per year per patient, rather than 2.42 (Table 6b, row *ag*): CE = $30,982

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening for, and treatment of, major depressive disorder (MDD) in adolescents ages 12 to 18 is estimated to be 1,564 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated at $28,359 per QALY (see Table 8).

In male adolescents ages 12-18, the CPB with screening for, and treatment of, MDD is estimated to be 591 QALYs while the CE is estimated at $26,659 per QALY (see Table 8a).

In female adolescents ages 12-18, the CPB with screening for, and treatment of, MDD is estimated to be 942 QALYs while the CE is estimated at $30,982 per QALY (see Table 8b).

Table 8: Screening for MDD in Adolescents Ages 12 - 18 in a BC Birth Cohort of 40,000
Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume No Current Service			
1.5% Discount Rate	**1,564**	756	2,247
3% Discount Rate	1,377	665	1,985
0% Discount Rate	1,880	908	2,689
CE ($/QALY) ***including*** patient time costs			
1.5% Discount Rate	**$28,359**	$21,922	$44,688
3% Discount Rate	$29,797	$22,372	$48,197
0% Discount Rate	$26,423	$21,172	$40,089
CE ($/QALY) ***excluding*** patient time costs			
1.5% Discount Rate	$11,737	$7,882	$18,769
3% Discount Rate	$12,190	$7,791	$20,145
0% Discount Rate	$11,245	$8,049	$17,114

Table 8a: Screening for MDD in Male Adolescents Ages 12 - 18 in a BC Birth Cohort of 40,000
Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume No Current Service			
1.5% Discount Rate	**591**	338	848
3% Discount Rate	507	290	730
0% Discount Rate	739	422	1,055
CE ($/QALY) ***including*** patient time costs			
1.5% Discount Rate	**$26,659**	$20,411	$42,486
3% Discount Rate	$28,900	$21,754	$47,260
0% Discount Rate	$23,746	$18,648	$36,449
CE ($/QALY) ***excluding*** patient time costs			
1.5% Discount Rate	$10,385	$7,761	$17,035
3% Discount Rate	$11,167	$8,152	$18,911
0% Discount Rate	$9,501	$7,365	$14,823

Table 8b: Screening for MDD in Female Adolescents Ages 12 - 18 in a BC Birth Cohort of 40,000
Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume No Current Service			
1.5% Discount Rate	**942**	389	1,358
3% Discount Rate	856	354	1,236
0% Discount Rate	1,078	445	1,548
CE ($/QALY) ***including*** patient time costs			
1.5% Discount Rate	**$30,982**	$23,804	$51,606
3% Discount Rate	$31,447	$23,496	$53,938
0% Discount Rate	$30,420	$24,183	$48,220
CE ($/QALY) ***excluding*** patient time costs			
1.5% Discount Rate	$13,350	$9,071	$22,237
3% Discount Rate	$13,357	$8,655	$22,910
0% Discount Rate	$13,493	$9,728	$21,388

United States Preventive Services Task Force Recommendations (2022)

The USPSTF recommends screening for anxiety in children and adolescents aged 8 to 18 years. (B Recommendation)

The USPSTF concludes that the current evidence is insufficient to assess the balance of benefits and harms of screening for anxiety in children 7 years or younger. (I Recommendation)[145]

Best in the World

Screening

- In a survey of Pennsylvania primary care providers 67.1% reported screening their adolescent patients for general mental health problems at most well visits.[146]
- A large pediatric primary care network in the US was able to achieve annual screening rates for depression of 81.5% in adolescents ages 12 – 17 after they expanded their universal depression screening guideline to encompass all well-visits for adolescents ages 12 and older.[147]

- For modelling purposes, we have assumed a best in the world screening rate of 81.5%.

Visits to a Primary Care Provider

- Using data provided by the BC Ministry of Health, Health Sector Information, Analysis and Reporting Division[148] we were able to generate BC-specific rates of primary care visits and average visits per year for the fiscal years ending in 2012/13 to 2016/17, in total and by sex, as shown in Table 1 below.
- For the five years considered, the average proportion of adolescents ages 10-19 visiting a GP is 70%, and the average number of GP visits per adolescent is 2.07 per year. The proportion of males visiting a GP was 65.4% and for females it was 75.0%. The average number of visits per male in the population was 1.75 and for females was 2.42.

[145] US Preventive Service Task Force. US Preventive Services Task Force Recommendation Statement. Screening for anxiety in children and adolescents: US Preventive Services Task Force recommendation statement. *JAMA*. 2022; 328(14): 1438-44.
[146] Diamond G,O'Malley A, Wintersteen M et al. Attitudes, practices, and barriers to adolescent suicide and mental health screening: A survey of Pennsylvania primary care providers. *Journal of Primary Care & Community Health*. 2012; 3(1): 29-35.
[147] Davis M, Jones J, So A et al. Adolescent depression screening in primary care: Who is screened and who is at risk? *Journal of Affective Disorders*. 2022; 299: 318-25.
[148] Aciemme (Sam) Ospan, Senior Manager, Lifetime Prevention Schedule, Healthy Living and Health Promotion Branch, BC Ministry of Health. January 30, 2019. Personal communication.

Table 1: General Practitioner Visits by Adolescents
British Columbia, 2012/13 to 2016/17

Age Group	2012/13	2013/14	2014/15	2015/16	2016/17	Total
	Population in Each Age Group					
10 - 14	234,780	231,544	230,178	230,177	232,010	1,158,689
15 - 19	284,482	282,214	279,997	276,909	272,677	1,396,279
Total	519,262	513,758	510,175	507,086	504,687	2,554,968
	Number of Unique Individuals with GP Visit					
10 - 14	163,332	160,912	158,653	160,260	159,826	802,983
15 - 19	205,821	200,410	196,629	192,566	189,547	984,973
Total	369,153	361,322	355,282	352,826	349,373	1,787,956
	Proportion of Individuals with a GP Visit					
10 - 14	69.6%	69.5%	68.9%	69.6%	68.9%	69.3%
15 - 19	72.3%	71.0%	70.2%	69.5%	69.5%	70.5%
Total	71.1%	70.3%	69.6%	69.6%	69.2%	70.0%
	Number of GP Visits					
10 - 14	429,881	422,188	412,182	413,411	407,442	2,085,104
15 - 19	681,806	659,038	641,316	619,790	601,925	3,203,875
Total	1,111,687	1,081,226	1,053,498	1,033,201	1,009,367	5,288,979
	GP Visits per Individual in Total Population					
10 - 14	1.83	1.82	1.79	1.80	1.76	1.80
15 - 19	2.40	2.34	2.29	2.24	2.21	2.29
Total	2.14	2.10	2.06	2.04	2.00	2.07

Table 1: General Practitioner Visits by Adolescents

British Columbia, 2012/13 to 2016/17

Males

Age Group	2012/13	2013/14	2014/15	2015/16	2016/17	Total
	Population in Each Age Group					
10 - 14	121,031	119,378	118,720	118,572	119,586	597,287
15 - 19	149,279	147,563	145,417	143,117	140,451	725,827
Total	270,310	266,941	264,137	261,689	260,037	1,323,114
	Number of Unique Males with GP Visit					
10 - 14	82,970	81,960	80,756	81,067	80,862	407,615
15 - 19	95,992	93,224	91,170	89,118	87,596	457,100
Total	178,962	175,184	171,926	170,185	168,458	864,715
	Proportion of Males with a GP Visit					
10 - 14	68.6%	68.7%	68.0%	68.4%	67.6%	68.2%
15 - 19	64.3%	63.2%	62.7%	62.3%	62.4%	63.0%
Total	66.2%	65.6%	65.1%	65.0%	64.8%	65.4%
	Number of GP Visits					
10 - 14	215,841	211,444	206,909	206,013	202,386	1,042,593
15 - 19	270,303	259,637	253,874	244,381	238,257	1,266,452
Total	486,144	471,081	460,783	450,394	440,643	2,309,045
	GP Visits per Male in Total Population					
10 - 14	1.78	1.77	1.74	1.74	1.69	1.75
15 - 19	1.81	1.76	1.75	1.71	1.70	1.74
Total	1.80	1.76	1.74	1.72	1.69	1.75

Table 1: General Practitioner Visits by Adolescents

British Columbia, 2012/13 to 2016/17

Females

Age Group	2012/13	2013/14	2014/15	2015/16	2016/17	Total
	Population in Each Age Group					
10 - 14	113,749	112,166	111,458	111,605	112,424	561,402
15 - 19	135,203	134,651	134,580	133,792	132,226	670,452
Total	248,952	246,817	246,038	245,397	244,650	1,231,854
	Number of Unique Females with GP Visit					
10 - 14	80,381	78,955	77,909	79,202	78,985	395,432
15 - 19	109,865	107,210	105,496	103,488	101,995	528,054
Total	190,246	186,165	183,405	182,690	180,980	923,486
	Proportion of Females with a GP Visit					
10 - 14	70.7%	70.4%	69.9%	71.0%	70.3%	70.4%
15 - 19	81.3%	79.6%	78.4%	77.3%	77.1%	78.8%
Total	76.4%	75.4%	74.5%	74.4%	74.0%	75.0%
	Number of GP Visits					
10 - 14	214,033	210,738	205,270	207,393	205,052	1,042,486
15 - 19	411,487	399,386	387,411	375,393	363,660	1,937,337
Total	625,520	610,124	592,681	582,786	568,712	2,979,823
	GP Visits per Female in Total Population					
10 - 14	1.88	1.88	1.84	1.86	1.82	1.86
15 - 19	3.04	2.97	2.88	2.81	2.75	2.89
Total	2.51	2.47	2.41	2.37	2.32	2.42

Source: BC Ministry of Health, Health Sector Information, Analysis and Reporting Division

Calculations by H. Krueger & Associates, Inc.

- In our model, we assume a maximum (best in the world) adolescent anxiety screening rate of 57.1% (81.5% times 70.0%) and that screening for this 57.1% of adolescents is completed once a year at a well-care visit, during the 11 years of life between 8 and 18 years of age.
- In our model for **males**, we assume a maximum (best in the world) anxiety screening rate of 53.3% (81.5% times 65.4%) and that screening for this 53.3% of males is completed once a year at a well-care visit, during the 11 years of life between 8 and 18 years of age.
- In our model for **females**, we assume a maximum (best in the world) anxiety screening rate of 61.1% (81.5% times 75.0%) and that screening for this 61.1% of females is completed once a year at a well-care visit, during the 11 years of life between 8 and 18 years of age.

Receipt of Treatment

- Based on a recent systematic review covering large representative / population-based epidemiological surveys that used rigorous diagnostic measures, just 44.2% of children ages 4-18 with mental disorders received any services for these conditions.[149]
- Based on evidence from 2 large health maintenance organizations in the western United States and a network of community health centers in the Northeast, 63.6% of adolescents ages 12 to 21 initiated treatment within the three months of being diagnosed with a mental disorder (63.0% of males and 63.9% of females).[150]

- For modelling purposes, we have assumed a best in the world treatment rate of 63.6%.

Modelling the Clinically Preventable Burden

In this section, we model the CPB associated with screening for, and treatment of, anxiety in children and adolescents aged 8 to 18 years of age.

Definitions

- "Anxiety can be a normal emotional and physiological response to potential threats. Fears during childhood and adolescence commonly occur as part of normal development. Anxiety disorders are distinguished from normal anxiety by persistent, disproportionate, or distorted responses leading to impaired functioning in everyday life."[151]
- "The Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5) defines seven anxiety disorders: separation anxiety disorder, selective mutism, specific phobia, social anxiety disorder (social phobia), panic disorder, agoraphobia, and generalized anxiety disorder. These diagnoses require a degree of severity, persistence, and associated impairment at home or school, or during other developmentally appropriate activities. Anxiety disorders co-occur frequently…The

[149] Barican J, Yung D, Schwartz C et al. Prevalence of childhood mental disorders in high-income countries: A systematic review and meta-analysis to inform policymaking. *Evidence Based Mental Health*. 2022; 25: 36-44.
[150] O'Connor B, Lewandowski E, Rodriguez S et al. Usual care for adolescent depression from symptom identification through treatment initiation. *JAMA Pediatrics*. 2016; 170(4): 373-80.
[151] Canadian Paediatric Society. *Position Statement: Anxiety in Children and Youth: Part 1 – Diagnosis*. October 2022. Available online at https://cps.ca/en/documents/position/anxiety-in-children-and-youth-diagnosis. Accessed July 2023.

ages of onset for specific anxiety disorders are associated with developmental stages. Anxiety disorders can have a waxing and waning course. They can also remit and relapse, and different anxiety disorders can resolve or emerge in the same child over time."[152]

Defining and Estimating the Population at Risk

- Based on a 2022 systematic review and meta-analysis analyzing high-quality, population-based epidemiological surveys that used robust diagnostic measures, the prevalence of **diagnosed anxiety disorders** at any given time among 4–18 years olds in high-income countries was estimated to be 5.2% (95% CI of 3.2% to 8.2%).[153]
- The 2019 Canadian Health Survey on Children and Youth found that 5.3% of 5 to 17 year-olds in BC had been **diagnosed** by a health professional as having an anxiety disorder; 4.7% in males and 6.0% in females.[154]
- While this provides us with an estimate of the number of children and youth with a **diagnosed anxiety disorder**, how many children and youth might have an **undiagnosed anxiety disorder** as "the rationale for routine screening is to identify undiagnosed youth who may benefit from effective treatment for anxiety disorders."[155]
- As much as half of all mental disorders in Canada may be undiagnosed.[156]
- According to the McCreary Centre Society *2018 BC Adolescent Health Survey*, 19% of students in grades 7 through 12 **self-reported** anxiety disorder/panic attacks, 13% in males and 29% in females.[157] Of students in grade 7, 13% self-reported an anxiety disorder.[158] Self-report may overestimate the true rate of potentially diagnosable anxiety disorders. Similar or even higher rates, however, have been observed when a sample of adolescents are assessed for a diagnosable anxiety disorder (see next bullet).
- In an assessment of a representative sample of the US population of adolescents aged 13 to 17 years (the National Comorbidity Survey Replication Adolescent Supplement) the prevalence estimates for diagnosable anxiety disorders was 24.9%. The authors note that most disorders diagnosed in the survey "do not meet criteria for a diagnosis of serious emotional disturbance (i.e., a DSM-IV disorder with a Children's Global Assessment Scale score ≤50)."[159]

[152] Ibid.
[153] Barican J, Yung D, Schwartz C et al. Prevalence of childhood mental disorders in high-income countries: A systematic review and meta-analysis to inform policymaking. *Evidence Based Mental Health*. 2022; 25: 36-44.
[154] Statistics Canada. Table 13-10-0763-01 Health characteristics of children and youth aged 1 to 17 years. *Canadian Survey on Children and Youth 2019*. Available online at https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310076301. Accessed November 2023.
[155] Viswanathan M, Wallace I, Middleton J et al. Screening for anxiety in children and adolescents: Evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2022; 328(14): 1445-55.
[156] Lim K., Jacobs P, Ohinmaa A et al. A new population-based measure of the economic burden of mental illness in Canada. *Chronic Diseases in Canada*. 2008; 28(3): 92-8.
[157] McCreary Centre Society. *Balance and Connection in BC: The Health and Well-being of Our Youth, Results of the 2018 BC Adolescent Health Survey*. 2019. Available online at www.mcs.bc.ca. Accessed July 2023.
[158] McCreary Centre Society. *The Health and Well-being of BC's Grade 7's*. Available online at https://www.mcs.bc.ca/pdf/2023_bc_ahs_grade7_infosheet.pdf. Accessed November 2023.
[159] Kessler R, Avenevoli S, Costello J et al. Prevalence, persistence, and sociodemographic correlates of DSM-IV disorders in the National Comorbidity Survey Replication Adolescent Supplement. *Archives of General Psychiatry*. 2012; 69(4): 372-80.

- In their assessment of the National Comorbidity Survey Replication Adolescent Supplement data, Merikangas et al estimated that 8.3% of adolescents ages 13-18 had a severe anxiety disorder. Severe disorders required certain levels of both distress and impairment to be present. Distress needed to be identified as "severe or very severe" and impairment needed to be identified as "a lot" or "extreme" impairment in activities of daily living.[160]

- For modelling purposes, we started with the assumption that 4.7% males and 6.0% of females in BC ages 5-17 have been **diagnosed** with anxiety.[161] Furthermore, actual rates of anxiety disorders could be as high as 13% in males and 29% in females.[162] In the sensitivity analysis we reduce the estimated actual rates of anxiety disorders by a third.

- Anxiety disorders are 2.0 times as prevalent in 13-19 year old vs 6-12 year old males. Anxiety disorders are 3.7 times as prevalent in 13-19 year old vs 6-12 year old females.[163]

- Based on these assumptions, a total of 8,353 (21.0%) of 18-year olds would have an anxiety disorder in a BC birth cohort of 40,000 (see Table 2). Of these 8,353, a total of 6,225 (74.5%) would currently be undiagnosed. The proportion of undiagnosed cases is higher in females (4,576 of 5,769 or 79.3%) than males (1,650 of 2,584 or 63.8%).

Table 2: Estimated Prevalence of Diagnosed and Undiagnosed Anxiety Disorders
Between the Ages of 8 and 18
In a British Columbia Birth Cohort of 40,000
Without a Child / Youth Screening Program and Treatment

	Female							*Male*							*Total Population*						
		Diagnosed		Undiagnosed		Total			*Diagnosed*		Undiagnosed		Total			*Diagnosed*		Undiagnosed		Total	
Age	# Alive	%	#	%	#	%	#	# Alive	%	#	%	#	%	#	# Alive	%	#	%	#	%	#
8	19,918	1.6%	319	6.2%	1,235	7.8%	1,554	19,907	2.4%	478	4.1%	816	6.5%	1,294	39,824	2.00%	796	5.2%	2,051	7.2%	2,848
9	19,917	2.2%	443	8.6%	1,710	10.8%	2,153	19,906	2.6%	518	4.5%	895	7.1%	1,413	39,822	2.42%	962	6.5%	2,604	9.0%	3,566
10	19,915	2.9%	568	11.0%	2,184	13.8%	2,753	19,904	2.8%	559	4.9%	973	7.7%	1,532	39,820	2.83%	1,127	7.9%	3,158	10.8%	4,285
11	19,914	3.5%	693	13.4%	2,659	16.8%	3,352	19,903	3.0%	599	5.3%	1,052	8.3%	1,651	39,817	3.25%	1,292	9.3%	3,711	12.6%	5,003
12	19,913	4.1%	817	15.7%	3,134	19.8%	3,951	19,902	3.2%	640	5.7%	1,130	8.9%	1,770	39,815	3.66%	1,457	10.7%	4,264	14.4%	5,721
13	19,911	4.4%	880	16.9%	3,374	21.4%	4,255	19,900	3.5%	689	6.1%	1,217	9.6%	1,906	39,812	3.94%	1,569	11.5%	4,592	15.5%	6,161
14	19,910	4.7%	943	18.2%	3,615	22.9%	4,558	19,898	3.7%	738	6.6%	1,304	10.3%	2,042	39,808	4.22%	1,681	12.4%	4,919	16.6%	6,600
15	19,907	5.1%	1,006	19.4%	3,856	24.4%	4,862	19,896	4.0%	787	7.0%	1,391	10.9%	2,178	39,803	4.51%	1,793	13.2%	5,246	17.7%	7,040
16	19,904	5.4%	1,069	20.6%	4,096	25.9%	5,165	19,891	4.2%	836	7.4%	1,477	11.6%	2,314	39,795	4.79%	1,905	14.0%	5,573	18.8%	7,478
17	19,900	5.7%	1,131	21.8%	4,336	27.5%	5,467	19,885	4.5%	885	7.9%	1,564	12.3%	2,449	39,784	5.07%	2,017	14.8%	5,900	19.9%	7,916
18	19,894	6.0%	1,194	23.0%	4,576	29.0%	5,769	19,876	4.7%	934	8.3%	1,650	13.0%	2,584	39,770	5.35%	2,128	15.7%	6,225	21.0%	8,353

[160] Merikangas K, He J, Burstein M et al. Lifetime prevalence of mental disorders in U.S. adolescents: Results from the National Comorbidity Survey Replication Adolescent Supplement (NCS-A). *Journal of the American Academy of Child & Adolescent Psychiatry*. 2010; 49(10): 980-9.
[161] Statistics Canada. Table 13-10-0763-01 Health characteristics of children and youth aged 1 to 17 years. *Canadian Survey on Children and Youth 2019*. Available online at https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310076301. Accessed November 2023.
[162] McCreary Centre Society. *Balance and Connection in BC: The Health and Well-being of Our Youth, Results of the 2018 BC Adolescent Health Survey*. 2019. Available online at www.mcs.bc.ca. Accessed July 2023.
[163] Gadermann A, Petteni M, Janus M et al. Prevalence of mental health disorders among immigrant, refugee, and non-immigrant children and youth in British Columbia, Canada. *JAMA Network Open - Psychiatry*. 2022; 5(2): e2144934. doi:10.1001/jamanetworkopen.2021.44934.

Harms Associated with Anxiety in Children and Youth

- "Several reviews of anxiety disorders in children and adolescents reported longitudinal associations of anxiety disorders over time both with the same disorder and other anxiety or depressive disorders, suggesting the heightened risk for secondary depression."[164]
- The Great Smoky Mountains Study (GSMS), started in 1992, is a longitudinal, community-representative study in North Carolina that followed up 1,420 participants from 9 years old aiming to assess the prevalence of psychiatric disorders in childhood and their development over time. Foley and colleagues assessed proximal psychiatric risk factors for suicidality in this cohort between the ages of 9 and 16.[165] Suicidality included wanting to die, suicidal ideation, suicide plans or suicide attempt(s). Depression was the major risk factor for suicidality, especially when depression was comorbid with an anxiety disorder. **Anxiety disorders on their own, however, did not significantly increase the risk of suicidality**.
- Common childhood psychiatric disorders are associated with a higher probability of adverse outcomes in adulthood such as health problems (e.g. multiple psychiatric problems, suicidality, life-threatening illness), legal (e.g. felony charge, incarceration), financial (e.g. high school dropout, being fired from multiple jobs) and social (e.g. teen parenthood, lack of familial and peer social support).[166]
- Anxiety disorders in children and adolescents have a negative impact on a families functioning, psychological well-being and physical health.[167]

Quality of Life

- Based on a community sample of 1,719 Norwegian adolescents aged 12–17, 17.0% had a medium or high level of anxiety (as measured by the Spence Children's Anxiety Scale), 8.9% in males and 24.2% in females.[168]
- In the Norwegian study, a high level of anxiety was observed in 7.1% (3.4% in males and 10.4% in females) and a medium level of anxiety was observed in a further 9.9% (5.5% in males and 13.8% in females).[169] That is, 42% (38% of males and 43% of females) had a high level of anxiety and 58% (62% of males and 57% of females) had a medium level of anxiety.

[164] Viswanathan M, Wallace I, Middleton J et al. *Screening for Depression, Anxiety, and Suicide Risk in Children and Adolescents: An Evidence Review for the U.S. Preventive Services Task Force.* Evidence Synthesis No. 221. AHRQ Publication No. 22-05293-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; 2022.
[165] Foley D, Goldston D, Costello J et al. Proximal risk factors for suicidality in youth: The Great Smokey Mountains Study. *Archives of General Psychiatry*. 2006; 63: 1017-24.
[166] Costello J, Copeland W, Angold A. The Great Smoky Mountains Study: Developmental epidemiology in the southeastern United States. *Social Psychiatry and Psychiatric Epidemiology*. 2016; 51(5): 639-46.
[167] Senaratne R, Van Ameringen M, Mancini C et al. The burden of anxiety disorders on the family. *The Journal of Nervous and Mental Disease*. 2010; 198(12): 876-80.
[168] Raknes S, Pallesen S, Himle J et al. Quality of life in anxious adolescents. *Child and Adolescent Psychiatry and Mental Health*. 2017; 11(33)
[169] Raknes S, Pallesen S, Himle J et al. Quality of life in anxious adolescents. *Child and Adolescent Psychiatry and Mental Health*. 2017; 11(33)

- In the Norwegian study, those with a medium or high level of anxiety had a reduction in QoL (as measured with the Questionnaire for Measuring Health-Related Quality of Life in Children and Adolescents Revised Version) of 16.7% and 25.2%, respectively, compared with those adolescents with a low level of anxiety.[170] We used these reductions in QoL in our modelling and modified these reductions in QoL by +/- 25% in the sensitivity analysis.

- Disability weights developed for the Global Burden of Disease (GBD) study are a useful source as a proxy for QoL.[171] While not specifically for children and/or adolescents, the disability weights for anxiety identified by the GBD are as follows:[172]

  Mild anxiety disorders - 0.03 (95% CI of 0.018 to 0.046) "Feels mildly anxious and worried, which makes it slightly difficult to concentrate, remember things, and sleep. The person tires easily but is able to perform daily activities."

  Moderate anxiety disorders - 0.133 (95% CI of 0.091 to 0.186) "Feels anxious and worried, which makes it difficult to concentrate, remember things, and sleep. The person tires easily and finds it difficult to perform daily activities."

  Severe anxiety disorders - 0.523 (95% CI of 0.362 to 0.677) "Constantly feels very anxious and worried, which makes it difficult to concentrate, remember things and sleep. The person has lost pleasure in life and thinks about suicide."

No Intervention

Estimating the Quality of Life Reduction Due to Undiagnosed Anxiety

- We calculated that living with undiagnosed anxiety disorders in children and youth between the ages of 8 and 18 in a BC birth cohort of 40,000 would be associated with a loss of 9,765 QALYs. The majority of this loss of QALYs would be in the female population (7,080 QALYs lost or 72.5% of the total) (see Table 3).

[170] Raknes S, Pallesen S, Himle J et al. Quality of life in anxious adolescents. *Child and Adolescent Psychiatry and Mental Health*. 2017; 11(33)

[171] Salomon JA, Haagsma JA, Davis A et al. Disability weights for the Global Burden of Diseases 2013 study. *The Lancet Global Health*. 2015; 3: e712-e723.

[172] Institute for Health Metrics and Evaluation. *GBD 2016 sequelae, health states, health state lay descriptions, and disability weights*. Available online at http://ghdx.healthdata.org/record/global-burden-disease-study-2016-gbd-2016-disability-weights. Accessed August 2023.

Table 3: QALYs Lost Due to Undiagnosed Anxiety Disorders

Between the Ages of 8 and 18

In a British Columbia Birth Cohort of 40,000

Without a Child / Youth Screening Program and Treatment

Level of Anxiety

	Female							***Male***						
		Diagnosed		**Undiagnosed**		**Total**			***Diagnosed***		**Undiagnosed**		**Total**	
Age	**# Alive**	Medium	High	Medium	High	Medium	High	**# Alive**	Medium	High	Medium	High	Medium	High
		57%	***43%***	***57%***	***43%***				***62%***	***38%***	***62%***	***38%***		
8	19,918	182	137	704	531	886	668	19,907	296	182	506	310	802	492
9	19,917	253	191	975	735	1,227	926	19,906	321	197	555	340	876	537
10	19,915	324	244	1,245	939	1,569	1,184	19,904	347	212	603	370	950	582
11	19,914	395	298	1,516	1,143	1,911	1,441	19,903	372	228	652	400	1,024	627
12	19,913	466	352	1,786	1,347	2,252	1,699	19,902	397	243	701	429	1,098	673
13	19,911	502	379	1,923	1,451	2,425	1,830	19,900	427	262	755	462	1,182	724
14	19,910	538	406	2,061	1,555	2,598	1,960	19,898	458	281	808	495	1,266	776
15	19,907	573	433	2,198	1,658	2,771	2,090	19,896	488	299	862	528	1,350	828
16	19,904	609	459	2,335	1,761	2,944	2,221	19,891	519	318	916	561	1,434	879
17	19,900	645	486	2,472	1,864	3,116	2,351	19,885	549	336	969	594	1,518	931
18	19,894	680	513	2,608	1,968	3,288	2,481	19,876	579	355	1,023	627	1,602	982
QALYS Lost														
8				118	134						85	78		
9				163	185						93	86		
10				208	237						101	93		
11				253	288						109	101		
12				298	340						117	108		
13				321	366						126	117		
14				344	392						135	125		
15				367	418						144	133		
16				390	444						153	141		
17				413	470						162	150		
18				436	496						171	158		
Total				**3,312**	**3,768**						**1,395**	**1,290**		

- The next sections will provide evidence on the effectiveness of available interventions in treating anxiety in those ages 8-18, how many undiagnosed 8-18 years olds with anxiety disorder would be diagnosed with a screening program and how many of these formerly undiagnosed 8-18 years olds would receive and benefit from treatment.

Screening Tools

- "Currently, only 2 screening instruments are widely used in clinical practice for detecting anxiety: Screen for Child Anxiety Related Disorders (SCARED) and Social Phobia Inventory (SPIN)."[173]
- SCARED is a 41-item parent and child self-report measure used to screen for anxiety disorders in children ages 8 to 18 years. A total score is available as well as for the following scales: GAD, separation anxiety disorder, panic disorder, and social

[173] US Preventive Service Task Force. US Preventive Services Task Force Recommendation Statement. Screening for anxiety in children and adolescents: US Preventive Services Task Force recommendation statement. *JAMA*. 2022; 328(14): 1438-44.

anxiety disorder. Administration time is 10 minutes. A 10-item short form is also available.[174]

- SPIN is a 21-item scale to assess social anxiety using DSM-IV criteria, including an item assessing duration of symptoms (social anxiety must be present for at least 6 months). Administration time is 10 minutes.[175]
- SPIN is specific to assessing symptoms of social anxiety. The sensitivity of SPIN ranges from 0.80 to 0.86 while the specificity ranges from 0.77 to 0.85.[176,177,178]
- The sensitivity and specificity of SCARED is dependent to some degree on the anxiety disorder. Diagnosing global anxiety, separation anxiety, social phobia or any anxiety have a sensitivity ranging from 0.78 – 0.88 and a specificity ranging from 0.56 – 0.81.[179,180,181] For modelling purpose we will use the mid-point of the range for sensitivity (0.83) and the mid-point of the range for specificity after excluding the 0.56 (0.75 for a range from 0.68 to 0.81).
- With a true prevalence rate for anxiety disorder of 7.7% (the estimated average rate in BC males ages 8-12, see *Defining and Estimating the Population at Risk)*, a sensitivity of 0.83 and a specificity of 0.75, 78% of positive screens would be false positive results. With a true prevalence of 13.8% (the estimated average rate in BC females ages 8-12), 65% of positive screens would be false positive results. With a true prevalence of 11.3% (the estimated average rate in BC males ages 13-18), 70% of positive screens would be false positive results. With a true prevalence of 25.2% (the estimated average rate in BC females ages 13-18), 47% of positive screens would be false positive results.
- It is because of these high false positive rates that "anxiety screening tools alone are not sufficient to diagnose anxiety. If the screening test is positive for anxiety, a confirmatory diagnostic assessment and follow-up is required."[182]

[174] Viswanathan M, Wallace I, Middleton J et al. *Screening for Depression, Anxiety, and Suicide Risk in Children and Adolescents: An Evidence Review for the U.S. Preventive Services Task Force*. Evidence Synthesis No. 221. AHRQ Publication No. 22-05293-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; 2022.
[175] Viswanathan M, Wallace I, Middleton J et al. *Screening for Depression, Anxiety, and Suicide Risk in Children and Adolescents: An Evidence Review for the U.S. Preventive Services Task Force*. Evidence Synthesis No. 221. AHRQ Publication No. 22-05293-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; 2022.
[176] Tsai C, Wang S, Juang K et al. Use of the Chinese (Taiwan) version of the Social Phobia Inventory (SPIN) among early adolescents in rural areas: Reliability and validity study. *Journal of the Chinese Medical Association*. 2009; 72(8): 422-9.
[177] Ranta K, Kaltiala-Heino R, Rantanen P et al. Screening social phobia in adolescents from general population: The validity of the Social Phobia Inventory (SPIN) against a clinical interview. *European Psychiatry*. 2007; 22(4): 244-51.
[178] Ranta K, Kaltiala-Heino R, Rantanen P et al. The Mini-Social Phobia Inventory: Psychometric properties in an adolescent general population sample. *Comprehensive Psychiatry*. 2012; 53(5): 630-7.
[179] Canals J, Hernández-Martínez C, Cosi S et al. Examination of a cutoff score for the Screen for Child Anxiety Related Emotional Disorders (SCARED) in a non-clinical Spanish population. *Journal of Anxiety Disorders*. 2012; 26(8): 785-91.
[180] Bailey K, Chavira D, Stein M et al. Brief measures to screen for social phobia in primary care pediatrics. *Journal of Pediatric Psychology*. 2006; 31(5): 512-21.
[181] Muris P, Merckelbach H, Kindt M et al. The utility of Screen for Child Anxiety Related Emotional Disorders (SCARED) as a tool for identifying children at high risk for prevalent anxiety disorders. *Anxiety, Stress & Coping: An International Journal*. 2001; 14(3): 265-83.
[182] US Preventive Service Task Force. US Preventive Services Task Force Recommendation Statement. Screening for anxiety in children and adolescents: US Preventive Services Task Force recommendation statement. *JAMA*. 2022; 328(14): 1438-44.

- The five essential components of an anxiety-focused assessment in children and youth include:[183]
    - Patient history and parent-reported symptoms and functioning
    - Focused medical, developmental, and mental health history
    - Results from standardized rating scales
    - A review of past assessments (e.g., reports from allied HCPs, early child care, or school settings), and
    - Direct observation of the child and parent-child interactions

Effectiveness of the Intervention(s)

- The two primary interventions include pharmacotherapy and cognitive behavioural therapy (CBT). Pharmacotherapy appears to be less effective than CBT in improving functioning and producing remission or the loss of all anxiety diagnoses.
- Pharmacotherapy, on average, results in a 5.14 (95% CI 3.21 to 7.08) improvement in functioning as measured by the *Children's Global Assessment Scale* (CGAS) while CBT results in a 7.54 (95% CI 2.84 to 12.23) improvement.[184]
- The CGAS is a rating of functioning aimed at children and young people aged 6-17 years old. The child or young person is given a single score between 1 and 100, based on a clinician's assessment of a range of aspects related to a child's psychological and social functioning. The score will put them in one of ten categories that range from 'extremely impaired' (1-10) to 'doing very well' (91-100).
- With respect to producing remission or the loss of all anxiety diagnosis, pharmacotherapy has a modest effect (risk ratio of 1.20 [95% CI of 1.00 to 1.45]) while CBT, on average, results in a risk ratio of 3.09 (95% CI of 1.98 to 4.80).[185]

Cognitive Behavioural Therapy

Examples of the Interventions

- Villabø and colleagues randomly assigned 165 children ages 7 – 13 to individual (ICBT) or group cognitive behavioural therapy (GCBT) or to be on a waitlist (WL). Treatment in both conditions consisted of 14 sessions (12 child sessions and two parent sessions) delivered over a 12-week period following the *Coping Cat* manual. Each child received training in anxiety management skills and faced anxiety-provoking situations (i.e., "exposure"). Children randomized to GCBT met individually with one of the two group therapists for the first three sessions before joining a group from session four onwards. The GCBT approach comprised treatment groups consisting of a mean of 4.63 participants each with treatment provided by 32 community therapists (most being clinical psychologists or social workers with a master's degree). The therapists had an average of 44 months of clinical experience with youth. A loss of all anxiety disorders was observed in 6% for WL, 38% for ICBT and 56% for GCBT. These gains improved to 72% and 78% for ICBT and

[183] Klein B, Rajendram R, Hrycko S et al. Canadian Paediatric Society Position Statement. Anxiety in children and youth: Part 1 – diagnosis. *Paediatrics & Child Health*. 2023; 28: 45–51.
[184] Viswanathan M, Wallace I, Middleton J et al. *Screening for Depression, Anxiety, and Suicide Risk in Children and Adolescents: An Evidence Review for the U.S. Preventive Services Task Force*. Evidence Synthesis No. 221. AHRQ Publication No. 22-05293-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; 2022.
[185] Viswanathan M, Wallace I, Middleton J et al. *Screening for Depression, Anxiety, and Suicide Risk in Children and Adolescents: An Evidence Review for the U.S. Preventive Services Task Force*. Evidence Synthesis No. 221. AHRQ Publication No. 22-05293-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; 2022.

GCBT, respectively, at 24-months. Drop-out rates were lower in GCBT (7% vs. 29%), suggesting that GCBT may be better tolerated than ICBT.[186]

- Arendt et al. randomly allocated 109 children and adolescents ages 7 to 17 to receive group CBT or remain on a waitlist. The group CBT consisted of the *Cool Kids* program that has a focus on teaching youths to recognize their emotions, challenge negative automatic thinking and gradually confront feared situations. The treatment consisted of ten 2-hour weekly group sessions with six to seven youths and their parents in each group. For those receiving group CBT, 48.2% were free of all anxiety diagnosis post-treatment, compared with 5.7% on the waitlist. This improvement increased to 57.9% at 3 months post-treatment and was maintained at this improved level at 12 months post-treatment.[187]
- Stjerneklar and co-authors randomly allocated 70 adolescents (13–17 years) with anxiety disorders to the 14-weeks therapist-guided internet-based CBT (ICBT) program *ChilledOut Online* or to a waitlist condition. The program teaches CBT strategies for adolescents through eight online modules of approximately 30 minutes, with a focus on psychoeducation, cognitive restructuring and graded exposure. Those assigned to the ICBT received a 20-minute phone call introducing them to the program and during which the therapist and adolescent agreed to and scheduled a weekly supportive phone call. For those receiving group CBT, 28.6% were free of all anxiety diagnosis post-treatment, compared with 3.1% on the waitlist. These gains were maintained at 3-month follow-up.[188]

Effectiveness of CBT in Producing the Loss of All Anxiety Diagnosis

- The examples above are three of the RCTs included in the USPSTF analysis of the effectiveness of CBT interventions in leading to the loss of all anxiety diagnosis following treatment in children and youth. In Table 4 below we have included summary results from the relevant studies included by the USPSTF.[189]

- Three studies had at least one year of follow-up and also focused on group CBT (see Table 4).[190,191,192] Based on the weighted average for these three studies, group CBT results in remission in 68% of children and youth participating, versus remission in 6% of controls. For modelling purposes, we have assumed that group CBT is effective in 62% (68% - 6%) of children and youth, with a range from 52% to 71%.

[186] Villabø M, Narayanan M, Compton S et al. Cognitive–behavioral therapy for youth anxiety: An effectiveness evaluation in community practice. *Journal of Consulting Clinical Psychology*. 2018; 86(9): 751-64.
[187] Arendt K, Thastum M, Hougaard E. Efficacy of a Danish version of the Cool Kids program: A randomized wait-list controlled trial. *Acta Psychiatrica Scandinavica*. 2015; DOI: 10.1111/acps.12448.
[188] Stjerneklar S, Hougaard E, McLellan L et al. A randomized controlled trial examining the efficacy of an internet-based cognitive behavioral therapy program for adolescents with anxiety disorders. *PLoS ONE*. 2019; 14(9): e0222485.
[189] Viswanathan M, Wallace I, Middleton J et al. *Screening for Depression, Anxiety, and Suicide Risk in Children and Adolescents: An Evidence Review for the U.S. Preventive Services Task Force*. Evidence Synthesis No. 221. AHRQ Publication No. 22-05293-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; 2022. See Appendix G Figure 19 on page 290.
[190] Villabø M, Narayanan M, Compton S et al. Cognitive–behavioral therapy for youth anxiety: An effectiveness evaluation in community practice. *Journal of Consulting Clinical Psychology*. 2018; 86(9): 751-64.
[191] Arendt K, Thastum M, Hougaard E. Efficacy of a Danish version of the Cool Kids program: A randomized wait-list controlled trial. *Acta Psychiatrica Scandinavica*. 2015; DOI: 10.1111/acps.12448.
[192] Shortt A, Barrett P, Fox T. Evaluating the FRIENDS program: A cognitive-behavioral group treatment for anxious children and their parents. *Journal of Clinical Child Psychology*. 2001; 30(4): 525-35.

Table 4: Remission or Loss Of All Anxiety Diagnosis in Children and Youth
Following Cognitive Behavioural Therapy

						Results (Loss of All Anxiety Diagnosis)				
Author	**Year Published**	**N**	**Age**	**Intervention**	**Dropout %**	Post-Treatment	3 Months	6 Months	12 Months	24 Months
Villabø et al	2018	55	7 - 13	Individual CBT	29.0%	38.0%	45.0%			72.0%
		55		Group CBT	7.0%	56.0%	48.0%			78.0%
		55		Control		6.0%				
Arendt et al	2015	56	7 - 16	Group CBT		48.2%	57.9%		57.9%	
		53		Control		5.7%				
Shortt et al	2001	54	6 - 10	Group Family CBT	11.1%	69.0%			68.0%	
		17		Control		6.0%				
Barrett et al	1996	28	7 - 14	Individual CBT	9.7%	57.1%		71.4%		
		25		Ind + Family CBT	7.4%	84.0%		84.0%		
		26		Control		26.0%				
Ishikawa et al	2019	26	8 - 15	Ind + Family CBT	0.0%	15.4%	33.3%	49.0%		
		25		Control		4.0%				
Stjerneklar et al	2019	35	13-17	Internet CBT		28.6%	30.3%			
		35		Control		3.1%				
Perrin et al	2019	20	10 - 18	Individual CBT	10.0%	80.0%	90.0%			
		20		Control		0.0%				
Holmes et al	2014	20	7 - 12	Ind + Family CBT	10.0%	17.6%	50.0%			
		22		Control		0.0%				
Thirlwall et al	2013	64	7 - 12	Full Guided Parent-Delivered CBT	21.9%	50.0%				
		61		Brief Guided Parent-Delivered CBT	24.6%	39.0%				
		69		Control		25.0%				
Waite et al	2019	15	13 - 18	Internet CBT	6.7%					
		15		Internet CBT with Parents	13.3%	26.7%				
		30		Control		13.3%				

Summary

- "CBT should be offered to all children with anxiety disorders as first-line treatment, while fluoxetine should be considered for children who do not improve with CBT alone."[193]

- For modelling purposes, we have assumed that the vast majority of individuals with anxiety disorders detected by routine screening will be in the mild to moderate range and thus favour CBT over pharmacotherapy. CBT would occur in group sessions (mean of 6 participants) which appear to be better tolerated and likely more cost-effective than individual CBT sessions. The sessions will be led by a PhD trained clinical psychologist or a master's trained social worker. Group sessions start with 2-3 individual sessions to acclimatize the child/adolescent.

[193] Schwartz C, Barican J, Yung D et al. Six decades of preventing and treating childhood anxiety disorders: A systematic review and meta-analysis to inform policy and practice. *Evidence Based Mental Health*. 2019; 22: 103-10.

With Intervention

Prevalence of Diagnosed vs. Undiagnosed Anxiety

- In Table 2 we had estimated that, of the 19,918 females alive in the BC cohort of 40,000 at age eight, 319 would have been diagnosed with anxiety and 1,235 would be living with undiagnosed anxiety. That is, 19,599 (19,918 – 319) of the females alive in the cohort at age 8 would not have diagnosed anxiety and would thus be eligible for screening (see Table 5). Of these 19,599, 70.4% would visit a GP (13,798) of whom 81.5% (11,245) would be screened (see Table 10). With an estimated 6.2% undiagnosed anxiety disorder rate (see Table 2), we would expect 697 (11,245 * 6.2%) new cases of anxiety disorder to be identified. However, based on the sensitivity (0.83) and specificity (0.75) of the screening test (SCARED), we would expect 579 of the 697 (697 * 0.83) cases to be identified as true positive cases and a further 1,091 cases would be identified as false positives (see Table 10). These false positives would then be ruled out by a confirmatory diagnostic assessment.
- Using this approach, we have modelled that the number of undiagnosed 18 year old females in the BC birth cohort would be reduced from 4,576 without a child / youth screening program (see Table 2) to 613 with a child / youth screening program (see Table 5).
- Using this same approach for males, we have modelled that the number of undiagnosed 18 year old males in the BC birth cohort would be reduced from 1,650 without a child / youth screening program (see Table 2) to 224 with a child / youth screening program (see Table 6).

Table 5: Estimated Prevalence of Diagnosed and Undiagnosed Anxiety Disorders
Females Between the Ages of 8 and 18
In a British Columbia Birth Cohort of 40,000
With a Child / Youth Screening Program and Treatment

		Estimated # with Anxiety			# Without Diagnosed	Visit GP (Table 1)		# Screened	True +		Cumulative
Age	# Alive	Diag	Undiag	Total	Anxiety	%	#	81.5%	0.83	False +	True +
8	19,918	319	1,235	1,554	19,599	70.4%	13,798	11,245	579	1,091	579
9	19,917	1,022	1,131	2,153	18,895	70.4%	13,302	10,841	511	963	1,090
10	19,915	1,658	1,095	2,753	18,258	70.4%	12,853	10,476	478	901	1,568
11	19,914	2,260	1,091	3,352	17,654	70.4%	12,428	10,129	461	869	2,028
12	19,913	2,846	1,105	3,951	17,067	70.4%	12,015	9,792	451	851	2,480
13	19,911	3,360	895	4,255	16,552	70.4%	11,652	9,497	354	317	2,834
14	19,910	3,777	781	4,558	16,133	70.4%	11,357	9,256	302	270	3,135
15	19,907	4,141	720	4,862	15,766	78.8%	12,424	10,125	304	272	3,439
16	19,904	4,508	657	5,165	15,396	78.8%	12,132	9,888	271	242	3,710
17	19,900	4,841	626	5,467	15,058	78.8%	11,866	9,671	252	226	3,963
18	19,894	5,156	613	5,769	14,738	78.8%	11,613	9,465	242	216	4,205

Table 6: Estimated Prevalence of Diagnosed and Undiagnosed Anxiety Disorders

Males Between the Ages of 8 and 18

In a British Columbia Birth Cohort of 40,000

With a Child / Youth Screening Program and Treatment

Age	# Alive	Estimated # with Anxiety Diag	Undiag	Total	# Without Diagnosed Anxiety	Visit GP (Table 1) %	#	# Screened 81.5%	True + 0.83	False +	Cumulative True +
8	19,907	478	816	1,294	19,429	68.2%	13,250	10,799	367	1,326	367
9	19,906	886	527	1,413	19,020	68.2%	12,971	10,572	232	838	600
10	19,904	1,159	373	1,532	18,746	68.2%	12,785	10,419	162	585	762
11	19,903	1,362	290	1,651	18,542	68.2%	12,645	10,306	124	449	887
12	19,902	1,527	244	1,770	18,375	68.2%	12,532	10,214	104	374	990
13	19,900	1,680	227	1,906	18,221	68.2%	12,427	10,128	96	227	1,086
14	19,898	1,824	218	2,042	18,074	68.2%	12,326	10,046	91	216	1,177
15	19,896	1,965	213	2,178	17,931	63.0%	11,296	9,207	82	194	1,259
16	19,891	2,096	218	2,314	17,795	63.0%	11,211	9,137	83	197	1,342
17	19,885	2,228	221	2,449	17,657	63.0%	11,124	9,066	84	198	1,426
18	19,876	2,360	224	2,584	17,516	63.0%	11,035	8,993	84	199	1,510

Estimating Receipt of Treatment and Treatment Effectiveness

- Not all children and youth with a newly diagnosed anxiety disorder would go on to receive treatment. We have assumed that of the 5,715 with a newly diagnosed anxiety disorder (4,205 females and 1,510 males), 63.6% (or 3,635, see Table 7) would go on to receive treatment. Treatment would be effective in producing remission of the anxiety disorder in 62% (or 2,253, see Table 7) of individuals who receive treatment.

Table 7: Newly Diagnosed, Receipt of Treatment and Remission of Anxiety Disorder

Between the Ages of 8 and 18

In a British Columbia Birth Cohort of 40,000

With a Child / Youth Screening Program and Treatment

Age	Newly Diagnosed Females Table 5	Males Table 11	Total	Receive Treatment Females 63.6%	Males	Total	Treatment Effective Females 62%	Males	Total
8	579	367	**946**	368	234	**602**	228	145	**373**
9	511	232	**743**	325	148	**473**	201	92	**293**
10	478	162	**640**	304	103	**407**	188	64	**252**
11	461	124	**585**	293	79	**372**	182	49	**231**
12	451	104	**555**	287	66	**353**	178	41	**219**
13	354	96	**450**	225	61	**286**	140	38	**177**
14	302	91	**393**	192	58	**250**	119	36	**155**
15	304	82	**386**	193	52	**246**	120	32	**152**
16	271	83	**354**	172	53	**225**	107	33	**140**
17	252	84	**336**	161	53	**214**	100	33	**133**
18	242	84	**326**	154	53	**207**	95	33	**129**
Total	**4,205**	**1,510**	**5,715**	**2,674**	**960**	**3,635**	**1,658**	**595**	**2,253**

- The quality of life for these 2,253 individuals in remission would return to normal, resulting in a gain of 3,246 QALYs (2,330 in females and 916 in males, see Table 8).

Table 8: QALYs Gained Due to Newly Treated Anxiety Disorders
Between the Ages of 8 and 18
In a British Columbia Birth Cohort of 40,000
With a Child / Youth Screening Program and Treatment

	Cumulative # in Remission			Level of Anxiety				QALYs Gained					
	Females	Males		Females		Males		Females			Males		
Age	Table 7	Table 7	**Total**	Medium	High	Medium	High	Medium	High	**Total**	Medium	High	**Total**
				57%	*43%*	*57%*	*43%*	*16.7%*	*25.2%*		*16.7%*	*25.2%*	
8	228	145	373	130	98	83	62	21.7	24.7	**46.4**	13.8	15.7	**29.5**
9	430	237	666	245	185	135	102	40.9	46.6	**87**	22.5	25.6	**48.1**
10	618	301	919	352	266	171	129	58.8	67.0	**126**	28.6	32.6	**61.2**
11	800	350	1,149	456	344	199	150	76.1	87	**163**	33.3	37.9	**71.2**
12	978	391	1,368	557	420	223	168	93	106	**199**	37.2	42.3	**79.5**
13	1,117	428	1,546	637	480	244	184	106	121	**227**	40.8	46.4	**87**
14	1,236	464	1,701	705	532	265	200	118	134	**252**	44.2	50.3	**94**
15	1,356	497	1,853	773	583	283	214	129	147	**276**	47.3	53.8	**101**
16	1,463	529	1,992	834	629	302	228	139	159	**298**	50.4	57	**108**
17	1,563	562	2,125	891	672	321	242	149	169	**318**	54	61	**114**
18	1,658	595	2,253	945	713	339	256	158	180	**337**	57	65	**121**
Total										**2,330**			**916**

- Other assumptions used in assessing the clinically preventable burden are detailed in the Reference Document.

Summary of CPB – Males and Females

Based on these assumptions, the CPB associated with screening for, and treatment of, anxiety in children and adolescents aged 8 to 18 years of age in a BC birth cohort of 40,000 is 3,247 QALYs (see Table 9).

Table 9: CPB of Screening for and Treatment of Anxiety in Children and Youth in a B.C. Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
a	Age to start screening	8	√
b	Age to stop screening / brief intervention	18	√
	Without an Adolescent Screening Program / Treatment		
c	Prevalence of **females** with undiagnosed anxiety at age 18	4,576	Table 2
d	Prevalence of **males** with undiagnosed anxiety at age 18	1,650	Table 2
e	Prevalence of undiagnosed anxiety at age 18	6,225	= c + d
f	QALYs lost in **females** due to undiagnosed anxiety disorders	7,080	Table 3
g	QALYs lost in **males** due to undiagnosed anxiety disorders	2,685	Table 3
h	QALYs lost due to undiagnosed anxiety disorders	9,765	= f + g
	With an Adolescent Screening Program / Treatment		
i	Prevalence of **females** with undiagnosed anxiety at age 18	613	Table 5
j	Prevalence of **males** with undiagnosed anxiety at age 18	224	Table 6
k	Prevalence of undiagnosed anxiety at age 18	837	= c + d
l	QALYs lost in **females** due to undiagnosed anxiety disorders	4,750	= f - Table 8 p22
m	QALYs lost in **males** due to undiagnosed anxiety disorders	1,769	= g - Table 8 s22
n	QALYs lost due to undiagnosed anxiety disorders	6,519	= l + m
	QALYs Gained With Screening / Treatment		
o	**Total QALYs gained - Females (CPB)**	2,331	= f - l
p	**Total QALYs gained - Males (CPB)**	916	= g - m
q	**Total QALYs gained (CPB)**	**3,247**	= o + p

√ = Estimates from the literature

We also modified a number of major assumptions and recalculated the CPB as follows:

- Reduce the estimated actual rates of anxiety disorders by a third, from 29.0% to 19.3% in females and from 13.0% to 8.3% in males - **CPB = 2,001**
- Reduce the QoL values by 25% - CPB = 2,435
- Increase the QoL values by 25% - CPB = 4,058
- Reduce the number who receive treatment by 25%, from 63.6% to 47.7% - CPB = 2,435
- Increase the number who receive treatment by 25%, from 63.6% to 79.5% - **CPB = 4,058**
- Reduce the proportion receiving treatment for whom the treatment is effective from 62% to 52% - CPB = 2,723
- Increase the proportion receiving treatment for whom the treatment is effective from 62% to 71% - CPB = 3,718

Summary of CPB – Females Only

Based on these assumptions, the CPB associated with screening for, and treatment of, anxiety in females aged 8 to 18 years of age in a BC birth cohort of 40,000 is 2,330 QALYs (see Table 9).

We also modified a number of major assumptions and recalculated the CPB as follows:

- Reduce the estimated actual rates of anxiety disorders by a third, from 29.0% to 19.3% - **CPB = 1,474**
- Reduce the QoL values by 25% - CPB = 1,748
- Increase the QoL values by 25% - CPB = 2,913
- Reduce the number who receive treatment by 25%, from 63.6% to 47.7% - CPB = 1,748
- Increase the number who receive treatment by 25%, from 63.6% to 79.5% - **CPB = 2,913**
- Reduce the proportion receiving treatment for whom the treatment is effective from 62% to 52% - CPB = 1,955
- Increase the proportion receiving treatment for whom the treatment is effective from 62% to 71% - CPB = 2,669

Summary of CPB – Males Only

Based on these assumptions, the CPB associated with screening for, and treatment of, anxiety in males aged 8 to 18 years of age in a BC birth cohort of 40,000 is 916 QALYs (see Table 9).

We also modified a number of major assumption and recalculated the CPB as follows:

- Reduce the estimated actual rates of anxiety disorders by a third, from 13.0% to 8.3% - **CPB = 526**
- Reduce the QoL values by 25% - CPB = 687
- Increase the QoL values by 25% - CPB = 1,145
- Reduce the number who receive treatment by 25%, from 63.6% to 47.7% - CPB = 687
- Increase the number who receive treatment by 25%, from 63.6% to 79.5% - **CPB = 1,145**
- Reduce the proportion receiving treatment for whom the treatment is effective from 62% to 52% - CPB = 768
- Increase the proportion receiving treatment for whom the treatment is effective from 62% to 71% - CPB = 1,049

Modelling Cost-Effectiveness

In this section, we model CE associated with screening for, and treatment of, anxiety in children and adolescents aged 8 to 18 years of age in a BC birth cohort of 40,000.

In calculating CE, we made the following assumptions:

- The cost of an office visit to a General Practitioner (GP) in BC is estimated at $35.97.[194] The administration of SCARED for screening purposes would take 10 minutes, or the entirety of one office visit.
- A follow-up anxiety-focused assessment in children and youth would be required for all individuals who test 'positive' on the screen, including those with true and false positive results. The assessment will rule out the false positive results.
- As noted previously, the five essential components of an anxiety-focused assessment in children and youth include:[195]
    - Patient history and parent-reported symptoms and functioning
    - Focused medical, developmental, and mental health history
    - Results from standardized rating scales
    - A review of past assessments (e.g., reports from allied HCPs, early child care, or school settings), and
    - Direct observation of the child and parent-child interactions
- We have assumed that the follow-up anxiety-focused assessment in children and youth to confirm a true positive and to rule out a false positive would involve MSP Fee Code 00622 – A full consultation for an emotionally disturbed child by a psychiatrist: "Diagnostic interview or examination, including mental status and treatment recommendation, assessment of parents, guardian, or other relatives and written report" is reimbursed at $450.67 by MSP.[196] A follow-up anxiety-focused assessment in children and youth would be required for all individuals who test 'positive' on the screen
- Treatment costs – for costing purposes we have assumed that CBT would occur in 12 sessions with the first 3 sessions being one-on-one with the therapist (to acclimatize the child/adolescent) before joining a group of with 6 participants for 9 sessions. The individual and group sessions will be led by a PhD trained clinical psychologist paid $59.31 / hour[197] (annual salary of $115,655) or a master's trained social worker paid $47.47 / hour[198] (annual salary of $92,567). For modelling purposes we have used the mid-point between these two wage rates. The individual sessions will be one hour in length while the group sessions will be two hours in length. The average cost per individual receiving treatment would be $601 (see Table 10).

[194] Ministry of Health. *Medical Services Commission Payment Schedule*. 2021. Available at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msc-payment-schedule-may-2021.pdf. Accessed September 2022.
[195] Klein B, Rajendram R, Hrycko S et al. Canadian Paediatric Society Position Statement. Anxiety in children and youth: Part 1 – diagnosis. *Paediatrics & Child Health*. 2023; 28: 45–51.
[196] Ministry of Health. *Medical Services Commission Payment Schedule*. May 1, 2022. Available online at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msc_payment_schedule_-_may_2022.pdf. Accessed September 2023.
[197] Wage rate based on a Grade A Psychologist with four years of experience effective April 1, 2022. See Health Sciences Association of BC *Wage Calculator* available at https://calc.hsabc.org/. Accessed November 2023.
[198] Wage rate based on a Grade IV Social Worker with four years of experience effective April 1, 2022. See Health Sciences Association of BC *Wage Calculator* available at https://calc.hsabc.org/. Accessed November 2023.

Table 10: Estimated Costs per Treatment		
# of hours direct contact - One-on-one Sessions	18	(3 * 6)
# of hours direct contact - Group Sessions	18	(9 * 2)
Prep time - One-on-one Sessions	9	(0.5 * 18)
Prep time - Group Sessions	9	(1.0 * 9)
Total Hours	**54**	
Hourly Rate - Master's trained Social Worker	$47.47	
Hourly Rate - PhD trained Psychologist	$59.31	
Wages	$2,883	
Benefit Rate	25%	
Benefit costs	$721	
Estmated Cost per Group Treatment	**$3,604**	
Estmated Treatment Cost per Attendee	**$601**	

- Patient/parent time costs resulting from receiving, as well as travelling to and from, a service are valued based on the average hourly wage rate in BC in 2022 ($31.49[199]) plus 18% benefits for an average cost per hour of $37.16. In the absence of specific data on the amount of time required, we assume two hours per service.
- For those receiving treatment, we have assumed 30 minutes of travel time to and from treatment plus the actual treatment time. Patient time costs associated with treatment would therefore be 6 hours for the three one-on-one sessions and 27 hours for the nine group sessions.
- Table 11 provides an overview of the costs of screening and treatment in females between the ages of 8 and 18 in a BC birth cohort of 40,000. For example, 11,245 8-year olds would be screened. Screening costs include primary care provider costs of $404,489 (11,245 screens times $35.97 per screen) and patient costs of $835,742 (11,245 screens times 2 hours per screen times $37.16 per hour). Screening would result in 1,670 positive results. In order to rule out false positive results, all 1,670 individuals would receive a full assessment costing $450.67. Of the 579 true positive results (see Table 5), 368 would go on to receive treatment (see Table 7) at a cost of $601 per treatment (see Table 10). Patient costs during treatment consist of 33 hours per patient times $37.16 per hour.
- Table 12 provides an overview of the costs of screening and treatment in males between the ages of 8 and 18 in a BC birth cohort of 40,000.

[199] BC Stats. *Earning & Employment Trends – August 2022*. Available at https://www2.gov.bc.ca/assets/gov/data/statistics/people-population-community/income/earnings_and_employment_trends_data_tables.pdf. Accessed September 2022.

Table 11: Estimated Cost of Screening and Treatment for Anxiety

Females Between the Ages of 8 and 18

In a British Columbia Birth Cohort of 40,000

Age	# Screened *Table 5*	PCP Cost	Patient Cost	Positive Screens: Total *Table 5*	Positive Screens: Physician Cost	Positive Screens: Patient Cost	Receive Treatment *Table 7*	Receive Treatment: Cost	Receive Treatment: Patient Cost
8	11,245	$404,489	$835,742	1,670	$752,540	$124,101	368	$221,058	$451,319
9	10,841	$389,948	$805,697	1,474	$664,488	$109,581	325	$195,193	$398,511
10	10,476	$376,804	$778,539	1,379	$621,550	$102,500	304	$182,580	$372,760
11	10,129	$364,342	$752,791	1,330	$599,226	$98,818	293	$176,022	$359,372
12	9,792	$352,234	$727,774	1,302	$586,685	$96,750	287	$172,338	$351,851
13	9,497	$341,594	$705,790	671	$302,378	$49,865	225	$135,335	$276,303
14	9,256	$332,949	$687,929	571	$257,349	$42,439	192	$115,181	$235,157
15	10,125	$364,211	$752,519	576	$259,588	$42,809	193	$116,183	$237,203
16	9,888	$355,658	$734,849	513	$231,064	$38,105	172	$103,417	$211,138
17	9,671	$347,856	$718,729	478	$215,464	$35,532	161	$96,434	$196,884
18	9,465	$340,452	$703,430	458	$206,609	$34,072	154	$92,471	$188,792
TOTAL	**110,385**	**$3,970,537**	**$8,203,790**	**10,422**	**$4,696,939**	**$774,572**	**2,674**	**$1,606,211**	**$3,279,289**

Table 12: Estimated Cost of Screening and Treatment for Anxiety

Males Between the Ages of 8 and 18

In a British Columbia Birth Cohort of 40,000

Age	# Screened *Table 6*	PCP Cost	Patient Cost	Positive Screens: Total *Table 6*	Positive Screens: PCP Cost	Positive Screens: Patient Cost	Receive Treatment *Table 7*	Receive Treatment: Cost	Receive Treatment: Patient Cost
8	10,799	$388,445	$802,592	1,693	$763,038	$125,833	234	$140,385	$286,614
9	10,572	$380,266	$785,693	1,071	$482,535	$79,575	148	$88,778	$181,251
10	10,419	$374,785	$774,368	747	$336,787	$55,540	103	$61,963	$126,505
11	10,306	$370,707	$765,942	573	$258,455	$42,622	79	$47,551	$97,081
12	10,214	$367,384	$759,075	478	$215,488	$35,536	66	$39,646	$80,942
13	10,128	$364,293	$752,691	322	$145,300	$23,961	61	$36,582	$74,687
14	10,046	$361,356	$746,622	307	$138,445	$22,831	58	$34,856	$71,164
15	9,207	$331,160	$684,232	276	$124,262	$20,492	52	$31,285	$63,873
16	9,137	$328,661	$679,068	280	$126,064	$20,789	53	$31,739	$64,799
17	9,066	$326,105	$673,786	282	$127,021	$20,947	53	$31,980	$65,291
18	8,993	$323,492	$668,387	283	$127,429	$21,014	53	$32,083	$65,501
TOTAL	**108,887**	**$3,916,653**	**$8,092,456**	**6,312**	**$2,844,826**	**$469,140**	**960**	**$576,847**	**$1,177,708**

Summary of CE – Males and Females

- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the CE associated with screening for, and treatment of, anxiety in children and adolescents aged 8 to 18 years of age in a BC birth cohort of 40,000 is $12,552 per QALY (Table 13, row *aa*).

Table 13: CE of Screening for and Treatment of Anxiety in Children and Youth in a B.C. Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
	Cost of Screening and Treatment		
a	Screening - Primary care provider costs - Females	$3,970,537	Table 11
b	Screening - Patient time costs - Females	$8,203,790	Table 11
c	Screening - Primary care provider costs - Males	$3,916,653	Table 12
d	Screening - Patient time costs - Males	$8,092,456	Table 12
e	Full assessment - Physician costs - Females	$4,696,939	Table 11
f	Full assessment - Patient time costs - Females	$774,572	Table 11
g	Full assessment - Physician costs - Males	$2,844,826	Table 12
h	Full assessment - Patient time costs - Males	$469,140	Table 12
i	Treament costs - Females	$1,606,211	Table 11
j	Treatment patient costs - Females	$3,279,289	Table 11
k	Treament costs - Males	$576,847	Table 12
l	Treatment patient costs - Males	$1,177,708	Table 12
m	Females	$22,531,338	= a + b + e + f + i + j
n	Males	$17,077,631	= c + d + g + h + k + l
o	**Total Cost** of Screening and Treatment	**$39,608,969**	= m + n
	CE per QALY Gained		
p	Total QALYs gained - Females	2,331	Table 9
q	CE ($/QALY gained) - Females	$9,667	= m / p
r	Total QALYs gained - Males	916	Table 9
s	CE ($/QALY gained) - Males	$18,646	= n / r
t	Total QALYs gained - Total	3,247	Table 9
u	CE ($/QALY gained) - Total	$12,200	= o / t
v	Total QALYs gained, 1.5% Discount - Females	2,123	Calculated
w	**CE ($/QALY gained), 1.5% Discount - Females**	**$9,957**	Calculated
x	Total QALYs gained, 1.5% Discount - Males	839	Calculated
y	**CE ($/QALY gained), 1.5% Discount - Males**	**$19,125**	Calculated
z	Total QALYs gained, 1.5% Discount - Total	2,962	Calculated
aa	**CE ($/QALY gained), 1.5% Discount - Total**	**$12,552**	Calculated

√ = Estimates from the literature

We also modified several major assumptions and recalculated the cost per QALY as follows:

- Reduce the estimated actual rates of anxiety disorders by a third, from 29.0% to 19.3% in females and from 13.0% to 8.3% in males - **CE = $17,228**
- Reduce the QoL values by 25% - CE = $16,737
- Increase the QoL values by 25% - **CE = $10,042**
- Reduce the number who receive treatment by 25%, from 63.6% to 47.7% - CE = $16,031

- Increase the number who receive treatment by 25%, from 63.6% to 79.5% - CE = $10,465
- Reduce the proportion receiving treatment for whom the treatment is effective from 62% to 52% - CE = $14,966
- Increase the proportion receiving treatment for whom the treatment is effective from 62% to 71% - CE = $10,961

Summary of CE – Females Only

Based on these assumptions, the CE associated with screening for, and treatment of, anxiety in female children and adolescents aged 8 to 18 years of age is $9,957 per QALY (Table 13, row *w*).

We also modified several major assumptions and recalculated the cost per QALY as follows:

- Reduce the estimated actual rates of anxiety disorders by a third, from 29.0% to 19.3% - CE = $13,165
- Reduce the QoL values by 25% - **CE = $13,276**
- Increase the QoL values by 25% - **CE = $7,965**
- Reduce the number who receive treatment by 25%, from 63.6% to 47.7% - CE = $12,553
- Increase the number who receive treatment by 25%, from 63.6% to 79.5% - CE = $8,399
- Reduce the proportion receiving treatment for whom the treatment is effective from 62% to 52% - CE = $11,871
- Increase the proportion receiving treatment for whom the treatment is effective from 62% to 71% - CE = $8,695

Summary of CE – Males Only

Based on these assumptions, the CE associated with screening for, and treatment of, anxiety in male children and adolescents aged 8 to 18 years of age is $19,125 per QALY (Table 13, row *y*).

We also modified several major assumptions and recalculated the cost per QALY as follows:

- Reduce the estimated actual rates of anxiety disorders by a third, from 13.0% to 8.3% - **CE = $28,498**
- Reduce the QoL values by 25% - CE = $25,500
- Increase the QoL values by 25% - **CE = $15,300**
- Reduce the number who receive treatment by 25%, from 63.6% to 47.7% - CE = $24,836
- Increase the number who receive treatment by 25%, from 63.6% to 79.5% - CE = $15,698
- Reduce the proportion receiving treatment for whom the treatment is effective from 62% to 52% - CE = $22,803
- Increase the proportion receiving treatment for whom the treatment is effective from 62% to 71% - CE = $16,700

Summary

Males and Females

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening for, and treatment of, anxiety in children and adolescents aged 8 to 18 years of age in a British Columbia birth cohort of 40,000 is estimated to be 2,962 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $12,552 per QALY (see Table 14).

Table 14: Screening for and Treatment of Anxiety in Children and Youth

In a B.C. Birth Cohort of 40,000

Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
1.5% Discount Rate	**2,962**	**1,835**	**3,702**
3% Discount Rate	2,707	1,687	3,384
0% Discount Rate	3,247	2,001	4,058
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$12,552**	**$10,042**	**$17,228**
3% Discount Rate	$12,921	$10,337	$17,629
0% Discount Rate	$12,200	$9,760	$16,844
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	**$5,603**	**$4,482**	**$7,006**
3% Discount Rate	$5,790	$4,632	$7,207
0% Discount Rate	$5,425	$4,340	$6,814

Females Only

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening for, and treatment of, anxiety in female children and adolescents aged 8 to 18 years of age in a British Columbia birth cohort of 40,000 is estimated to be 2,123 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $9,957 per QALY (see Table 15).

Table 15: Screening for and Treatment of Anxiety in Children and Youth
In a B.C. Birth Cohort of 40,000
Summary - Females Only

	Base Case	Range	
CPB (Potential QALYs Gained)			
1.5% Discount Rate	**2,123**	**1,349**	**2,654**
3% Discount Rate	1,938	1,237	2,422
0% Discount Rate	2,331	1,474	2,913
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$9,957**	**$7,965**	**$13,276**
3% Discount Rate	$10,260	$8,208	$13,680
0% Discount Rate	$9,667	$7,734	$12,890
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	**$4,555**	**$3,644**	**$6,074**
3% Discount Rate	$4,710	$3,768	$6,279
0% Discount Rate	$4,408	$3,526	$5,877

Males Only

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening for, and treatment of, anxiety in male children and adolescents aged 8 to 18 years of age in a British Columbia birth cohort of 40,000 is estimated to be 839 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $19,125 per QALY (see Table 16).

Table 16: Screening for and Treatment of Anxiety in Children and Youth
In a B.C. Birth Cohort of 40,000
Summary - Males Only

	Base Case	Range	
CPB (Potential QALYs Gained)			
1.5% Discount Rate	**839**	**486**	**1,048**
3% Discount Rate	769	450	962
0% Discount Rate	916	526	1,145
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$19,125**	**$15,300**	**$28,498**
3% Discount Rate	$19,624	$15,699	$28,971
0% Discount Rate	$18,646	$14,917	$28,041
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	**$8,256**	**$6,605**	**$11,079**
3% Discount Rate	$8,510	$6,808	$11,334
0% Discount Rate	$8,012	$6,410	$10,833

Behavioural Counselling Interventions

Growth Monitoring and Healthy Weight Management in Children and Youth

United States Preventive Services Task Force Recommendations (2017)[200]

Approximately 17% of children and adolescents aged 2 to 19 years in the United States have obesity, and almost 32% of children and adolescents are overweight or have obesity. Obesity in children and adolescents is associated with morbidity such as mental health and psychological issues, asthma, obstructive sleep apnea, orthopedic problems, and adverse cardiovascular and metabolic outcomes (e.g., high blood pressure, abnormal lipid levels, and insulin resistance). Children and adolescents may also experience teasing and bullying behaviors based on their weight. Obesity in childhood and adolescence may continue into adulthood and lead to adverse cardiovascular outcomes or other obesity-related morbidity, such as type 2 diabetes.

The USPSTF recommends that clinicians screen for obesity in children and adolescents 6 years and older and offer or refer them to comprehensive, intensive behavioral interventions to promote improvements in weight status. (Grade B recommendation)

Canadian Task Force on Preventive Health Care (2015)[201]

We recommend growth monitoring[202] at all appropriate[203] primary care visits using the 2014 WHO Growth Charts for Canada. (Strong recommendation; very low quality evidence)

This growth monitoring recommendation applies to all children and youth 0–17 years of age who present to primary care.

For children and youth aged 2 to 17 years who are overweight or obese, we recommend that primary care practitioners offer or refer to structured behavioural interventions[204] aimed at healthy weight management. (Weak recommendation; moderate quality evidence)

These management recommendations apply to children and youth 2–17 years of age who are overweight or obese. Children and youth with health conditions where weight management is inappropriate are excluded.

The CTFPHC concludes that "the most effective behavioural interventions were those that were delivered by a specialized interdisciplinary team, involved group sessions, and

[200] US Preventive Services Task Force. Screening for obesity in children and adolescents: US Preventive Services Task Force Recommendation Statement. *Journal of American Medical Association*. 2017; 317(23): 2417-26.
[201] Canadian Task Force on Preventive Health Care. Recommendations for growth monitoring, and prevention and management of overweight and obesity in children and youth in primary care. *Canadian Medical Association Journal*. 2015; 187(6): 411-21.
[202] **Growth monitoring** consists of measurement of height or length, weight and BMI calculation or weight for length according to age.
[203] **Appropriate primary care visits** include scheduled health supervision visits, visits for immunizations or medication renewal, episodic care or acute illness, and other visits where the primary care practitioner deems it appropriate. Primary care visits are completed at primary health care settings, including those outside of a physician's office (e.g. public health nurses carrying out a well-child visit at a community setting).
[204] **Structured interventions** are behavioural modification programs that involve several sessions that take place over weeks to months, follow a comprehensive-approach delivered by a specialized inter-disciplinary team, involve group sessions, and incorporate family and parent involvement. Behaviourally-based interventions may focus on diet, increasing exercise, making lifestyle changes, or any combination of these. These can be delivered by a primary health care team in the office or through a referral to a formal program within or outside of primary care, such as hospital-based, school-based or community programs.

incorporated family and parent involvement". Furthermore, "where structured behavioural interventions for weight management in children and youth are not yet available in Canada, primary care practitioners and policy makers should consider their development a priority."[205]

Best in the World

- Research evidence suggests that growth monitoring in children and youth is, at best, inconsistent in paediatric practice. Dorsey et al. found that BMI was documented in only 3 of 600 (0.5%) charts they reviewed. Of the 239 children/youth at risk of being overweight or obese, 41 (17%) had documented treatment recommendations, usually consisting of general advice regarding diet and exercise.[206]
- Barlow and colleagues noted that only 6.1% of charts they reviewed contained a plot of BMI. They conclude, however, that "despite low BMI curve use, paediatricians recognized most overweight/obese children with a BMI at or above the 95th percentile. BMI plotting may increase recognition in mildly overweight children." [207]
- Based on self-report, an estimated 11% of Community Paediatricians and 7% of Family Physicians across Canada routinely assess their paediatric patients for obesity. Furthermore, only 60% of Community Paediatricians and 30% of Family Physicians across Canada use recommended methods for identifying paediatric obesity.[208]
- Based on a review of medical records in the US, only 5.5% of physicians documented BMI and 4.3% plotted BMI. Residents were more likely to document (13.0% vs 3.0%) and plot (9.0% vs 2.7%) BMI than attending physicians.[209]
- For the purposes of this project, we have assumed that documented growth monitoring in children and youth of 13% are equivalent to the best in the world (based on rates observed for US physician residents[210]).
- Estimating the best in the world rate for the proportion of children with obesity who have been referred to a comprehensive, intensive behavioral intervention is challenging. In the UK, MEND has been implemented on a national scale since 2007.[211] Between 2007 and 2010, 21,132 families were referred to MEND 7-13 in that country.[212,213] We were unable to find more recent estimates. In 2016, there were

[205] Canadian Task Force on Preventive Health Care. Recommendations for growth monitoring, and prevention and management of overweight and obesity in children and youth in primary care. *Canadian Medical Association Journal*. 2015; 187(6): 411-21.
[206] Dorsey KB, Wells C, Krumholz HM et al. Diagnosis, evaluation, and treatment of childhood obesity in pediatric practice. *Archives of Pediatrics & Adolescent Medicine*. 2005; 159(7): 632-8.
[207] Barlow SE, Bobra SR, Elliott MB et al. Recognition of childhood overweight during health supervision visits: Does BMI help pediatricians? *Obesity*. 2007; 15(1): 225-32.
[208] He M, Piché L, Clarson CL et al. Childhood overweight and obesity management: A national perspective of primary health care providers' views, practices, perceived barriers and needs. *Paediatrics & Child Health*. 2010; 15(7): 419-26.
[209] Hillman JB, Corathers SD and Wilson SE. Pediatricians and screening for obesity with body mass index: Does level of training matter? *Public Health Reports*. 2009; 124(4): 561-7.
[210] Hillman JB, Corathers SD and Wilson SE. Pediatricians and screening for obesity with body mass index: Does level of training matter? *Public Health Reports*. 2009; 124(4): 561-7.
[211] Aicken C, Roberts H and Arai L. Mapping service activity: The example of childhood obesity schemes in England. *BioMed Central Public Health*. 2010; 10(1): 310.
[212] Fagg J, Chadwick P, Cole T et al. From trial to population: A study of a family-based community intervention for childhood overweight implemented at scale. *International Journal of Obesity*. 2014; 38(10): 1343-49.
[213] Fagg J, Cole T, Cummins S et al. After the RCT: Who comes to a family-based intervention for childhood overweight and obesity when it is implemented at scale in the community? *Journal of Epidemiology and Community Health*. 2015; 69: 142-8.

5,328,000 children ages 7-13 in the UK[214] with a 19% rate of obesity[215] (or 1,012,320 7-13 year-olds with obesity). The 21,132 families thus represents approximately 2.1% of children with obesity in the UK.

- In New South Wales, Australia, an estimated 8.2% of children ages 7-13 with obesity participated in the Go4Fun child obesity treatment program between 2009 and 2012.[216]
- In BC, approximately 0.8% of children/youth with obesity and their families began a structured behavioural intervention aimed at healthy weight management in a given year (see section on *Structured Interventions in BC* below).

- For the purposes of this project, we have assumed that a cumulative (over 12 years) program start rate of approximately 9.8% of children/youth with obesity to a comprehensive, intensive behavioral intervention, as observed in BC, is equivalent to the best rate in the world.

Structured Interventions in BC

A number of organizations, including the BC Ministry of Health, the Childhood Obesity Foundation and Child Health BC, have worked diligently during the last decade and a half in developing a "comprehensive approach including promotion, prevention and intervention for children and teens who are departing from a healthy weight trajectory."[217] Structured interventions that have been implemented in the province include 1) Shapedown BC, 2) Mind, Exercise, Nutrition, Do It! (MEND) (which was replaced by Generation Health), and 3) HealthLinkBC Eating and Activity Program for Kids (HEAPK). There are numerous additional healthy lifestyle resources available in BC (including Canadian online resources), such as Live 5-2-1-0, Aim2Be and Kidsport BC.[218]

Shapedown BC

- The Shapedown BC intervention was funded through ActNow in 2006, at which time it was the only available intervention for BC children and youth with obesity. Shapedown BC is a "multidisciplinary weight management program that provides medical, nutritional, and psychological support for children and youth aged 6-17 years who are working with their families to recognize and overcome challenges to active living and healthy eating."[219] The intervention consists of 10 weekly group sessions lasting 2 hours with each session including 10-12 families. Children and their families are eligible for referral if the child/adolescent is obese (BMI > 97%ile) or overweight (BMI >85%ile) with at least one co-morbidity (e.g. impaired glucose

[214] Fagg J, Chadwick P, Cole T et al. From trial to population: A study of a family-based community intervention for childhood overweight implemented at scale. *International Journal of Obesity*. 2014; 38(10): 1343-49.
[215] Arai L, Panca M, Morris S et al. Time, monetary and other costs of participation in family-based child weight management interventions: Qualitative and systematic review evidence. *PloS ONE*. 2015; 10(4): 1-12.
[216] Welsby D, Nguyen B, O-Hara B et al. Process evaluation of an up-scaled community based child obesity treatment program. *BMC Public Health*. 2014; 14: 140.
[217] Childhood Obesity Foundation. *Childhood Healthy Weights Intervention Initiative: Our Journey*. March 2014. Available online at https://childhoodobesityfoundation.ca/wp-content/uploads/2015/02/COF_CHWII_Our_Journey_Mar_2014_FINAL1.pdf. Accessed July 2020.
[218] BC Children's Hospital. Endocrinology & Diabetes Unit. *Lifestyle Intervention Programs in BC.* 2020. Available at http://www.bcchildrens.ca/endocrinology-diabetes-site/documents/lifestylebc.pdf. Accessed October 2020.
[219] Bradbury J, Day M, & Scarr J. *British Columbia's Continuum for the Prevention, Management, and Treatment of Health Issues Related to Overweight and Obesity in Children and Youth, BC*. Childhood Obesity Foundation & Child Health BC. October 2015. Available online at http://childhoodobesityfoundation.ca/wp-content/uploads/2016/07/ChildhoodObesity_report_webMRsingle_fnl-1.pdf. Accessed July 2020.

fasting, dyslipidemia, hypertension, obstructive sleep apnea). A medical referral is required.[220]

- Of the original 214 referrals between March of 2007 and March of 2009, 144 were invited to participate and 119 attended the first session while 39 completed all 10 sessions.[221]
- In 2012, the Ministry of Health entered into a partnership with the Childhood Obesity Foundation (COF) to expand the Shapedown BC program model to all health authorities over a two year period. By March of 2015, a program had been established in each health authority, although the program in Northern Health closed in January of 2015.[222]
- During the 2.5 year time period between January of 2013 and June of 2015, a total of 1,071 referrals were made. Of the 1,071 referrals, 446 were invited to participate and 395 attended the first session while 292 completed at least 7 of the group sessions.[223]
- Additional information for the fiscal years from 2015/16 through 2019/20 is summarized in Table 1.[224,225] On average, 40% of referrals are invited to participate. Prior to this invitation, each potential participant goes through an initial primary screening process and then a comprehensive four hour multi-disciplinary intake review. Of those invited to participate, 79% begin the program and of those who begin the program, 74% complete at least 7 of the 10 sessions.
- Individual counselling sessions are offered for the families throughout the process and until the youth turns 18 (see Table 1). These sessions include a post-group debrief and may include a session(s) during the group process to convince a child/youth to stay with the process.

[220] Panagiotopoulos C, Ronsley R, Al-Dubayee M et al. The Centre for Healthy Weights—Shapedown BC: A family-centered, multidisciplinary program that reduces weight gain in obese children over the short-term. *International Journal of Environmental Research and Public Health*. 2011; 8(12): 4662-78.
[221] Panagiotopoulos C, Ronsley R, Al-Dubayee M et al. The Centre for Healthy Weights—Shapedown BC: A family-centered, multidisciplinary program that reduces weight gain in obese children over the short-term. *International Journal of Environmental Research and Public Health*. 2011; 8(12): 4662-78.
[222] Centre for Healthy Weights - Shapedown BC. *Provincial Management and Evaluation Report Cycles I – VII: January 2013 – June 2015*. September 2015.
[223] Centre for Healthy Weights - Shapedown BC. *Provincial Management and Evaluation Report Cycles I – VII: January 2013 – June 2015*. September 2015.
[224] Centre for Healthy Weights - Shapedown BC. *Provincial Management and Evaluation Report: March 31, 2015 – April 1, 2016*.
[225] Arlene Cristall, Provincial Lead, The Centre for Healthy Weights – Shapedown BC. September 8, 2020. Personal communication.

Table 1: Shapedown BC

Trends in Program Referrals to Program Completion

	Time Period						
	Jan '13 to June '15	2015/16	2016/17	2017/18	2018/19	2019/20**	Total
Referrals	**1,071**	**556**	**557**	**623**	**729**	**637**	**4,173**
Invited to Participate	**446**	**288**	**250**	**238**	**262**	**204**	**1,688**
% of Referrals Invited to Participate	42%	52%	45%	38%	36%	32%	40%
Began Program	**395**	**230**	**201**	**195**	**207**	**104**	**1,332**
% of Invited to Participate Who Began Program	89%	80%	80%	82%	79%	51%	79%
Completed Program*	**292**	**143**	**170**	**162**	**159**	**59**	**985**
% Who Began Program Who Completed Program	74%	62%	85%	83%	77%	57%	74%
% of Referrals Who Completed Program	27%	26%	31%	26%	22%	9%	24%
Individual Counselling							
Families		79	102	121	77	95	474
Sessions		179	217	258	185	286	1,125
Sessions / Family		2.3	2.1	2.1	2.4	3.0	2.4

* Completed at least 7 of the 10 group sessions.

** The Covid pandemic began in March of 2020.

MEND / Generation Health

- Mind, Exercise, Nutrition, Do It! (MEND) is a community-based age-specific (MEND 5-7 and MEND 7-13) 10-week program delivered by trained leaders with recreation and /or health backgrounds. Children must have a BMI-for-age above the 85th percentile. Families self-refer to the program.[226]
- Between April 2013 and June 2014, 351 children and their families enrolled in 33 MEND 7-13 programs. Of the 351, a total of 329 began the program and 226 attended at least 70% of the sessions.[227]
- During the three months from April to June of 2014, 26 children and their families enrolled in 3 MEND 5-7 programs. Of the 26, a total of 25 began the program and 20 attended at least 70% of the sessions. The evaluation of the program noted that there were significant recruitment challenges for this age cohort.[228]

[226] Childhood Obesity Foundation. *Shifting the Destination by Shifting the Trajectory: Evaluation Report*. March 2015. Available online at https://childhoodobesityfoundation.ca/wp-content/uploads/2015/02/CHWII-Healthy-Weights-Evaluation-Full-Report.pdf. Accessed July 2020.

[227] Childhood Obesity Foundation. *Shifting the Destination by Shifting the Trajectory: Evaluation Report*. March 2015. Available online at https://childhoodobesityfoundation.ca/wp-content/uploads/2015/02/CHWII-Healthy-Weights-Evaluation-Full-Report.pdf. Accessed July 2020.

[228] Childhood Obesity Foundation. *Shifting the Destination by Shifting the Trajectory: Evaluation Report*. March 2015. Available online at https://childhoodobesityfoundation.ca/wp-content/uploads/2015/02/CHWII-Healthy-Weights-Evaluation-Full-Report.pdf. Accessed July 2020.

- Between September 2014 and June 2015, 246 children and their families enrolled in 27 MEND 7-13 programs. Of the 246, a total of 185 began the program. No information is provided on how many attended at least 70% of the sessions.[229]
- Between July 2015 and June 2016, 485 children and their families enrolled in 45 MEND 7-13 programs. During this phase, the BMI entry criteria were temporarily expanded to include children of a healthy weight, if a risk factor was present. Of the 485, however, a total of 304 began the program who had a BMI-for-age 85th percentile or above. No information is provided on how many attended at least 70% of the sessions.[230]

Table 2: MEND 5-7 and 7-13
Trends in Enrollment to Program Completion

	Program and Time Period				
	MEND 7-13 Apr '13 to June '14	**MEND 5-7** April '14 - June '14	**MEND 7-13** July '14 to June '15	**MEND 7-13** July '15 to June '16	Total
Enrolled in Program	**351**	**26**	**246**	**485**	**377**
Began Program	**329**	**25**	**185**	**304**	**354**
% of Enrolled in Program Who Began Program	94%	96%	75%	63%	94%
Completed Program*	**226**	**20**	**NA**	**NA**	**246**
% Who Began Program Who Completed Program	69%	80%			69%

* Completed at least 70% of the sessions.

Generation Health

- Between April of 2017 and February of 2018 the Childhood Obesity Foundation, the BC Ministry of Health and the University of Victoria initiated a planning and consultation phase to develop a community-based "made in BC" childhood healthy weights early intervention program for families with children between ages 8 and 12 who are above the 85th percentile for BMI-for-age. The program was designed between January and August of 2018 with an initial implementation between September 2018 and June 2019. Finally, the program, called Generation Health, was scaled up between September of 2019 and June of 2020.[231]
- The program uses a lifestyle behaviour approach to promoting healthy weights in children and youth with a focus on healthy eating habits, physical activity and a healthy body image. The program includes 10 weekly group sessions 1.5 to 2 hours long with a focus on "healthy eating and active living, goal setting, family mealtimes and family physical activity, sleep hygiene, healthy body image and self-compassion, as well as positive parenting." In addition, the program includes 10 weekly online

[229] Childhood Obesity Foundation. *MEND Scale-Up and Implementation Evaluation Report: 2014 – 2016.* January 2017.Available online at https://childhoodobesityfoundation.ca/wp-content/uploads/2015/02/COF-MEND-2014-16-Eval-Report-2017-FINAL.pdf. Accessed July 2020.
[230] Childhood Obesity Foundation. *MEND Scale-Up and Implementation Evaluation Report: 2014 – 2016.* January 2017.Available online at https://childhoodobesityfoundation.ca/wp-content/uploads/2015/02/COF-MEND-2014-16-Eval-Report-2017-FINAL.pdf. Accessed July 2020.
[231] Childhood Obesity Foundation. *Introducing …Generation Health*. Available online at https://generationhealth.ca/wp-content/uploads/2019/10/FHLP-BROCHURE-FINAL.pdf. Accessed July 2020.

sessions, 4 group activities as well as a maintenance phase during which program participants receive regular virtual check-ins.[232]

- Between October of 2018 and April of 2019, the program delivered two full 10-week program cycles at seven sites in the province (the prototype phase). During those two cycles, 88 children and their families enrolled in the programs, 66 began the program and 39 attended at least 70% of the sessions. [233]
- Between October of 2019 and April of 2020, the program delivered two full 10-week program cycles at eight sites in the province (the partial scale-up phase). During those two cycles, 117 children and their families enrolled in the programs, 80 began the program and 52 attended at least 70% of the sessions.[234]

Table 3: Generation Health (8 - 12 Years of Age)
Trends in Enrollment to Program Completion

	Time Period		
	Oct '18 to Apr '19	Oct '19 to Apr '20	Total
Enrolled in Program	**88**	**117**	**205**
Began Program	**63**	**80**	**143**
% of Enrolled in Program Who Began Program	72%	68%	70%
Completed Program*	**39**	**52**	**91**
% Who Began Program Who Completed Program	62%	65%	64%

* Completed at least 70% of the sessions.

HealthLinkBC Eating and Activity Program for Kids

- HealthLinkBC Eating and Activity Program for Kids (HEAPK) is a telephone-based intervention that includes 8 scheduled telephone calls with a pediatric registered dietitian and a qualified exercise professional. Calls take from 30-60 minutes each and focus on topics such as family mealtimes, healthy drink choices, increasing fun physical activities and reducing screen time.[235]
- Between 2014/15 and 2019/20, a total of 341 participants participated in at least one phone call with either the dietitian or the exercise professional. Between 2015/16 and 2018/19 (years with complete information), 306 participants began the program (an average of 77 per year) and 116 (38%) participated in at least four of the eight calls.[236]

[232] Childhood Obesity Foundation. *Generation Health*. Available online at https://childhoodobesityfoundation.ca/early-intervention-program-2/#toggle-id-7. Accessed July 2020.
[233] Childhood Obesity Foundation. *Family Healthy Living Program: Final Evaluation Report June 2019.*
[234] Childhood Obesity Foundation. *Generation Health: Evaluation Report June 2020*.
[235] Childhood Obesity Foundation. *HealthLinkBC Eating and Activity Program for Kids.* Available online at https://childhoodobesityfoundation.ca/healthlinkbc-eating-activity-program-kids/. Accessed July 2020.
[236] Margaret Yandel, Policy Lead, Office of the Provincial Dietitian. Personal Communication. June 2020.

Summary

- Combining the 2018/19 fiscal year data from Shapedown BC and Generation Health, a total of 270 (207 + 63) children and their families began a structured behavioural intervention aimed at healthy weight management. Of these 270 children and their families, 198 (159 + 39) attended at least 70% of the sessions. The 73% completion rate (198/270) is better than the 50-60% completion rate observed in similar programs in Australia[237] and the UK[238] (see below). Potential reasons for this include the enhanced screening upon referral and the inclusion of ono-on-one counselling throughout the group process provided by Shapedown BC. Consistent attendance is important in achieving the beneficial program outcomes.[239]
- During the three years from 2016/17 to 2018/19, Shapedown BC had a completion rate of 81% (Table 1).
- We did not use the more current 2019/20 data due to the potential effect of the Covid-19 pandemic (starting in March of 2020) on attendance and completion rates.
- Of 3,148 children / youth recruited between July 2009 and October of 2012 to the Go4Fun community-based child obesity treatment program in New South Wales, Australia, 336 (10.7%) did not attend any sessions, 2,812 (89.3%) attended one or more sessions and 1,520 (48.3%) completed ≥75% of sessions.[240] Poor program adherence is associated with a low level of parental literacy.[241]
- In the UK, of 18,289 children and their families referred to MEND 7-13 (Mind, Exercise, Nutrition…Do It!), 13,998 (76.5%) started the program and 8,311 (45.4% of 'referrals' and 59.4% of 'starters') attended at least 75% of the sessions.[242]
- In 2021, there were an estimated 33,878 children/youth ages 6 – 17 in BC with obesity (see Table 8 below). If we assume an approximate equal distribution by age, then there would be approximately 2,823 (33,878 / 12 years) children/youth in any given age group. Assuming a similar equal distribution in treated cases (22.5 in each age group), then approximately 0.8% in each age group begin treatment each year. Assuming that there are no individuals repeating the intervention in subsequent years, a cumulative 9.8% of the cohort of 2,823 6-year-olds that progress through 12 years of intervention opportunity (until they are 17) will have started a treatment program. With a completion rate of 73.3%, 7.2% of BC children/youth with obesity would receive the full benefits of a structured behavioural intervention aimed at healthy weight management in a given year.

[237] Hardy L, Mihrshahi S, Gale J et al. Translational research: Are community-based child obesity treatment programs scalable? *BMC Public Health*. 2015; 15: 652.
[238] Fagg J, Cole T, Cummins S et al. After the RCT: Who comes to a family-based intervention for childhood overweight and obesity when it is implemented at scale in the community? *Journal of Epidemiology and Community Health*. 2015; 69: 142-8.
[239] Khanal S, Choi L, Innes-Hughes C et al. Dose response relationship between program attendance and children's outcomes in a community based weight management program for children and their families. *BMC Public Health*. 2019; 19: 716.
[240] Hardy L, Mihrshahi S, Gale J et al. Translational research: Are community-based child obesity treatment programs scalable? *BMC Public Health*. 2015; 15: 652.
[241] Khanal S, Choi L, Innes-Hughes C et al. Dose response relationship between program attendance and children's outcomes in a community based weight management program for children and their families. *BMC Public Health*. 2019; 19: 716.
[242] Fagg J, Cole T, Cummins S et al. After the RCT: Who comes to a family-based intervention for childhood overweight and obesity when it is implemented at scale in the community? *Journal of Epidemiology and Community Health*. 2015; 69: 142-8.

- The estimated coverage of 9.8% is higher than the 2.1% observed in the UK and the 8.2% in Australia (see section on *Best in the World* above). We model using a cumulative 9.8% of the cohort starting the intervention and 73.3% of those starting completing the intervention.

Modelling the Clinically Preventable Burden

In this section, we model CPB associated with growth monitoring in children and youth ages 0-17 and the offer of, or referral to, structured behavioural interventions aimed at healthy weight management for children and youth aged 2 to 17 years who are overweight or obese.

In modelling CPB, we made the following assumptions:

Defining the Population at Risk – Number of Children and Youth in BC

- There were 873,990 children and youth ages 0 – 17 living in BC in 2021 (Table 4).[243] The majority of these children and youth would be eligible for growth monitoring.
- There were 787,763 children and youth ages 2 – 17 living in BC in 2017 (Table 4). Children and youth ages 2 – 17 who are overweight or obese could be offered structured behavioural interventions aimed at healthy weight management.

Table 4: Number of Children and Youth
British Columbia, 2021 by Age and Sex

Age Group	Population
Males	
0 - 1	44,539
2 - 5	95,740
6 - 11	153,672
12 - 17	154,197
Subtotal - 0 to 17	**448,148**
Subtotal - 2 to 17	**403,609**
Females	
0 - 1	41,688
2 - 5	89,926
6 - 11	144,491
12 - 17	149,737
Subtotal - 0 to 17	**425,842**
Subtotal - 2 to 17	**384,154**
Total	
0 - 1	86,227
2 - 5	185,666
6 - 11	298,163
12 - 17	303,934
Total - 0 to 17	**873,990**
Total - 2 to 17	**787,763**

[243] BC Stats. *British Columbia Population Estimates*. Available online at https://bcstats.shinyapps.io/popApp/. Accessed March 2023.

- In adults, a BMI of between 25.0 kg/m^2 and 29.9 kg/m^2 is considered overweight and a BMI $\geq$ 30.0 kg/m^2 is considered obese. In children, however, median BMI changes dramatically with age, suggesting that an age-specific approach is required when estimating excess weight in children. [244] Three different organizations have attempted to address this by suggesting an approach to defining excess weight in children.
- In 2000, the Centres for Diseases Control (CDC) in the United States recommended that children/youth with a BMI at or above the 95th percentile on the current US growth curve be considered obese and that children/youth between the 85th and 95th percentile be considered overweight.
- Also in 2000, the International Obesity Task Force (IOTF) suggested an alternative approach, specifically designed for international comparisons. They recommended extrapolating the adult cut-points of 25 and 30 kg/m^2 backwards to sex- and age-specific cut-points for children and youth. Growth curves were generated from using large, nationally representative cross-sectional surveys from the US, Brazil, Great Britain, Hong Kong, the Netherlands and Singapore.
- In 2006 and 2007 the World Health Organization (WHO) suggested an approach which used ideal growth curves. Children/youth with a BMI of between one to two standard deviations (SD) above the mean would be considered overweight and those with a BMI greater than two SD above the mean considered obese. One SD approximates the 84th percentile while two SD approximates the 97.7th percentile.[245]
- The approach used matters. In a comparison of the three approaches applied to Canadian children / youth ages 2-17 using measured height and weight from 2004, the WHO approach yielded an overall prevalence of excess weight of 34.7%, the CDC approach 28.4% and the IOTF approach 26.2%.[246]

- We use IOTF cut-offs in our modelling. Where WHO cut-offs have been used in the source data, we have scaled these to estimate excess weight based on IOTF cut-offs.

- Ideally, excess weight should be calculated based on measured, rather than self-reported, height and weight. Unfortunately, data using measured height and weight is collected less frequently due to the additional costs involved.
- We estimated the prevalence of overweight and obesity in BC children as follows:
    - **For 2 – 5 year-olds**: The proportion of 2-5 years olds with overweight and obesity, based on measured height and weight, is available in Canada for 2004 based on IOTF cut-offs (overweight – males 13.1%, females 17.3%; obese – males 6.3%, females 6.4%).[247] Excess weight rates in Canadian children have remained relatively stable since the early 2000s.[248,249] Absent more recent

[244] Cole TJ, Bellizzi MC, Flegal KM et al. Establishing a standard definition for child overweight and obesity worldwide: international survey. *British Medical Journal.* 2000; 320(7244): 1240-45.
[245] Note that only 0-2 year-old children have WHO longitudinal data; 2-5 year-old data is mostly cross-sectional from six countries and data thereafter have been added by the WHO using modified CDC data from older US studies.
[246] Shields M and Tremblay MS. Canadian childhood obesity estimates based on WHO, IOTF and CDC cut-points. *International Journal of Pediatric Obesity*. 2010; 5(3): 265-73.
[247] Statistics Canada. *Measured Obesity. Overweight Canadian Children and Adolescents*. 2005. Available at https://www150.statcan.gc.ca/n1/pub/82-620-m/2005001/pdf/4193660-eng.pdf. Accessed May 2020.
[248] Rokholm B, Baker J, Sorensen T. The levelling off of the obesity epidemic since the year 1999: A review of evidence and perspectives. *Obesity Reviews.* 2010; 11: 835-46.
[249] Jaacks L, Vandevijvere S, Pan A et al. The obesity epidemic: Stages of the global epidemic. *The Lancet Diabetes and Endocrinology*. 2019; 7: 231-40.

measured data for Canada or BC, we use measured 2004 Canadian data and assume that the excess weight rates in this age group have continued to remain stable to the present.

- **For 6 – 17 year-olds**: The prevalence of excess weight, based on measured height and weight, is available in Canada for children ages 5-11 and 12-17 for 2011, 2013, 2015 and 2017 (see Table 5).[250]
  - The prevalence in Table 3 is based on WHO cut-offs. We adjusted this WHO-based prevalence to IOTF-based prevalence using data from Shields and Tremblay (see Table 6).[251]
  - On average, rates of excess weight in BC are lower than the Canadian average.[252] To adjust from Canadian to BC estimates, we used the most recent five years of excess weight prevalence data in the H. Krueger & Associates Inc. risk factor model[253,254,255] for Canada and BC. We compared rates of overweight and obesity in both jurisdictions for children and youth ages 5 – 17 and calculated a 5-year average ratio between Canadian and BC prevalence rates by sex and excess weight class (see Table 7). These ratios were then applied to the current Canadian prevalence data to estimate BC prevalence rates by sex and excess weight class.
  - Based on these adjustments, the rate of *overweight* in BC males/females ages 2-5 was reduced from 13.1% / 17.3% to 12.3% / 16.2% and the rate of *obesity* in BC males/females ages 2-5 was reduced 6.3% / 6.4% to 5.5% / 4.4% (see Table 8).

[250] Statistics Canada. *Overweight and obesity based on measured body mass index, by age group and sex*. Available at https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=1310037301#timeframe. Accessed June 2020.
[251] Shields M and Tremblay MS. Canadian childhood obesity estimates based on WHO, IOTF and CDC cut-points. *International Journal of Pediatric Obesity*. 2010; 5(3): 265-73.
[252] Krueger H, Krueger J, Koot J. Variation across Canada in the economic burden attributable to excess weight, tobacco smoking and physical inactivity. *Canadian Journal of Public Health*. 2015; 106(4): e171-77.
[253] Krueger H, Williams D, Ready A et al. Improved estimation of the health and economic burden of chronic disease risk factors in Manitoba, Canada. *Chronic Diseases and Injuries in Canada*. 2013; 33(4): 236-246.
[254] Krueger H, Krueger J, Koot J. Variation across Canada in the economic burden attributable to excess weight, tobacco smoking and physical inactivity. *Canadian Journal of Public Health*. 2015; 106(4): e171-77.
[255] Krueger H, Koot J, Andres E. The economic benefits of fruit and vegetable consumption in Canada. *Canadian Journal of Public Health*. 2017; 108(2): e152-61.

Table 5: Prevalence of Measured Excess Weight in Canada, 2011 - 2017

Ages 5 - 17

Overweight

		2011			2013			2015			2017		
			95% Confidence Interval			95% Confidence Interval			95% Confidence Interval			95% Confidence Interval	
	Age Group	Prevalence	Low	High	Prevalence	Low	High	Prevalence	Low	High	Prevalence	Low	High
Males	5 - 11	19.7%	14.8%	25.8%	14.1%	10.9%	18.0%	13.7%	9.2%	20.0%	15.8%	13.2%	18.8%
	12 - 17	19.0%	12.6%	27.6%	23.4%	17.8%	30.2%	21.2%	16.9%	26.3%	15.5%	9.2%	25.1%
	All (5 - 17)	**19.3%**	**15.1%**	**24.4%**	**18.7%**	**15.4%**	**22.5%**	**17.2%**	**14.2%**	**20.6%**	**15.7%**	**12.4%**	**19.7%**
Females	5 - 11	19.3%	15.8%	23.3%	19.4%	14.1%	26.2%	15.0%	11.0%	20.2%	21.3%	17.5%	25.7%
	12 - 17	20.9%	14.8%	28.6%	17.6%	10.7%	27.5%	18.9%	13.4%	26.0%	20.6%	14.5%	28.4%
	All (5 - 17)	**20.1%**	**15.6%**	**25.4%**	**18.5%**	**13.0%**	**25.6%**	**16.9%**	**14.5%**	**19.6%**	**21.0%**	**16.8%**	**25.9%**
Both sexes	5 - 11	19.5%	16.2%	23.2%	16.7%	13.4%	20.6%	14.3%	11.2%	18.1%	18.5%	15.7%	21.7%
	12 - 17	19.9%	15.0%	25.9%	20.6%	16.7%	25.0%	20.1%	16.9%	23.7%	18.1%	14.7%	22.0%
	All (5 - 17)	**19.7%**	**16.5%**	**23.3%**	**18.6%**	**15.9%**	**21.7%**	**17.0%**	**15.3%**	**18.9%**	**18.3%**	**16.3%**	**20.6%**

Obese

		2011			2013			2015			2017		
			95% Confidence Interval			95% Confidence Interval			95% Confidence Interval			95% Confidence Interval	
	Age Group	Prevalence	Low	High	Prevalence	Low	High	Prevalence	Low	High	Prevalence	Low	High
Males	5 - 11	19.6%	15.6%	24.3%	8.4%	4.8%	14.1%	13.9%	10.3%	18.7%	11.5%	6.8%	19.0%
	12 - 17	10.7%	7.5%	14.9%	21.0%	12.6%	33.0%	15.3%	10.4%	22.0%	12.6%	8.7%	17.9%
	All (5 - 17)	**15.1%**	**12.6%**	**17.9%**	**14.6%**	**10.2%**	**20.4%**	**14.6%**	**11.5%**	**18.4%**	**12.0%**	**9.2%**	**15.5%**
Females	5 - 11	6.3%	4.1%	9.7%	9.4%	6.7%	13.0%	10.6%	7.3%	15.3%	7.6%	5.5%	10.3%
	12 - 17	9.6%	6.0%	15.2%	11.7%	8.7%	15.6%	12.1%	7.1%	19.9%	10.9%	7.7%	15.3%
	All (5 - 17)	**8.0%**	**5.7%**	**11.1%**	**10.5%**	**8.1%**	**13.5%**	**11.4%**	**7.5%**	**16.9%**	**9.1%**	**7.4%**	**11.1%**
Both sexes	5 - 11	13.2%	10.5%	16.4%	8.9%	6.6%	11.7%	12.4%	9.2%	16.4%	9.6%	6.7%	13.5%
	12 - 17	10.2%	7.3%	14.1%	16.5%	11.7%	22.9%	13.8%	10.5%	17.9%	11.8%	8.9%	15.4%
	All (5 - 17)	**11.7%**	**9.9%**	**13.7%**	**12.6%**	**10.0%**	**15.8%**	**13.0%**	**10.1%**	**16.6%**	**10.6%**	**8.7%**	**12.7%**

Table 6: Prevalence of Measured Excess Weight in Canada 2017

Adjusted to IOTF Cut-offs

Ages 5 - 17

Overweight

		WHO (Base)			IOTF		
			95% Confidence Interval			95% Confidence Interval	
	Age Group	Prevalence	Low	High	Prevalence	Low	High
Males	5 - 11	15.8%	13.2%	18.8%	11.4%	9.5%	13.6%
	12 - 17	15.5%	9.2%	25.1%	15.0%	8.9%	24.3%
	All (5 - 17)	**15.7%**	**12.4%**	**19.7%**	-	-	-
Females	5 - 11	21.3%	17.5%	25.7%	19.1%	15.7%	23.0%
	12 - 17	20.6%	14.5%	28.4%	19.3%	13.6%	26.7%
	All (5 - 17)	**21.0%**	**16.8%**	**25.9%**	-	-	-

Obese

		WHO (Base)			IOTF		
			95% Confidence Interval			95% Confidence Interval	
	Age Group	Prevalence	Low	High	Prevalence	Low	High
Males	5 - 11	11.5%	6.8%	19.0%	6.1%	3.6%	10.0%
	12 - 17	12.6%	8.7%	17.9%	9.3%	6.4%	13.2%
	All (5 - 17)	**12.0%**	**9.2%**	**15.5%**	-	-	-
Females	5 - 11	7.6%	5.5%	10.3%	4.6%	3.3%	6.2%
	12 - 17	10.9%	7.7%	15.3%	8.6%	6.1%	12.0%
	All (5 - 17)	**9.1%**	**7.4%**	**11.1%**	-	-	-

Table 7: Prevalence of Measured Excess Weight in Canada and BC IOTF Cut-offs, 2017 Ages 5 - 17					
		Canada		BC	
	Age Group	Overweight	Obese	Overweight	Obese
Males	5 - 11	11.4%	6.1%	10.7%	5.3%
	12 - 17	15.0%	9.3%	14.1%	8.1%
Females	5 - 11	19.1%	4.6%	17.8%	3.1%
	12 - 17	19.3%	8.6%	18.1%	5.9%

- In 2021, an estimated 160,438 children and youth ages 2-17 in BC had excess weight, with 43,072 having obesity (see Table 8). The 33,878 children and youth ages 6 – 17 with obesity are most likely to be offered structured behavioural interventions aimed at healthy weight management.

Table 8: Number of Children and Youth with Excess Weight
British Columbia, 2021 by Age and Sex

		Percent			Number		
Age Group	**Population**	Overweight	Obese	Excess Weight	Overweight	Obese	Excess Weight
Males							
2 - 5	95,740	12.3%	5.5%	**17.8%**	11,763	5,260	**17,023**
6 - 11	153,672	10.7%	5.3%	**16.0%**	16,446	8,136	**24,582**
12 - 17	154,197	14.1%	8.1%	**22.1%**	21,699	12,455	**34,154**
Subtotal - 2 to 17	**403,609**	**12.4%**	**6.4%**	**18.8%**	**49,908**	**25,851**	**75,759**
Females							
2 - 5	89,926	16.2%	4.4%	**20.6%**	14,562	3,934	**18,496**
6 - 11	144,491	17.8%	3.1%	**21.0%**	25,790	4,504	**30,294**
12 - 17	149,737	18.1%	5.9%	**24.0%**	27,105	8,783	**35,889**
Subtotal - 2 to 17	**384,154**	**17.6%**	**4.5%**	**22.0%**	**67,458**	**17,221**	**84,679**
Total							
2 - 5	185,666	14.2%	5.0%	**19.1%**	26,325	9,194	**35,519**
6 - 11	298,163	14.2%	4.2%	**18.4%**	42,236	12,640	**54,877**
12 - 17	303,934	16.1%	7.0%	**23.0%**	48,805	21,238	**70,042**
Total - 2 to 17	**787,763**	14.9%	5.5%	**20.4%**	**117,366**	**43,072**	**160,438**

Excess Weight in Childhood and Youth as a Predictor of Excess Weight in Adulthood

- Evidence suggests that excess weight in children/youth often persists into adulthood. The USPSTF recommendation statement references a systematic review and meta-analysis by Simmonds and colleagues which found that obese children had a relative risk of obesity as adults of 5.21 (95% CI, 4.50 - 6.02) and that 70% of obese youth will still be obese after 30 years of age.[256,257]

[256] Simmonds M, Llewellyn A, Owen C et al. Predicting adult obesity from childhood obesity: a systematic review and meta-analysis. *Obesity reviews*. 2016; 17(2): 95-107.
[257] Grossman DC, Bibbins-Domingo K, Curry SJ et al. Screening for obesity in children and adolescents: US Preventive Services Task Force recommendation statement. *Journal of the American Medical Association*. 2017; 317(23): 2417-26.

- For modelling purposes, we assumed that there would be a linear change in obesity from age 17 to age 30, and that at 30 years of age, 70% of obese 17-year-olds would continue to be obese. We assumed no further transitions between weight classes for the original group of 17 year-olds with excess weight after age 30.

Calculating Life Years Lost

- Obesity *reduces an individual's longevity*.[258,259]
- Di Angelantonio and colleagues published a study assessing the relationship between excess weight and all-cause mortality based on a meta-analysis of 239 prospective studies from four continents.[260] Based on strict inclusion criteria (the study analyses excluded the first 5 years of follow-up and was restricted to never-smokers without pre-existing chronic disease), males who are overweight (BMI of 25 to <30), obese class I (BMI of 30 to <35), obese class II (BMI of 35 to < 40) or obese class III (BMI of ≥40) have a 12%, 70%, 168% and 324%, respectively, increased risk of premature mortality, compared with males of a healthy weight. Females who are overweight, obese class I, obese class II or obese class III have an 8%, 37%, 86% and 173%, respectively, increased risk of premature mortality, compared with females of a healthy weight.
- Research by Fontaine and colleagues suggests that the number of life years lost by the US white population ages 20-29 increases with increasing levels of excess weight, from 0.6 (0.8 for males and 0.4 for females) years for overweight, 1.9 years (2.2 for males and 1.6 for females) for obese class I and 3.8 years (4.2 for males and 3.4 for females) for obese class II.[261]
- In Australia, compared with normal weight females age 20-29, females age 20-29 who are overweight would live 3.6 fewer years, females with class I obesity would live 6.1 fewer years and females with class II/III obesity would live 7.7 fewer years. Compared with normal weight males age 20-29, males age 20-29 who are overweight would live 4.2 fewer years, males with class I obesity would live 8.3 fewer years and males with class II/III obesity would live 10.5 fewer years.[262]
- Not all research studies have found this association. Research by Steensma et al in Canada found that life expectancy was *significantly longer* for both males and females with overweight compared with their normal weight colleagues.[263] This so-called "obesity paradox" found in a number of studies may be at least partially due to using self-reported height and weight in calculating BMI, the imperfect nature of

[258] Peeters A, Barendregt JJ, Willekens F et al. Obesity in adulthood and its consequences for life expectancy: a life-table analysis. *Annals of Internal Medicine*. 2003; 138(1): 24-32.
[259] Finkelstein EA, Brown DS, Wrage LA et al. Individual and aggregate years-of-life-lost associated with overweight and obesity. *Obesity*. 2010; 18(2): 333-9.
[260] Di Angelantonio E, Bhupathiraju SN, Wormser D et al. Body-mass index and all-cause mortality: individual-participant-data meta-analysis of 239 prospective studies in four continents. *The Lancet*. 2016; 388(10046): 776-86. See etable 7 in the Supplementary Material.
[261] Fontaine K, Redden D, Wang C et al. Years of life lost due to obesity. *JAMA*. 2003; 289(2): 187-93.
[262] Lung T, Jan S, Tan E et al. Impact of overweight, obesity and severe obesity on life expectancy of Australian adults. *Epidemiology and Population Health*. 2019; 43: 782-9.
[263] Steensma C, Loukine L, Orpana H et al. Comparing life expectancy and health-adjusted life expectancy by body mass index category in adult Canadians: a descriptive study. *Population health metrics*. 2013; 11(1): 21.

BMI as a predictor of metabolic risk, confounding due to pre-existing diseases at baseline and inadequately controlling for tobacco use.[264,265]

- For modelling purposes we have assumed a mid-point in life years lost (LYL) between the US[266] and Australian estimates[267] and used the range in the sensitivity analysis.

  Obese class I males – 5.25 LYL (2.2 to 8.3)

  Obese class II/III males – 7.35 LYL (4.2 to 10.5)

  Obese class I females – 3.85 LYL (1.6 to 6.1)

  Obese class II/III females – 5.55 LYL (3.4 to 7.7)

- Based on 2011 data, Twells and colleagues found that 11.7% / 9.7% of males/females ages 18 and older in BC would be in obese class I, 2.7% / 2.5% in class II and 0.6% / 1.7% in class III.[268]

- We combine the sex-specific proportion of BC individuals in each weight class with the life years lost estimates from the US and Australia to determine a weighted average life years lost for an individual with obesity in BC (see Table 9). Males with obesity lose an average of 5.7 (2.6 to 8.8) years of life (see Table 13, row l) while females lose an average of 4.4 (2.1 to 6.6) years of life (see Table 13, row m). For modelling purposes, we reduce life years based on obesity status at 30 years old.

Table 9: Weighted Average Life Years Lost Due to Obesity

		Obesity Distribution in BC Population in 2011[1]	Proportion of Individuals with Obesity in each Class	Life Years Lost[2,3]			Weighted Average Life Years Lost for Individual with Obesity		
				Base	Low	High	Base	Low	High
Male	Class I	11.7%	78.0%	5.25	2.2	8.3			
	Class II	2.7%	18.0%	7.35	4.2	10.5	***5.7***	2.6	8.8
	Class III	0.6%	4.0%	7.35	4.2	10.5			
Female	Class I	9.7%	69.8%	3.85	1.6	6.1			
	Class II	2.5%	18.0%	5.55	3.4	7.7	***4.4***	2.1	6.6
	Class III	1.7%	12.2%	5.55	3.4	7.7			

[1] Twells et al. [2] Fontaine et al. [3] Lung et al.

[264] Di Angelantonio E, Bhupathiraju SN, Wormser D et al. Body-mass index and all-cause mortality: individual-participant-data meta-analysis of 239 prospective studies in four continents. *The Lancet*. 2016; 388(10046): 776-86. See etable 7 in the Supplementary Material.
[265] Chrysant S and Chrysant G. The single use of body mass index for the obesity paradox is misleading and should be used in conjunction with other obesity indices. *Postgraduate Medicine*. 2019; 131(2): 96–102.
[266] Fontaine K, Redden D, Wang C et al. Years of life lost due to obesity. *JAMA*. 2003; 289(2): 187-93.
[267] Lung T, Jan S, Tan E et al. Impact of overweight, obesity and severe obesity on life expectancy of Australian adults. *Epidemiology and Population Health*. 2019; 43: 782-9.
[268] Twells LK, Gregory DM, Reddigan J et al. Current and predicted prevalence of obesity in Canada: a trend analysis. *CMAJ Open.* 2014; 2(1): E18.

- Obesity also *reduces an individual's quality of life.*

In Children / Youth

- An Australian study used a community-based sample of 1,569 children (mean age of 10.4 years) to assess the effect of excess weight on QoL.[269] They found that QoL as identified by parents was reduced by 3.7% for overweight and 9.7% for obesity whereas QoL as identified by children was reduced by 1.5% for overweight and 8.1% for obesity.
- A further Australian study of 2,890 adolescents also assessed the effect of excess weight on QoL.[270] They found that overweight is associated with a disutility of 0.018 while obesity is associated with a disutility of 0.059. The disutility associated with overweight was only significant in girls (0.039) while the disutility associated with obesity was significant in both girls (0.084) and boys (0.041).
- Based on a meta-analysis of 11 studies with 13,210 study participants using the PedsQL index to assess QoL in children and youth, Ul-Haq and colleagues found a clear dose relationship between excess weight and QoL.[271] Overweight was associated with a reduction in the total PedsQL score of 1.43 (95% CI of 0.32 to 2.55) while obesity was associated with a reduction of 10.63 (95% CI of 7.24 to 14.03). This is based on the assessment being completed by the child/adolescent. If the parent completes the assessment, overweight was associated with a reduction in the total PedsQL score of 2.60 (95% CI of 1.19 to 4.00) while obesity was associated with a reduction of 18.87 (95% CI of 11.14 to 26.60).
- The relationship between excess weight and poor QoL is strengthened with increasing age through childhood and adolescence.[272]
- For the purposes of this project, we adjusted the PedsQL overall scores as identified by children/youth in the Ul-Haq et al study[273] to reflect Child Health Utility-9 Dimension (CHU-9D) scores.[274] The CHU-9D has been specifically developed for economic evaluations in children 5 years of age and older. The results suggest a change in utility associated with overweight and obesity of 0.003 (95% CI of 0.0 to 0.006) and 0.026 (95% CI of 0.017 to 0.036), respectively. We apply the QoL disutility of 0.026 (or 2.6%) (see Table 13, row e) associated with ***obesity***, but not overweight, to children and youth between the ages of 6 – 17.
- Based on a meta-analysis of 21 studies assessing paediatric obesity interventions, Steele et al found that weight loss is strongly and significantly associated with

[269] Williams J, Wake M, Hesketh K et al. Health-related quality of life of overweight and obese children. *JAMA*. 2005; 293(1): 70-6.
[270] Keating CL, Moodie ML, Richardson J et al. Utility-based quality of life of overweight and obese adolescents. *Value in Health*. 2011; 14(5): 752-8.
[271] Ul-Haq Z, Mackay D, Fenwick E et al. Meta-analysis of the association between Body Mass Index and Health-related Quality of Life among children and adolescents, assessed using the Pediatric Quality of Life Inventory Index. *The Journal of Pediatrics*. 2013; 162(2): 280-6.
[272] Killedar A, Lung T, Petrou S et al. Weight status and health-related quality of life during childhood and adolescence: Effects of age and socioeconomic position. *Pediatrics.* 2020; 44: 637-45.
[273] Ul-Haq Z, Mackay D, Fenwick E et al. Meta-analysis of the association between Body Mass Index and Health-related Quality of Life among children and adolescents, assessed using the Pediatric Quality of Life Inventory Index. *The Journal of Pediatrics*. 2013; 162(2): 280-6.
[274] Lamb T, Frew E, Ives N et al. Mapping the Paediatric Quality of Life Inventory (PedQL™) generic core scales onto the Child Health Utility Index-9 Dimension (CHU-9D) score for economic evaluation in children. *PharmacoEconomics*. 2018; 36: 451-65.

increases in QoL ($R^2 = 0.87$). An estimated decrease of 1 BMI unit (approximately 5 pounds in a 10-year old) is required for a clinically significant change in QoL.[275]

In Adults

- A UK study used a community-based sample ≥ 16 years of age of 14,117 to assess the effect of excess weight on QoL.[276] They found a utility of -0.019 (95% CI of -0.026 to -0.011) associated with overweight (BMI of 25 to <30) compared to normal weight (BMI of 18.5 to <25) in their unadjusted model. After adjusting for age, sex, alcohol use, physical activity, fruit and vegetable consumption, smoking status, ethnicity, marital status, educational attainment, and income, however, this utility was no longer statistically significant (-0.005 with a 95% CI of -0.029 to 0.019). The utility associated with obesity class I & II (BMI of 30 to <40) and class III (BMI ≥40) remained significant after adjustment at -0.031 (95% CI of -0.020 to -0.041) and -0.105 (95% CI of -0.072 to -0.137) respectively. Table 10 shows the weighted disutility results based on the distribution of obesity classes in BC.[277]

Table 10: Weighted Average Disutility in Adults (16+) Due to Obesity

		Obesity Distribution in BC Population in 2011[1]	Proportion of Individuals with Obesity in each Class	Disutility[2]			Weighted Average Disutility for Individual with Obesity		
				Base	Low	High	Base	Low	High
Male	Class I	11.7%	78.0%	0.031	0.020	0.041	**0.034**	0.022	0.045
	Class II	2.7%	18.0%	0.031	0.020	0.041			
	Class III	0.6%	4.0%	0.105	0.070	0.137			
Female	Class I	9.7%	69.8%	0.031	0.020	0.041	**0.040**	0.026	0.053
	Class II	2.5%	18.0%	0.031	0.020	0.041			
	Class III	1.7%	12.2%	0.105	0.070	0.137			

[1] Twells et al. [2] Maheswaran et al.

- For modelling purposes, we assume a QoL disutility of 0.026 (0.017 to 0.036) in children and youth ages 6 – 17 with obesity and a QoL disutility of 0.034 (0.022 to 0.045) in males ages 18 and older with obesity (see Table 13, row f) and of 0.040 (0.026 to 0.053) in females ages 18 and older with obesity (see Table 13, row g).

- We combine life years, prevalence of obesity and reduction in quality of life to generate the current (in the absence of an intervention) burden of child / adolescent obesity in BC as shown in Table 11. Life years lived by the cohort is shown in the "Life Years" column(s). Males have a shorter life expectancy so the male column ends at 81 years of age compared with 85 for females. Life years lost due to obesity is reflected in the "Proportion Obese" column which ends at 75 and 81 years for males and females respectively.

- In the absence of an intervention, obesity in children and youth between the ages of 6 and 17 would result in a reduction of 4,908 QALYs (2,567 in males and 2,341 in females) due to a reduction in QoL associated with obesity (see Table 11 and Table 13, rows h & i).

[275] Steele R, Gayes L, Dalton III W et al. Change in health-related quality of life in the context of paediatric obesity interventions: A meta-analytic review. *Health Psychology*. 2016; 35(10): 1097-1109.
[276] Maheswaran H, Petrou S, Rees K et al. Estimating EQ-5D utility values for major health behavioural risk factors in England. *Journal of Epidemiology and Community Health*. 2013; 67(1): 172-80.
[277] Twells LK, Gregory DM, Reddigan J et al. Current and predicted prevalence of obesity in Canada: a trend analysis. *CMAJ Open.* 2014; 2(1): E18.

Table 11: Life Years Lived and QALYs Lost Living with Obesity

Age 6 - 85 in a BC Cohort of 40,000

	Life Years		Proportion Obese		Life Years Lived with Obesity		Quality of Life Reduction		QALYs Lost Due to Obesity	
Age	M	F	M	F	M	F	M	F	M	F
6	19,909	19,920	5.3%	3.1%	1,054	621	0.026	0.026	27	16
7	19,907	19,918	5.3%	3.1%	1,054	621	0.026	0.026	27	16
8	19,906	19,917	5.3%	3.1%	1,054	621	0.026	0.026	27	16
9	19,905	19,916	5.3%	3.1%	1,054	621	0.026	0.026	27	16
10	19,904	19,915	5.3%	3.1%	1,054	621	0.026	0.026	27	16
11	19,903	19,914	5.3%	3.1%	1,054	621	0.026	0.026	27	16
12	19,901	19,912	8.1%	5.9%	1,607	1,168	0.026	0.026	42	30
13	19,899	19,911	8.1%	5.9%	1,607	1,168	0.026	0.026	42	30
14	19,897	19,908	8.1%	5.9%	1,607	1,168	0.026	0.026	42	30
15	19,893	19,906	8.1%	5.9%	1,607	1,168	0.026	0.026	42	30
16	19,888	19,902	8.1%	5.9%	1,606	1,167	0.026	0.026	42	30
17	19,880	19,897	8.1%	5.9%	1,606	1,167	0.026	0.026	42	30
18	19,870	19,891	7.9%	5.7%	1,568	1,140	0.034	0.040	53	46
19	19,858	19,885	7.7%	5.6%	1,530	1,113	0.034	0.040	52	45
20	19,843	19,878	7.5%	5.5%	1,492	1,085	0.034	0.040	51	43
21	19,826	19,871	7.3%	5.3%	1,454	1,058	0.034	0.040	49	42
22	19,807	19,863	7.1%	5.2%	1,415	1,031	0.034	0.040	48	41
23	19,786	19,855	7.0%	5.1%	1,377	1,003	0.034	0.040	47	40
24	19,763	19,847	6.8%	4.9%	1,338	976	0.034	0.040	45	39
25	19,739	19,839	6.6%	4.8%	1,300	949	0.034	0.040	44	38
26	19,714	19,830	6.4%	4.6%	1,262	922	0.034	0.040	43	37
27	19,689	19,821	6.2%	4.5%	1,223	894	0.034	0.040	42	36
28	19,662	19,811	6.0%	4.4%	1,185	867	0.034	0.040	40	35
29	19,635	19,801	5.8%	4.2%	1,147	840	0.034	0.040	39	34
30	19,607	19,790	5.7%	4.1%	1,109	813	0.034	0.040	38	33
31	19,579	19,779	5.7%	4.1%	1,107	812	0.034	0.040	38	33
32	19,550	19,767	5.7%	4.1%	1,105	812	0.034	0.040	38	33
33	19,520	19,755	5.7%	4.1%	1,104	811	0.034	0.040	37	32
34	19,489	19,742	5.7%	4.1%	1,102	811	0.034	0.040	37	32
35	19,458	19,729	5.7%	4.1%	1,100	810	0.034	0.040	37	32
36	19,425	19,715	5.7%	4.1%	1,098	810	0.034	0.040	37	32
37	19,392	19,700	5.7%	4.1%	1,096	809	0.034	0.040	37	32
38	19,357	19,685	5.7%	4.1%	1,094	808	0.034	0.040	37	32
39	19,321	19,669	5.7%	4.1%	1,092	808	0.034	0.040	37	32
40	19,283	19,652	5.7%	4.1%	1,090	807	0.034	0.040	37	32
41	19,245	19,634	5.7%	4.1%	1,088	806	0.034	0.040	37	32
42	19,204	19,615	5.7%	4.1%	1,086	805	0.034	0.040	37	32
43	19,162	19,594	5.7%	4.1%	1,083	805	0.034	0.040	37	32
44	19,117	19,572	5.7%	4.1%	1,081	804	0.034	0.040	37	32
45	19,071	19,549	5.7%	4.1%	1,078	803	0.034	0.040	37	32
46	19,022	19,524	5.7%	4.1%	1,075	802	0.034	0.040	37	32
47	18,970	19,497	5.7%	4.1%	1,073	801	0.034	0.040	36	32
48	18,915	19,469	5.7%	4.1%	1,069	799	0.034	0.040	36	32
49	18,857	19,438	5.7%	4.1%	1,066	798	0.034	0.040	36	32
50	18,795	19,405	5.7%	4.1%	1,063	797	0.034	0.040	36	32
51	18,729	19,370	5.7%	4.1%	1,059	795	0.034	0.040	36	32
52	18,659	19,332	5.7%	4.1%	1,055	794	0.034	0.040	36	32
53	18,583	19,291	5.7%	4.1%	1,051	792	0.034	0.040	36	32
54	18,503	19,247	5.7%	4.1%	1,046	790	0.034	0.040	36	32
55	18,417	19,199	5.7%	4.1%	1,041	788	0.034	0.040	35	32
56	18,325	19,148	5.7%	4.1%	1,036	786	0.034	0.040	35	31
57	18,226	19,092	5.7%	4.1%	1,030	784	0.034	0.040	35	31
58	18,120	19,032	5.7%	4.1%	1,024	781	0.034	0.040	35	31
59	18,006	18,966	5.7%	4.1%	1,018	779	0.034	0.040	35	31
60	17,884	18,895	5.7%	4.1%	1,011	776	0.034	0.040	34	31
61	17,752	18,817	5.7%	4.1%	1,004	773	0.034	0.040	34	31
62	17,610	18,733	5.7%	4.1%	996	769	0.034	0.040	34	31
63	17,458	18,641	5.7%	4.1%	987	765	0.034	0.040	34	31
64	17,293	18,541	5.7%	4.1%	978	761	0.034	0.040	33	30
65	17,116	18,432	5.7%	4.1%	968	757	0.034	0.040	33	30
66	16,925	18,312	5.7%	4.1%	957	752	0.034	0.040	32	30
67	16,719	18,181	5.7%	4.1%	945	747	0.034	0.040	32	30
68	16,496	18,038	5.7%	4.1%	933	741	0.034	0.040	32	30
69	16,256	17,881	5.7%	4.1%	919	734	0.034	0.040	31	29
70	15,997	17,709	5.7%	4.1%	904	727	0.034	0.040	31	29
71	15,718	17,520	5.7%	4.1%	889	719	0.034	0.040	30	29
72	15,416	17,313	5.7%	4.1%	872	711	0.034	0.040	30	28
73	15,092	17,085	5.7%	4.1%	853	702	0.034	0.040	29	28
74	14,742	16,835	5.7%	4.1%	833	691	0.034	0.040	28	28
75	14,365	16,561	5.7%	4.1%	812	680	0.034	0.040	28	27
76	13,960	16,260	-	4.1%	-	668	0.034	0.040	-	27
77	13,526	15,929	-	4.1%	-	654	0.034	0.040	-	26
78	13,061	15,567	-	4.1%	-	639	0.034	0.040	-	26
79	12,563	15,171	-	4.1%	-	623	0.034	0.040	-	25
80	12,033	14,737	-	4.1%	-	605	0.034	0.040	-	24
81	11,469	14,263	-	4.1%	-	586	0.034	0.040	-	23
82	-	13,747	-	-	-	-	0.034	0.040	-	-
83	-	13,186	-	-	-	-	0.034	0.040	-	-
84	-	12,579	-	-	-	-	0.034	0.040	-	-
85	-	11,925	-	-	-	-	0.034	0.040	-	-
Total	**1,385,340**	**1,492,943**			**79,337**	**62,206**			**2,567**	**2,341**

Note that this table ONLY accounts for the population with obesity as these are the individuals that would be targeted by weight management interventions.

Effectiveness of the Intervention

- The CTFPHC notes that "structured interventions are behavioural modification programs that involve several sessions that take place over weeks to months, follow a comprehensive-approach delivered by a specialized inter-disciplinary team, involve group sessions, and incorporate family and parent involvement. Behaviourally-based interventions may focus on diet, increasing exercise, making lifestyle changes, or any combination of these. These can be delivered by a primary health care team in the office or through a referral to a formal program within or outside of primary care, such as hospital-based, school-based or community programs."[278]
- The systematic review and meta-analysis for the CTFPHC found that the overall effectiveness of behavioural interventions resulted in a -0.54 drop in BMI (95% CI from -0.73 to -0.36). This decrease, however, was not maintained 6-12 months after the intervention (0.08 change in BMI, 95% CI from -0.07 to 0.23). The most effective interventions included a focus on both diet and exercise (-1.09 drop in BMI, 95% CI from -1.84 to -0.34). The review also found a statistically significant improvement in blood pressure and QoL.[279] Interventions reduced the prevalence of overweight from 40% to 35% and obesity from 33% to 31% over a duration of up to 36 months.[280]
- The USPSTF review grouped interventions by intensity using hours of contact (≤ 5 hours, 6 to 25 hours, 26 to 51 hours and ≥ 52 hours. The comprehensiveness of the interventions was determined by a focus on both diet and physical activity as well as instruction in and support for the use of behavioural management techniques. Effective higher intensity interventions included multipole components, including "sessions targeting both the parent and child (separately, together, or both); offered individual sessions (both family and group); provided information about healthy eating, safe exercising, and reading food labels; encouraged the use of stimulus control (e.g., limiting access to tempting foods and limiting screen time), goal setting, self-monitoring, contingent rewards, and problem solving; and included supervised physical activity sessions."[281] Most often these interventions were delivered by a multi-disciplinary team outside of the clinician's office.
- In interventions with ≥ 52 hours of contact time, a mean decrease in BMI of 1.10 (95% CI from 0.89 to 1.30) was observed at 6-12 months. In interventions with 26 to 51 hours of contact time, the mean decrease in BMI was 0.34 (95% CI from 0.16 to 0.54). Just 4 of 26 (15%) interventions with less than 26 hours of contact time showed statistically significant benefits.[282]
- The USPSTF identified four RCTs of family-based behavioural treatment programs with a longer follow-up (10 years). In these studies, 85% of children had obesity at baseline. Among the children with obesity who participated in interventions involving at least 30 contact hours, 52% continued to have obesity as adults. By way

[278] Canadian Task Force on Preventive Health Care. Recommendations for growth monitoring, and prevention and management of overweight and obesity in children and youth in primary care. *Canadian Medical Association Journal*. 2015; 187(6): 411-21.
[279] Peirson L, Fitzpatrick-Lewis D, Morrison K et al. Treatment of overweight and obesity in children and youth: a systematic review and meta-analysis. *Canadian Medical Association Open Access Journal*. 2015; 3(1): e35-e46.
[280] Canadian Task Force on Preventive Health Care. Recommendations for growth monitoring, and prevention and management of overweight and obesity in children and youth in primary care. *Canadian Medical Association Journal*. 2015; 187(6): 411-21.
[281] US Preventive Services Task Force. Screening for obesity in children and adolescents: US Preventive Services Task Force Recommendation Statement. *JAMA*. 2017; 317(23): 2417-26.
[282] O'Conner E, Evans C, Burda B et al. Screening for obesity and intervention for weight management in children and adolescents: Evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2017; 317(23): 2427-44.

of comparison, longitudinal studies without interventions and with similar follow-up reported obesity rates of 64% to 87% among adults who had obesity as children.[283]

- A systematic review and meta-analysis by King and co-authors found that participation in structured physical activity interventions for children and youth with obesity was associated with reduced depression, increased self-esteem and improved body image.[284]
- A systematic review and meta-analysis by Gow et al. found that "pediatric obesity treatment improves self-esteem and body image in the short and medium term."[285]

- In our modelling we assume a reduction of 18.8% (52% of obese children / youth receiving the intervention who are obese adults compared with 64% in untreated children / youth). We use the CTFPHC results (reduction from 33% to 31% after 36 months, or 6.1%) as our lower sensitivity bound and 40.2% (52% of obese children / youth receiving the intervention who are obese adults compared with [the upper USPSTF case] 87% in untreated children / youth) (Table 13, row *s*).

- With an intervention, obesity in children and youth between the ages of 6 and 17 would result in a reduction of 62.4 QALYs (32.3 in males and 30.1 in females) due to a reduction in QoL associated with obesity (see Table 12 and Table 13, rows t & u).

[283] US Preventive Services Task Force. Screening for obesity in children and adolescents: US Preventive Services Task Force Recommendation Statement. *JAMA*. 2017; 317(23): 2417-26.
[284] King J, Jebeile H, Garnett S et al. Physical activity based pediatric obesity treatment, depression, self-esteem and body image: A systematic review and meta-analysis. *Mental Health and Physical Activity*. 2020; 19: 100342.
[285] Gow M, Tee M, Garnett S et al. Pediatric obesity treatment, self-esteem, and body image: A systematic review with meta-analysis. *Pediatric Obesity*. 2020; 15(3).

Table 12: Life Years Lived and QALYs Lost Living with Obesity Post-Intervention

Age 6 - 85 in a BC Cohort of 40,000

Age	Life Years Lived with Obesity (Table 11) M	F	Cummulative Proportion Starting Treatment	Cummulative Proportion Stopping Treatment	Cummulative Proportion Starting Treatment	Finishing Treatment	Obesity Reduction From Treatment	Impacted by Intervention M	F	Quality of Life Reduction M	F	QALYs Saved due to Intervention M	F
6	1,054	621	0.8%		0.8%	73%	18.8%	1.2	0.7	0.026	0.026	0.03	0.02
7	1,054	621	1.6%		1.6%	73%	18.8%	2.4	1.4	0.026	0.026	0.06	0.04
8	1,054	621	2.5%		2.5%	73%	18.8%	3.5	2.1	0.026	0.026	0.09	0.05
9	1,054	621	3.3%		3.3%	73%	18.8%	4.7	2.8	0.026	0.026	0.12	0.07
10	1,054	621	4.1%		4.1%	73%	18.8%	5.9	3.5	0.026	0.026	0.15	0.09
11	1,054	621	4.9%		4.9%	73%	18.8%	7.1	4.2	0.026	0.026	0.18	0.11
12	1,607	1,168	5.7%		5.7%	73%	18.8%	12.6	9.2	0.026	0.026	0.33	0.24
13	1,607	1,168	6.5%		6.5%	73%	18.8%	14.4	10.5	0.026	0.026	0.38	0.27
14	1,607	1,168	7.4%		7.4%	73%	18.8%	16.2	11.8	0.026	0.026	0.42	0.31
15	1,607	1,168	8.2%		8.2%	73%	18.8%	18.0	13.1	0.026	0.026	0.47	0.34
16	1,606	1,167	9.0%	0.0%	9.0%	73%	18.8%	19.8	14.4	0.026	0.026	0.52	0.37
17	1,606	1,167	9.8%	0.0%	9.8%	73%	18.8%	21.6	15.7	0.026	0.026	0.56	0.41
18	1,568	1,140	9.8%	0.0%				21.1	15.4	0.034	0.040	0.72	0.61
19	1,530	1,113	9.8%	0.0%				20.6	15.0	0.034	0.040	0.70	0.60
20	1,492	1,085	9.8%	0.0%				20.1	14.6	0.034	0.040	0.68	0.59
21	1,454	1,058	9.8%	0.0%				19.6	14.2	0.034	0.040	0.66	0.57
22	1,415	1,031	9.8%	0.0%				19.1	13.9	0.034	0.040	0.65	0.56
23	1,377	1,003	9.8%	0.0%				18.5	13.5	0.034	0.040	0.63	0.54
24	1,338	976	9.8%	0.0%				18.0	13.1	0.034	0.040	0.61	0.53
25	1,300	949	9.8%	0.0%				17.5	12.8	0.034	0.040	0.59	0.51
26	1,262	922	9.8%	0.0%				17.0	12.4	0.034	0.040	0.58	0.50
27	1,223	894	9.8%	0.0%				16.5	12.0	0.034	0.040	0.56	0.48
28	1,185	867	9.8%	0.0%				16.0	11.7	0.034	0.040	0.54	0.47
29	1,147	840	9.8%	0.0%				15.4	11.3	0.034	0.040	0.52	0.45
30	1,109	813	9.8%	0.0%				14.9	10.9	0.034	0.040	0.51	0.44
31	1,107	812	9.8%	0.0%				14.9	10.9	0.034	0.040	0.51	0.44
32	1,105	812	9.8%	0.0%				14.9	10.9	0.034	0.040	0.51	0.44
33	1,104	811	9.8%	0.0%				14.9	10.9	0.034	0.040	0.50	0.44
34	1,102	811	9.8%	0.0%				14.8	10.9	0.034	0.040	0.50	0.44
35	1,100	810	9.8%	0.0%				14.8	10.9	0.034	0.040	0.50	0.44
36	1,098	810	9.8%	0.0%				14.8	10.9	0.034	0.040	0.50	0.44
37	1,096	809	9.8%	0.0%				14.8	10.9	0.034	0.040	0.50	0.44
38	1,094	808	9.8%	0.0%				14.7	10.9	0.034	0.040	0.50	0.44
39	1,092	808	9.8%	0.0%				14.7	10.9	0.034	0.040	0.50	0.44
40	1,090	807	9.8%	0.0%				14.7	10.9	0.034	0.040	0.50	0.44
41	1,088	806	9.8%	0.0%				14.7	10.9	0.034	0.040	0.50	0.43
42	1,086	805	9.8%	0.0%				14.6	10.8	0.034	0.040	0.50	0.43
43	1,083	805	9.8%	0.0%				14.6	10.8	0.034	0.040	0.50	0.43
44	1,081	804	9.8%	0.0%				14.6	10.8	0.034	0.040	0.49	0.43
45	1,078	803	9.8%	0.0%				14.5	10.8	0.034	0.040	0.49	0.43
46	1,075	802	9.8%	0.0%				14.5	10.8	0.034	0.040	0.49	0.43
47	1,073	801	9.8%	0.0%				14.4	10.8	0.034	0.040	0.49	0.43
48	1,069	799	9.8%	0.0%				14.4	10.8	0.034	0.040	0.49	0.43
49	1,066	798	9.8%	0.0%				14.4	10.8	0.034	0.040	0.49	0.43
50	1,063	797	9.8%	0.0%				14.3	10.7	0.034	0.040	0.49	0.43
51	1,059	795	9.8%	0.0%				14.3	10.7	0.034	0.040	0.48	0.43
52	1,055	794	9.8%	0.0%				14.2	10.7	0.034	0.040	0.48	0.43
53	1,051	792	9.8%	0.0%				14.2	10.7	0.034	0.040	0.48	0.43
54	1,046	790	9.8%	0.0%				14.1	10.6	0.034	0.040	0.48	0.43
55	1,041	788	9.8%	0.0%				14.0	10.6	0.034	0.040	0.48	0.43
56	1,036	786	9.8%	0.0%				14.0	10.6	0.034	0.040	0.47	0.42
57	1,030	784	9.8%	0.0%				13.9	10.6	0.034	0.040	0.47	0.42
58	1,024	781	9.8%	0.0%				13.8	10.5	0.034	0.040	0.47	0.42
59	1,018	779	9.8%	0.0%				13.7	10.5	0.034	0.040	0.47	0.42
60	1,011	776	9.8%	0.0%				13.6	10.4	0.034	0.040	0.46	0.42
61	1,004	773	9.8%	0.0%				13.5	10.4	0.034	0.040	0.46	0.42
62	996	769	9.8%	0.0%				13.4	10.4	0.034	0.040	0.46	0.41
63	987	765	9.8%	0.0%				13.3	10.3	0.034	0.040	0.45	0.41
64	978	761	9.8%	0.0%				13.2	10.3	0.034	0.040	0.45	0.41
65	968	757	9.8%	0.0%				13.0	10.2	0.034	0.040	0.44	0.41
66	957	752	9.8%	0.0%				12.9	10.1	0.034	0.040	0.44	0.41
67	945	747	9.8%	0.0%				12.7	10.1	0.034	0.040	0.43	0.40
68	933	741	9.8%	0.0%				12.6	10.0	0.034	0.040	0.43	0.40
69	919	734	9.8%	0.0%				12.4	9.9	0.034	0.040	0.42	0.40
70	904	727	9.8%	0.0%				12.2	9.8	0.034	0.040	0.41	0.39
71	889	719	9.8%	0.0%				12.0	9.7	0.034	0.040	0.41	0.39
72	872	711	9.8%	0.0%				11.7	9.6	0.034	0.040	0.40	0.38
73	853	702	9.8%	0.0%				11.5	9.4	0.034	0.040	0.39	0.38
74	833	691	9.8%	0.0%				11.2	9.3	0.034	0.040	0.38	0.37
75	812	680	9.8%	0.0%				10.9	9.2	0.034	0.040	0.37	0.37
76	-	668	9.8%	0.0%				-	9.0	0.034	0.040	-	0.36
77	-	654	9.8%	0.0%				-	8.8	0.034	0.040	-	0.35
78	-	639	9.8%	0.0%				-	8.6	0.034	0.040	-	0.34
79	-	623	9.8%	0.0%				-	8.4	0.034	0.040	-	0.34
80	-	605	9.8%	0.0%				-	8.1	0.034	0.040	-	0.33
81	-	586	9.8%	0.0%				-	7.9	0.034	0.040	-	0.32
82	-	-	9.8%	0.0%				-	-	0.034	0.040	-	-
83	-	-	9.8%	0.0%				-	-	0.034	0.040	-	-
84	-	-	9.8%	0.0%				-	-	0.034	0.040	-	-
85	-	-	9.8%	0.0%				-	-	0.034	0.040	-	-
Total	**79,337**	**62,206**						**981**	**783**			**32.3**	**30.1**

Note that this table ONLY accounts for the population with obesity as these are the individuals that would be targeted by weight management interventions.

Potential Harms Associated with the Intervention

- The CTFPHC review found no identified harms associated with the behavioural interventions.[286]
- A 2019 systematic review and meta-analysis by Jebeile and co-authors found that "structured, professionally run pediatric obesity treatment is not associated with an increased risk of depression or anxiety and may result in a mild reduction in symptoms."[287]

Summary of CPB

- Other assumptions used in assessing CPB are detailed in the Reference Document.

Based on these assumptions, the CPB associated with growth monitoring in children and youth ages 0-17 along with the offer of, or referral to, structured behavioural interventions aimed at healthy weight management for children and youth aged to 17 years who are overweight or obese is 195 QALYs (see Table 13, row z). The CPB of 195 represents the gap between no coverage and the 'best in the world' growth monitoring coverage as observed in BC, i.e. 9.8% of birth cohort would receive an intervention sometime between the ages of 6 and 17 and that 73.3% of those receiving the intervention would attend at least 70% of the sessions.

[286] Canadian Task Force on Preventive Health Care. Recommendations for growth monitoring, and prevention and management of overweight and obesity in children and youth in primary care. *Canadian Medical Association Journal*. 2015; 187(6): 411-21.

[287] Jebeile H, Gow M, Baur L et al. Association of pediatric obesity treatment, including a dietary component, with change in depression and anxiety: A systematic review and meta-analysis. *JAMA Pediatrics*. 2019; 173(1): e192841.

Table 13: CPB of Screening for Excess Weight and Healthy Weight Intervention In Children and Adolescents Ages 6 - 17 In a BC Birth Cohort of 40,000			
	Burden of Obesity		
a	Years of life lived in cohort, male	1,385,340	Table 11
b	Years of life lived in cohort, female	1,492,943	Table 11
c	Years of life lived in cohort, with obesity, male	79,337	Table 11
d	Years of life lived in cohort, with obesity, female	62,206	Table 11
e	Disutility of obesity, ages 6 - 17	0.026	√
f	Disutility of obesity, age 18+, male	0.034	√
g	Disutility of obesity, age 18+, female	0.040	√
h	QALYs lost due to obesity, male	2,567	Table 11
i	QALYs lost due to obesity, female	2,341	Table 11
j	Number of obese 30 year-olds, male	1,109	Table 11
k	Number of obese 30 year-olds, female	813	Table 11
l	Life years lost due to obesity, per individual, male	5.7	√
m	Life years lost due to obesity, per individual, female	4.4	√
n	Total life years lost due to obesity, male	6,332	= j * l
o	Total life years lost due to obesity, female	3,546	= k * m
p	Total life years lost due to obesity	9,878	= n + o
	Benefits of Screening and Intervention		
q	Cummulative proportion treated over 12 years	9.8%	√
r	Proportion completing treatment	73.3%	√
s	Reduction in obesity due to treatment	18.8%	√
t	QALYs saved due to treatment, male	32.3	Table 12
u	QALYs saved due to treatment, female	30.1	Table 12
v	Reduction in number of obese 30 year-olds, male	14.9	Table 12
w	Reduction in number of obese 30 year-olds, female	10.9	Table 12
x	Life years saved due to intervention, male	85.3	= v * l
y	Life years saved due to intervention, female	47.8	= w * m
z	**QALYs Gained due to intervention**	195	= t + u + x +y

√ = Estimates from the literature

Sensitivity Analysis

We also modified a number of major assumptions and recalculated the CPB as follows:

- Assume that the life years lost due to obesity is decreased from 5.7 years to 2.6 years in males and from 4.4 years to 2.1 years in females (Table 13, rows *l* & *m*): CPB = 127
- Assume that the life years lost due to obesity is increased from 5.7 years to 8.8 years in males and from 4.4 years to 6.6 years in females (Table 13, rows *l* & *m*): **CPB = 263**
- Assume that the quality of life reduction living with obesity changes from 0.026 to 0.017 for adolescents, from 0.034 to 0.022 in adult males, and from 0.040 to 0.026 in adult females (Table 13, rows e, f & g): CPB = 174
- Assume that the quality of life reduction living with obesity changes from 0.026 to 0.036 for adolescents, from 0.034 to 0.045 in adult males, and from 0.040 to 0.053 in adult females (Table 13, rows e, f & g): CPB = 216
- Assume that the reduction in obesity due to completing the intervention decreases from 18.8% to 6.1% (Table 13, row *s*): **CPB = 63**
- Assume that the reduction in obesity due to completing the intervention increases from 18.8% to 40.2% (Table 13, row *s*): CPB = 419

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with growth monitoring and healthy weight management in children and youth, in a British Columbia birth cohort of 40,000.

In estimating CE, we made the following assumptions:

Annual Visits to a General Practitioner

- Children in families that do not have a regular health care provider (HCP) are unlikely to enter a weight monitoring/management process. Based on 2017/18 CCHS data, 83.3% of families in BC have a regular HCP.[288]
- Between fiscal years 2012/13 and 2016/17, the average proportion of BC youth aged 10 – 14 who visited a general practitioner (GP) was 69.3% and for ages 15 – 19 the average was 70.5%.[289]
- In our model we assume that 100% of newborns (0 years) are seen by a primary care provider, and that the screening rate for 10 – 14 year-olds applies to 1 – 9 year-olds as well.

Screening Frequency

- The CTFPHC recommends growth monitoring at all appropriate primary care visits. Appropriate primary care visits are defined as "scheduled health supervision visits, visits for immunizations or medication renewal, episodic care or acute illness, and other visits where the primary care practitioner deems it appropriate. Primary care visits are completed at primary health care settings, including those outside of a

[288] Statistics Canada. *Canadian Community Health Survey: Public Use Microdata File, 2017/2018 (Catalogue number: 82M0013X2020001).* 2020: All computations, use and interpretation of these data are entirely that of H. Krueger & Associates Inc.

[289] Aciemme (Sam) Ospan, Senior Manager, Lifetime Prevention Schedule, Healthy Living and Health Promotion Branch, BC Ministry of Health. January 30, 2019. Personal communication. (*Taken from the adolescent depression model analysis*)

physician's office (e.g. public health nurses carrying out a well-child visit at a community setting)."[290] The Canadian Paediatric Association recommends that well-child visits take place at 1 week, at 2, 4, 6 and 12 months, annually from ages 2-5 and then every year or two until the child is 18 years of age.[291]

- For modelling purposes, we assumed that growth monitoring would occur annually between the ages of 0-17 at a well-child visit. Table 14 shows the number of screening opportunities and the number of actual screens conducted from 0 – 17 years of age based on the best in world rate of 13% observed in US physicians (residents).[292]

Table 14: Visits to Primary Care Provider and Weight Screens Conducted
Ages 0 - 17 for a BC Cohort of 40,000

	Life Years		Proportion Visiting Primary Care Provider		Number of Screening Opportunities		BiW Screening Rate	Screens Conducted	
Age	M	F	%	%	M	F	%	M	F
0	19,927	19,937	100.0%	100.0%	19,927	19,937	13.0%	2,591	2,592
1	19,920	19,931	69.3%	69.3%	13,804	13,812	13.0%	1,795	1,796
2	19,916	19,927	69.3%	69.3%	13,802	13,809	13.0%	1,794	1,795
3	19,914	19,925	69.3%	69.3%	13,801	13,808	13.0%	1,794	1,795
4	19,912	19,923	69.3%	69.3%	13,799	13,807	13.0%	1,794	1,795
5	19,910	19,921	69.3%	69.3%	13,798	13,805	13.0%	1,794	1,795
6	19,909	19,920	69.3%	69.3%	13,797	13,804	13.0%	1,794	1,795
7	19,907	19,918	69.3%	69.3%	13,796	13,803	13.0%	1,793	1,794
8	19,906	19,917	69.3%	69.3%	13,795	13,803	13.0%	1,793	1,794
9	19,905	19,916	69.3%	69.3%	13,794	13,802	13.0%	1,793	1,794
10	19,904	19,915	69.3%	69.3%	13,793	13,801	13.0%	1,793	1,794
11	19,903	19,914	69.3%	69.3%	13,793	13,800	13.0%	1,793	1,794
12	19,901	19,912	69.3%	69.3%	13,792	13,799	13.0%	1,793	1,794
13	19,899	19,911	69.3%	69.3%	13,790	13,798	13.0%	1,793	1,794
14	19,897	19,908	69.3%	69.3%	13,789	13,797	13.0%	1,793	1,794
15	19,893	19,906	70.5%	70.5%	14,025	14,033	13.0%	1,823	1,824
16	19,888	19,902	70.5%	70.5%	14,021	14,031	13.0%	1,823	1,824
17	19,880	19,897	70.5%	70.5%	14,016	14,027	13.0%	1,822	1,824
Total	**358,293**	**358,499**			**255,130**	**255,277**		**33,167**	**33,186**

Cost of Screening

- Patient time costs resulting from receiving, as well as travelling to and from, a service are valued based on the average hourly wage rate in BC in 2022 ($31.49[293]) plus 18% benefits for an average cost per hour of $37.16. In the absence of specific data on the amount of time required, we assume two hours per service (2 * $37.16 = $74.32) (Table 16, row *f*).

[290] Canadian Task Force on Preventive Health Care. Recommendations for growth monitoring, and prevention and management of overweight and obesity in children and youth in primary care. *Canadian Medical Association Journal*. 2015; 187(6): 411-21.
[291] Canadian Paediatric Association. *Caring for Kids: Information for parents from Canada's paediatricians*. Available at http://www.caringforkids.cps.ca/handouts/schedule_of_well_child_visits. Accessed July 2020.
[292] Hillman JB, Corathers SD and Wilson SE. Pediatricians and screening for obesity with body mass index: Does level of training matter? *Public Health Reports*. 2009; 124(4): 561-7.
[293] BC Stats. *Earning & Employment Trends – August 2022*. Available at https://www2.gov.bc.ca/assets/gov/data/statistics/people-population-community/income/earnings_and_employment_trends_data_tables.pdf. Accessed September 2022.

- The estimated cost of a visit to a GP of $35.97 (Table 16, row *e*) is based on the average cost of an office visit between the ages of 2 and 79. [294] A key question is whether one or more preventive maneuvers might be completed during an individual office visit. If evidence is available on this question, either research evidence or specific advice from our GP advisors given their knowledge of the BC practice environment, then that evidence is used in the modelling. If no evidence is available, however, then we assume that 50% of an office visit is required per preventive maneuver and modify this from 33% to 66% in the sensitivity analysis (Table 16, row *d*).

Program Costs

- The costs of operating Shapedown BC between April 1, 2019 and March 31, 2020 are $1,742,799 (or $1,853,463 in 2022 CAD).[295]
- During the three fiscal years from 2016/17 to 2018/19, a total of 603 families started the 10-week program at an average cost of $8,671 per family ($1,742,799 * 3 / 603) or $9,222 in 202 CAD. The average cost per family ranged from $8,419 in 2018/19 to $8,937 in 2017/18.
- Between October of 2019 and April of 2020, Generation Health delivered two full 10-week program cycles at eight sites in the province (the partial scale-up phase).[296] Once fully implemented, Generation Health is expected to operate two full 10-week program cycles at ten sites in the province allowing 200 children and their families to be enrolled in the program.[297]
- Not all families that enroll actually start the program. Based on data to date,[298] an estimated 70% of enrolled families start the program, or a projected 140 families. A number of families may also have more than one child in the program (an average of 1.12 children per family to date[299]) suggesting that 157 children would start the program once fully implemented.
- Estimated costs for Generation Health once fully implemented are $695,700 per year.[300] This includes costs for centralized management and support ($230,500), administration fees ($63,000), program resources ($20,000), centralized marketing and promotion ($30,000), training ($25,000) and local site delivery costs (staffing [$207,200], host organization fee [$40,000], recreation passes for families [$30,000], and other program materials [$50,000]).
- The estimated cost per child starting the program would be $4,431 ($695,700 / 157) or $4,712 in 2022 CAD.
- Combining the 2018/19 fiscal year data from Shapedown BC and Generation Health, a total of 270 (207 + 63) children and their families began a structured behavioural intervention aimed at healthy weight management. The weighted cost per child would

[294] Ministry of Health. *Medical Services Commission Payment Schedule*. 2021. Available at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msc-payment-schedule-may-2021.pdf. Accessed September 2022.
[295] Arlene Cristall, Provincial Lead, The Centre for Healthy Weights – Shapedown BC. September 2020. Personal communication.
[296] Childhood Obesity Foundation. *Generation Health: Evaluation Report June 2020*.
[297] Karen Strange, Project Director, Generation Health, Childhood Obesity Foundation. October 9, 2020. Personal communication.
[298] Childhood Obesity Foundation. *Generation Health: Evaluation Report June 2020*.
[299] Childhood Obesity Foundation. *Generation Health: Evaluation Report June 2020*.
[300] Karen Strange, Project Director, Generation Health, Childhood Obesity Foundation. October 9, 2020. Personal communication.

thus be $8,170 (207*$9,222 + 63*$4,712)/270)). Once Generation Health is fully implemented, we would expect the weighted cost per child to decrease to $7,277 (207*$9,222 + 157*$4,712)/364)).

- For modelling purposes, we assumed a program cost per child of $8,170 (Table 16, row *j*) and reduced this to $7,277 in the sensitivity analysis.

- Patient time costs resulting from receiving, as well as travelling to and from, the healthy weight intervention are estimated at 3 hours per session (a 2-hour session plus 30 minutes to travel to and then from the session) or $111.48 ($37.16 * 3) (Table 16, row *l*). We model that 10 sessions are offered.

- Table 15 shows the number in the cohort of 40,000 that begin a healthy weight intervention program each year.

Table 15: Number Starting Healthy Weight Treatment

Age 6 - 17 in a BC Cohort of 40,000

	Life Years Lived with Obesity (Table 11)		Proportion Starting	Number Starting Treatment	
Age	M	F	Treatment	M	F
6	1,054	621	0.8%	8.6	5.1
7	1,054	621	0.8%	8.6	5.1
8	1,054	621	0.8%	8.6	5.1
9	1,054	621	0.8%	8.6	5.1
10	1,054	621	0.8%	8.6	5.1
11	1,054	621	0.8%	8.6	5.1
12	1,607	1,168	0.8%	13.1	9.5
13	1,607	1,168	0.8%	13.1	9.5
14	1,607	1,168	0.8%	13.1	9.5
15	1,607	1,168	0.8%	13.1	9.5
16	1,606	1,167	0.8%	13.1	9.5
17	1,606	1,167	0.8%	13.1	9.5
Total	**15,964**	**10,731**	**9.8%**	**130**	**88**

Costs Avoided Due to a Reduction in Obesity

- Obesity is associated with higher *annual medical care costs* (e.g., hospitalization, physician, drug, etc.). Research in BC identified these costs as $698 (in males) and $952 (in females) per year for obesity (BMI of ≥30) in 2015 CAD or $794/$1,083 respectively in 2022 CAD (Table 16, rows *s* & *t*).[301]

- We assumed that the excess costs associated with obesity would be avoided during the remaining lifetime of the individual after a successful weight management program (Table 16, rows *q* & *r*). We also modified this assumption so that costs would only be avoided for a ten year period after a successful weight management program.

[301] H. Krueger & Associates Inc. *The Economic Burden of Risk Factors in British Columbia: Excess Weight, Tobacco Smoking, Alcohol Use, Physical Inactivity and Low Fruit and Vegetable Consumption.* 2018. Vancouver, B.C.: Provincial Health Services Authority, Population and Public Health Program.

Summary of CE

- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the CE associated with growth monitoring in children and youth ages 0 - 17 and the offer of, or referral to, structured behavioural interventions aimed at healthy weight management for children and youth ages 2 to 17 years who are obese is $33,680 / QALY(Table 16, row *v*).

Table 16: CE of Screening for Excess Weight and Healthy Weight Intervention
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
	Cost of Screening		
a	Screening frequency (in years)	1	√
b	Healthy weight monitoring screens conducted, 0 - 17 years, males	33,167	Table 14
c	Healthy weight monitoring screens conducted, 0 - 17 years, females	33,186	Table 14
d	Proportion of office visit required for short screen	50.0%	√
e	Cost of 10-minute office visit	$35.97	√
f	Patient time costs / office visit	$74.32	√
g	**Cost of healthy weight screening**	**$3,659,035**	= (b + c) * d * (e + f)
	Cost of Healthy Weight Intervention		
h	Number of interventions started, 6 - 17 years, males	130	Table 15
i	Number of interventions started, 6 - 17 years, females	88	Table 15
j	Cost of intervention, per individual	$8,170	√
k	**Cost of healthy weight intervention**	**$1,781,131**	= (h + i) * j
l	Patient time costs per session	$111.48	√
m	Number of intervention sessions	10	√
n	**Patient time cost**	**$243,036**	= (h + i) * l * m
o	**Total cost of intervention**	**$2,024,167**	= k + n
p	**Total cost of screening and healthy weight intervention, cohort**	**$5,683,202**	= g + o
	Costs Avoided due to Healthy Weight Intervention		
q	Life years with avoided obesity, lifetime, males	981	Table 12
r	Life years with avoided obesity, lifetime, females	783	Table 12
s	Annual excess medical cost for individuals with obesity, males	$794	√
t	Annual excess medical cost for individuals with obesity, females	$1,083	√
u	Cost avoided due to healthy weight intervention, males	$779,068	= q * s
v	Cost avoided due to healthy weight intervention, females	$847,602	= r * t
w	**Cost avoided due to healthy weight intervention, cohort**	**$1,626,670**	= u + v
	Cost Effectiveness of Screening and Healthy Weight Intervention		
x	Net Cost of Screening and Healthy Weight Intervention	$4,056,533	= p - w
y	QALYs gained due to intervention	195	Table 13, row z
z	CE ($/QALY Saved)	$20,756	= x / y
aa	Net Cost of Screening and Healthy Weight Intervention, 1.5% Discount	$4,023,200	Calculated
ab	QALYs saved, 1.5% Discount	119	Calculated
ac	**CE ($/QALY Saved), 1.5% Discount**	**$33,680**	= aa / ab

√ = Estimates from the literature

Sensitivity Analysis

We also modified a number of major assumptions and recalculated the CE as follows:

- Assume that the life years lost due to obesity is decreased from 5.7 years to 2.6 years in males and from 4.4 years to 2.1 years in females (Table 13, rows *l* & *m*): CE = $53,423
- Assume that the life years lost due to obesity is increased from 5.7 years to 8.8 years in males and from 4.4 years to 6.6 years in females (Table 13, rows *l* & *m*): CE = $24,685
- Assume that the quality of life reduction living with obesity changes from 0.026 to 0.017 for adolescents, from 0.034 to 0.022 in adult males, and from 0.040 to 0.026 in adult females (Table 13, rows e, f & g): CE = $37,442
- Assume that the quality of life reduction living with obesity changes from 0.026 to 0.036 for adolescents, from 0.034 to 0.045 in adult males, and from 0.040 to 0.053 in adult females (Table 13, rows e, f & g): CE = $30,782
- Assume that the reduction in obesity due to completing the intervention decreases from 18.8% to 6.1% (Table 13, row *s*): CE = $120,128
- Assume that the reduction in obesity due to completing the intervention increases from 18.8% to 40.2% (Table 13, row *s*): **CE = $11,635**
- Assume that the proportion of an office visit for weight measurement is decreased from 50% to 33% (Table 16, row *d*): CE = $24,630
- Assume that the proportion of an office visit for weight measurement is increased from 50% to 67% (Table 16, row *d*): CE = $42,729
- Assume that the cost of the weight management program per individual is reduced from $8,170 to $7,277 (Table 16, row *j*): CE = $32,320
- Assume that costs avoided would only last for ten years, rather than a lifetime, after a successful weight management program (Table 16, rows *m & n*): **CE = $597,544**

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with growth monitoring in children and youth ages 0-17 and the offer of, or referral to, structured behavioural interventions aimed at healthy weight management for children and youth ages 2 to 17 years who are overweight or obese is estimated to be 119 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $33,680 per QALY (see Table 17).

Table 17: Screening for Excess Weight and Healthy Weight Intervention in a Birth Cohort of 40,000
Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume No Current Service			
1.5% Discount Rate	**119**	39	256
3% Discount Rate	75	24	162
0% Discount Rate	195	63	419
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$33,680**	$11,635	$597,544
3% Discount Rate	$49,923	$19,349	$668,679
0% Discount Rate	$20,756	$5,230	$533,834
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$13,688	$2,317	$293,343
3% Discount Rate	$21,751	$6,219	$324,478
0% Discount Rate	$6,896	Cost saving	$264,885

Canadian Task Force on Preventive Health Care (2004)

Breastfeeding has been shown in both developing and developed countries to improve the health of infants and their mothers, making it the optimal method of infant nutrition.

The CTFPHC concludes that there is good evidence to recommend providing structured antepartum educational programs and postpartum support to promote breastfeeding initiation and duration. (A recommendation)

Unfortunately, advice from a woman's primary clinician (such as family physician, obstetrician or midwife) has not been sufficiently evaluated, and a research gap remains in this area.

The CTFPHC concludes that there is insufficient evidence to make a recommendation regarding advice by primary caregivers to promote breastfeeding. (I Recommendation)[302]

United States Preventive Services Task Force Recommendations (2008)

The USPSTF recommends interventions during pregnancy and after birth to promote and support breastfeeding. This is a grade B recommendation.

There is convincing evidence that breastfeeding provides substantial health benefits for children and adequate evidence that breastfeeding provides moderate health benefits for women.

Adequate evidence indicates that interventions to promote and support breastfeeding increase the rates of initiation, duration, and exclusivity of breastfeeding.

The USPSTF concludes that there is moderate certainty that interventions to promote and support breastfeeding have a moderate net benefit.

Interventions may include multiple strategies, such as formal breastfeeding education for mothers and families, direct support of mothers during breastfeeding observations, and the training of health professional staff about breastfeeding and techniques for breastfeeding support.

Although the activities of individual clinicians to promote and support breastfeeding are likely to be positive, additional benefit may result from efforts that are integrated into systems of care.[303]

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with interventions aimed at improving longer term (6 months) exclusive breastfeeding rates in a British Columbia birth cohort of 40,000.

Breastfeeding promotion interventions in developed countries are associated with a 28% increase (odds ratio or OR = 1.28, 95% CI of 1.11 – 1.48) in short-term (1–3 months)

[302] Palda VA, Guise J-M and Wathen CN. Interventions to promote breast-feeding: applying the evidence in clinical practice. *Canadian Medical Association Journal*. 2004; 170(6): 976-8.
[303] US Preventive Services Task Force. Primary care interventions to promote breastfeeding: US Preventive Services Task Force recommendation statement. *Annals of Internal Medicine*. 2008; 149(8): 560-4.

exclusive breastfeeding and a 44% increase (OR = 1.44, 95% CI of 1.13 – 1.84) in long-term (6–8 months) exclusive breastfeeding.[304]

Research evidence does not clearly identify which types or components of breastfeeding promotion interventions are effective. In their review for the USPSTF, Chung and colleagues "did not find that formal or structured breastfeeding education or individual-level professional support significantly affected the breastfeeding outcomes. [They] did find that lay support significantly increased the rate of any and exclusive breastfeeding in the short-term." They also noted that interventions including both pre- and post-natal components are important. Finally, "the BFHI (Baby Friendly Hospital Initiative) is effective in increasing exclusive breastfeeding rates, at least up to 6 months after delivery." [305]

From the perspective of a CPS, then, it may be most important for the clinician to refer their pregnant patient or new mother to an intervention including lay support.

Breastfeeding is associated with the following health benefits for the infant:

- Any breastfeeding is associated with a 40% reduction (OR = 0.60, 95% CI of 0.46 – 0.78) in the risk of otitis media (OM) compared to no breastfeeding (Table 2, row *k*). [306] The overall incidence of OM is 1.9 episodes in the first year of life (Table 2, row *j*).[307]
- Exclusive breastfeeding for 3 months or longer is associated with a 42% reduction (OR = 0.58, 95% CI of 0.41 – 0.92) in the risk of atopic dermatitis (AD) compared to exclusive breastfeeding for less than 3 months (Table 2, row *n*). [308] AD has a cumulative incidence of 0.165 in the first two years of life (Table 2, row *m*). [309]
- Any breastfeeding is associated with a 64% reduction (OR = 0.36, 95% CI of 0.32 – 0.41) in the risk of gastrointestinal infection (GI) compared to no breastfeeding (Table 2, row *q*). [310] GI is associated with 0.222 ambulatory visits (Table 2, row *p*) and 0.00298 hospitalizations per infant < 1 year old. [311]
- Exclusive breastfeeding for 4 months or longer is associated with a 72% reduction (OR = 0.28, 95% CI of 0.14 – 0.54) in the risk of lower respiratory tract infection (LRTI) compared to formula feeding (Table 2, row *t*). [312] The overall incidence of LRTI in infants is 0.0409 cases (Table 2, row *s*) with a death rate of 0.0000732 (Table 2, row *v*). [313]
- Breastfeeding for 3 months or longer is associated with a 27% reduction (OR = 0.73, 95% CI of 0.59 – 0.92) in the risk of asthma compared to no breastfeeding in families

[304] Chung M, Raman G, Trikalinos T et al. Interventions in primary care to promote breastfeeding: an evidence review for the US Preventive Services Task Force. *Annals of Internal Medicine*. 2008; 149(8): 565-82.
[305] Ibid.
[306] Ibid.
[307] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.
[308] Chung M, Raman G, Trikalinos T et al. Interventions in primary care to promote breastfeeding: an evidence review for the US Preventive Services Task Force. *Annals of Internal Medicine*. 2008; 149(8): 565-82.
[309] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.
[310] Chung M, Raman G, Trikalinos T et al. Interventions in primary care to promote breastfeeding: an evidence review for the US Preventive Services Task Force. *Annals of Internal Medicine*. 2008; 149(8): 565-82.
[311] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.
[312] Chung M, Raman G, Trikalinos T et al. Interventions in primary care to promote breastfeeding: an evidence review for the US Preventive Services Task Force. *Annals of Internal Medicine*. 2008; 149(8): 565-82.
[313] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.

without a history of asthma (Table 2, row *aa*).[314] The cumulative incidence of asthma during childhood is 0.127 (Table 2, row *z*) with a death rate of 0.00000273 (Table 2, row *cc*).[315]

- Any breastfeeding is associated with a 24% reduction (OR = 0.76, 95% CI of 0.67 – 0.86) in the risk of overweight or obesity compared to no breastfeeding (Table 2, row *hh & mm*). Each month of breastfeeding is associated with a 4% reduced risk of overweight or obesity.[316]

- The 2021 rate of overweight and obesity (adjusted-self reported) for ages 20 and older in BC is taken from Table of Statistics Canada (see Table 1).[317] Rates of overweight and obesity for those under the age of 20 are taken from Table 8 in the *Growth Monitoring and Healthy Weight Management in Children and Youth* section above. Based on these rates and mean survival rates by age group, a birth cohort of 40,000 in BC would be expected to include 978,388 years in a 'state' of overweight and 649,371 years in a 'state' of obesity (see Table 1).

Table 1: Years of Life as Overweight or Obese
In a BC Birth Cohort of 40,000

Age Group	Years of Life in Birth Cohort	% Overweigh	Years of Life Overweigh	% Obese	Years of Life Obese
0-4	199,377	14.2%	28,312	5.0%	9,969
5-9	199,132	14.2%	28,277	4.2%	8,364
10-14	199,065	16.1%	32,049	7.0%	13,935
15-19	198,894	16.1%	32,022	7.0%	13,923
20-24	198,385	28.3%	56,143	18.8%	37,296
25-29	197,592	28.3%	55,919	18.8%	37,147
30-34	196,633	28.3%	55,647	18.8%	36,967
35-39	195,517	37.9%	74,101	24.0%	46,924
40-44	194,174	37.9%	73,592	24.0%	46,602
45-49	192,462	37.9%	72,943	24.0%	46,191
50-54	190,154	34.2%	65,033	31.0%	58,948
55-59	186,897	34.2%	63,919	31.0%	57,938
60-64	182,174	34.2%	62,304	31.0%	56,474
65-69	175,175	38.6%	67,617	24.8%	43,443
70-74	164,644	38.6%	63,553	24.8%	40,832
75-79	148,766	38.6%	57,424	24.8%	36,894
80+	231,954	38.6%	89,534	24.8%	57,525
Total	**3,250,997**	**30.1%**	**978,388**	**20.0%**	**649,371**

[314] Chung M, Raman G, Trikalinos T et al. Interventions in primary care to promote breastfeeding: an evidence review for the US Preventive Services Task Force. *Annals of Internal Medicine*. 2008; 149(8): 565-82.
[315] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.
[316] Chung M, Raman G, Trikalinos T et al. Interventions in primary care to promote breastfeeding: an evidence review for the US Preventive Services Task Force. *Annals of Internal Medicine*. 2008; 149(8): 565-82.
[317] Statistics Canada. *Table 13-10-0096-01, Health Characteristics, Annual Estimates.* Available online at https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310009601. Accessed March 2023.

- Overweight/obesity is associated with a reduced life expectancy of approximately 0.6 and 5.0 years, respectively (see Reference Document). Given the average life expectancy in BC of 82.4 years, this represents a reduction in life expectancy of 0.73% (0.6 / 82.4) associated with overweight (Table 2, row *jj*) and 6.07% (5.0 / 82.4) for obesity (Table 2, row *oo*).
- Breastfeeding for 3 months or longer is associated with a 19% reduction (OR = 0.81, 95% CI of 0.74 – 0.89) in the risk of type 1 diabetes compared to breastfeeding for less than 3 months (Table 2, row *rr*). [318] The overall incidence of type 1 diabetes is 0.000186 (Table 2, row *qq*) with a death rate of 0.00000121 (Table 2, row *tt*). [319]
- Breastfeeding for less than 6 months is associated with a 12% reduction (OR = 0.88, 95% CI of 0.80 – 0.96) in the risk of childhood leukemia while breastfeeding for more than 6 months is associated with a 24% reduction (OR = 0.76, 95% CI of 0.68 – 0.84) in the risk of childhood leukemia compared to no breastfeeding (Table 2, row *yy*). [320] The overall incidence of childhood leukemia is 0.0000321 (Table 2, row *xx*) with a five-year death rate 39.8% (Table 2, row *aaa*) for children younger than 15. [321]
- Any breastfeeding is associated with a 36% reduction (OR = 0.64, 95% CI of 0.51 – 0.81) in the risk of sudden infant death syndrome (SIDS) compared to no breastfeeding (Table 2, row *fff*). [322] The overall incidence of SIDS is 0.00054 (Table 2, row *eee*).[323]

Breastfeeding is associated with the following health benefits for the mother:

- The risk of breast cancer is reduced by 4.3% for each year of breastfeeding. [324] We have assumed a reduced risk of 2.15% for each 6 months of breastfeeding (Table 2, row *jjj*). The lifetime probability of developing (female) breast cancer is 11.5% (Table 2, row *iii*).[325] Breast cancer is associated with a reduced life expectancy of 12.9 years (see Reference Document, Table 2, row *mmm*).
- Any breastfeeding is associated with a 21% reduction (OR = 0.79, 95% CI of 0.68–0.91) in the risk of ovarian cancer compared to no breastfeeding (Table 1-2, row *ppp*). Cumulative breastfeeding of at least 12 months is associated with a 28% reduction (OR = 0.72, 95% CI of 0.54–0.97) in the risk of ovarian cancer compared to no breastfeeding. [326] Ovarian cancer is associated with a reduced life expectancy of 16.5 years (see reference Document, Table 2, row *sss*).

[318] Chung M, Raman G, Trikalinos T et al. Interventions in primary care to promote breastfeeding: an evidence review for the US Preventive Services Task Force. *Annals of Internal Medicine*. 2008; 149(8): 565-82.
[319] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.
[320] Chung M, Raman G, Trikalinos T et al. Interventions in primary care to promote breastfeeding: an evidence review for the US Preventive Services Task Force. *Annals of Internal Medicine*. 2008; 149(8): 565-82.
[321] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.
[322] Chung M, Raman G, Trikalinos T et al. Interventions in primary care to promote breastfeeding: an evidence review for the US Preventive Services Task Force. *Annals of Internal Medicine*. 2008; 149(8): 565-82.
[323] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.
[324] Chung M, Raman G, Trikalinos T et al. Interventions in primary care to promote breastfeeding: an evidence review for the US Preventive Services Task Force. *Annals of Internal Medicine*. 2008; 149(8): 565-82.
[325] Canadian Cancer Society's Advisory Committee on Cancer Statistics. *Canadian Cancer Statistics 2014*. 2014. Canadian Cancer Society. Available at www.cancer.ca/statistics. Accessed February 2015.
[326] Chung M, Raman G, Trikalinos T et al. Interventions in primary care to promote breastfeeding: an evidence review for the US Preventive Services Task Force. *Annals of Internal Medicine*. 2008; 149(8): 565-82.

- Other assumptions used in assessing the clinically preventable burden are detailed in the Reference Document.

Based on these assumptions, the CPB associated with interventions aimed at improving rates of exclusive breastfeeding at 6 months from 0% to 60% is 9,291 QALYs (Table 2, row *vvv*).

Table 2: CPB of Promotion of Breastfeeding in a Birth Cohort of 40,000

Row Label	Variable	Base Case	Data Source
a	Infants in birth cohort	40,000	
b	Current proportion exclusively breastfed for 6 months	41%	√
c	Number exclusively breastfed for 6 months	16,400	= (a * c)
d	Effectiveness of breastfeeding promotion interventions in increasing adherence to breastfeeding for 6 months	44%	√
e	Increase in exclusive 6-month breastfeeding with 100% adherence	10,384	= (a - c) * d
f	Estimated adherence with intervention	75%	Assumed
g	Increase in exclusive 6-month breastfeeding with intervention	7,788	= (e * f)
h	Total proportion exclusively breastfed for 6 months with intervention	60%	= (c + g)/a
	Health Benefits for the Infant		
i	Average life expectancy of an infant in BC	82.4	√
j	Average cases of otitis media (OM) in first year	1.90	√
k	Effectiveness of breastfeeding in reducing risk of OM	40.0%	√
l	Reduced cases of OM with intervention	5,919	= (g * j) * k
m	Average cases of atopic dermatitis (AD) in first 2 years	0.165	√
n	Effectiveness of breastfeeding in reducing risk of AD	42.0%	√
o	Reduced cases of AD with intervention	540	= (g * m) * n
p	Average cases of gastrointestinal infection (GI) in first year	0.222	√
q	Effectiveness of breastfeeding in reducing risk of GI	64.0%	√
r	Reduced cases of GI with intervention	1,107	= (g * p) * q
s	Average cases of lower respiratory tract infection (LTRI) in first year	0.041	√
t	Effectiveness of breastfeeding in reducing risk of LTRI	72.0%	√
u	Reduced cases of LTRI with intervention	229	= (g * s) * t
v	Average rate of death due to LTRI	0.0000732	√
w	Effectiveness of breastfeeding in reducing risk of LTRI	72.0%	√
x	Reduced deaths due to LTRI with intervention	0.41	= (g * v) * w
y	Life years gained with intervention	33.8	= x * i
z	Average cases of childhood asthma	0.127	√
aa	Effectiveness of breastfeeding in reducing risk of asthma	27.0%	√
bb	Reduced cases of asthma with intervention	267	= (g * z) * aa
cc	Average rate of death due to asthma	0.0000027	√
dd	Effectiveness of breastfeeding in reducing risk of asthma	27.0%	√
ee	Reduced deaths due to asthma with intervention	0.01	= (g * cc) * dd
ff	Life years gained with intervention	0.5	= ee * i
gg	Average % of years as overweight	30.1%	Table 1-1
hh	Effectiveness of breastfeeding in reducing risk of overweight	24%	√
ii	Reduced years as overweight with intervention	46,351	= g * i * gg* hh
jj	% of life years lost with overweight	0.73%	√
kk	Life years gained with intervention	338	= ii * jj
ll	Average % of years as obese	20.0%	Table 1
mm	Effectiveness of breastfeeding in reducing risk of obesity	24%	√
nn	Reduced years as obese with intervention	30,764	= g * i * ll* mm
oo	% of life years lost with obesity	6.07%	√
pp	Life years gained with intervention	1,867	= nn * oo
qq	Average cases of type 1 diabetes in children	0.0001860	√
rr	Effectiveness of breastfeeding in reducing risk of type 1 diabetes	19.0%	√
ss	Reduced cases of type 1 diabetes with intervention	0.28	= (g * qq) * rr
tt	Average rate of death due to type 1 diabetes	0.0000012	√
uu	Effectiveness of breastfeeding in reducing risk of type 1 diabetes	19.0%	√
vv	Reduced deaths due to type 1 diabetes with intervention	0.002	= (g * tt) * uu
ww	Life years gained with intervention	0.15	= vv * i

Table 2: CPB of Promotion of Breastfeeding in a Birth Cohort of 40,000			
Row Label	**Variable**	**Base Case**	**Data Source**
xx	Average cases of childhood leukemia	0.0000321	√
yy	Effectiveness of breastfeeding in reducing risk of childhood leukemia	24.0%	√
zz	Reduced cases of childhood leukemia with intervention	0.06	= (g * xx) * yy
aaa	5 year death rate due to childhood leukemia	39.8%	√
bbb	Effectiveness of breastfeeding in reducing risk of childhood leukemia	24.0%	√
ccc	Reduced deaths due to childhood leukemia with intervention	0.006	= zz * aaa * bbb
ddd	Life years gained with intervention	0.47	= ccc * i
eee	Average rate of death due to Sudden Infant Death Syndrome (SIDS)	0.00054	√
fff	Effectiveness of breastfeeding in reducing risk of SIDS	36.0%	√
ggg	Reduced deaths due to SIDS with intervention	1.514	= (g * eee) * fff
hhh	Life years gained with intervention	124.8	= ggg * i
	Health Benefits for the Mother		
iii	Lifetime probability of developing breast cancer	11.5%	√
jjj	Effectiveness of breastfeeding in reducing risk of breast cancer	2.15%	√
kkk	Reduced breast cancer cases due to intervention	19.3	= (g * iii) * jjj
lll			
mmm	Life years lost per breast cancer	12.9	Ref Doc
nnn	Life years gained with intervention	248.4	= kkk * mmm
ooo	Lifetime probability of developing ovarian cancer	1.4%	√
ppp	Effectiveness of breastfeeding in reducing risk of ovarian cancer	21%	√
qqq	Reduced ovarian cancer cases due to intervention	22.9	= (g * ooo) * ppp
rrr			
sss	Life years lost per ovarian cancer	16.5	Ref Doc
ttt	Life years gained with intervention	377.8	= qqq * sss
uuu	**Potential QALYs gained, Intervention increasing from 41% to 60%**	**2,992**	= y + ff + kk + pp + ww + ddd + hhh + nnn + ttt
vvv	**Potential QALYs gained, Intervention increasing from 0% to 60%**	**9,291**	=(uuu/g) * (c+g)

√ = Estimates from the literature

We also modified a number of major assumptions and recalculated the CPB as follows:

- Assume the effectiveness of interventions aimed at improving rates of exclusive breastfeeding at 6 months is reduced from 44% to 13% (Table 2, row *d*): CPB = 7,184 QALYs
- Assume the effectiveness of interventions aimed at improving rates of exclusive breastfeeding at 6 months is increased from 44% to 84% (Table 2, row *d*): **CPB = 12,011 QALYs**
- Assume the effectiveness of breastfeeding in reducing overweight and obesity is reduced from 24% to 14% (Table 2, row *hh* & *mm*): **CPB = 6,437 QALYs**
- Assume the effectiveness of breastfeeding in reducing overweight and obesity is increased from 24% to 33% (Table 2, row *hh* & *mm*): CPB = 11,860 QALYs

Modelling Cost-Effectiveness

In this section, we will calculate the CPB associated with interventions aimed at improving longer term (6 months) exclusive breastfeeding rates in a British Columbia birth cohort of 40,000.

In modelling CE, we made the following assumptions:

- **Patient time costs for office visit** – We assumed that two hours of patient time would be required, including travel to and from the appointment.
- **Patient time costs for breastfeeding support groups** - We assumed that a new mother would attend a breastfeeding support group once per month (lasting two hours) for six months. We assumed an additional hour for travel time for a total patient time commitment of 18 hours.
- **Otitis media** - Two estimates from the US suggest a direct cost (ambulatory care and antibiotics) per case of $156 (2007 USD)[327] and $106 (2004 USD).[328] A Canadian study suggested additional hospital costs over and above physician and drug costs of 15.6%.[329] We have converted the $156 to 2022 Canadian dollars and then added 15.6% to this cost per case to reflect hospital costs for a total cost per case of $200 (Table 3, row *p*).
- **Atopic dermatitis** - The mean duration of atopic dermatitis is 10 years with 45% of cases being mild in severity, 45% moderate and 10% severe.[330] The direct annual costs per mild, moderate and severe case are $175, $300, and $405, respectively. The average weighted cost totalled $254 CAD in 2001[331] or $382 (in 2022 CAD) per case per year. Lifetime costs were estimated at $3,820 (Table 3, row *s*).
- **Gastrointestinal infection** - A US study suggests the direct costs for gastrointestinal infections and lower respiratory tract infections are $331 per case (in 1995 USD)[332] or $472 in 2022 CAD (Table 3, rows *v*).
- **Lower respiratory tract infection** - See above (Table 3, rows y).
- **Asthma** - A BC study estimated the annual direct costs attributable to asthma at $444 per person year (in 2006 CAD)[333] or $585 in 2022 CAD. Based on an average treatment duration of 10 years,[334] the total costs attributable to childhood asthma would be $5,850 per case (Table 3, row *bb*).
- **Type 1 diabetes** - The lifetime cost per case in the US has been estimated at $77,463 (in 2007 USD)[335] or $85,771 in 2022 CAD (Table 3, row *kk*).

[327] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.
[328] Zhou F, Shefer A, Kong Y et al. Trends in acute otitis media-related health care utilization by privately insured young children in the United States, 1997–2004. *Pediatrics*. 2008; 121(2): 253-60.
[329] Coyte PC, Asche CV and Elden LM. The economic cost of otitis media in Canada. *International Journal of Pediatric Otorhinolaryngology*. 1999; 49(1): 27-36.
[330] Barbeau M and Bpharm HL. Burden of atopic dermatitis in Canada. *International Journal of Dermatology*. 2006; 45(1): 31-6.
[331] Ibid.
[332] Ball TM and Wright AL. Health care costs of formula-feeding in the first year of life. *Pediatrics*. 1999; 103(Suppl. 1): 870-6.
[333] Sadatsafavi M, Lynd L, Marra C et al. Direct health care costs associated with asthma in British Columbia. *Canadian Respiratory Journal*. 2010; 17(2): 74-80.
[334] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.
[335] Ibid.

- **Childhood leukemia** - The lifetime cost per case in the US has been estimated at $136,444 (in 2007 USD)[336] or $151,078 in 2022 CAD (Table 3, row *nn*).
- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the CE associated with interventions aimed at improving rates of exclusive breastfeeding at 6 months is cost-saving (Table 3, row *bbb*).

[336] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.

Table 3: CE of Promotion of Breastfeeding in a Birth Cohort of 40,000			
Row Label	**Variable**	**Base Case**	**Data Source**
a	Infants in birth cohort	40,000	
b	Proportion already exclusively breastfeeding for 6 months	41%	Table 2, row b
c	Number exclusively breastfeeding for 6 months	16,400	= a * b
d	Women eligible for intervention (support group)	23,600	= a - c
e	Estimated adherence with intervention	75%	Assumed
f	Women attending intervention (support group)	17,700	= d * f
g	Effectiveness of breastfeeding promotion interventions in increasing adherence to breastfeeding for 6 months	44%	Table 2, row d
h	# of women attending intervention (support group) who exclusively breastfeed for 6 months	7,788	= f * g
	Costs of intervention		
i	Cost of 10-minute office visit	$35.97	Ref Doc
j	Value of patient time and travel for office visit	$74.32	=2 * $37.16
k	Portion of 10-minute office visit for screen/referral	50%	Ref Doc
l	Estimated cost of screening	$2,205,800	= a * (l + j) * k
m	Value of patient time and travel for intervention	$669	=18 * $37.16
n	Estimated cost of intervention over lifetime of birth cohort	$11,839,176	= f * m
	Cost avoided		
o	Cases of otitis media avoided	5,919	Table 2, row l
p	Cost per case	$200	v
q	Costs avoided	$1,183,776	= o * p
r	Cases of atopic dermatitis avoided	540	Table 2, row o
s	Cost per person with atopic dermatitis	$3,820	v
t	Costs avoided	$2,061,686	= r * s
u	Cases of gastrointestinal infection avoided	1,107	Table 2, row r
v	Cost per case	$472	v
w	Costs avoided	$522,277	= u * v
x	Cases of lower respiratory tract infection avoided	229	Table 2, row u
y	Cost per case	$462	v
z	Costs avoided	$105,956	= x * y
aa	Cases of asthma avoided	267	Table 2, row bb
bb	Cost per case	$5,230	v
cc	Costs avoided	$1,396,674	= aa * bb
dd	Years of overweight avoided	46,351	Table 2, row ii
ee	Cost per year	$258	Ref Doc
ff	Costs avoided	$11,958,554	= dd * ee
gg	Years of obesity avoided	30,764	Table 2, row nn
hh	Cost per year	$915	Ref Doc
ii	Costs avoided	$28,148,918	= gg * hh
jj	Cases of type 1 diabetes avoided	0.3	Table 2, row ss
kk	Cost per case	$85,771	v
ll	Costs avoided	$23,607	= jj * kk
mm	Cases of childhood leukemia avoided	0.06	Table 2, row zz
nn	Cost per case	$151,078	v
oo	Costs avoided	$9,064	= mm * nn
pp	Cases of breast cancer avoided	19.3	Table 2, row kkk
qq	Cost per case	$33,128	Ref Doc
rr	Costs avoided	$637,907	= pp * qq
ss	Cases of ovarian cancer avoided	22.9	Table 2, row qqq
tt	Cost per case	$93,913	Ref Doc
uu	Costs avoided	$2,150,300	= ss * tt
	CE calculation		
vv	Cost of intervention over lifetime of birth cohort	$14,044,976	= l + n
ww	Costs avoided	$48,198,718	= q + t + w + z + cc + ff + ii + ll + oo + rr + uu
xx	QALYs saved	2,992	Table 2, row uuu
yy	Cost of intervention over lifetime of birth cohort (1.5% discount)	$14,044,976	Calculated
zz	Costs avoided (1.5% discount)	$30,063,495	Calculated
aaa	QALYs saved (1.5% discount)	1,748	Calculated
bbb	**CE ($/QALY saved)**	**-$9,162**	= (yy-zz)/aaa

v = Estimates from the literature

We also modified several major assumptions and recalculated the cost per QALY as follows:

- Assume the effectiveness of interventions aimed at improving rates of exclusive breastfeeding at 6 months is reduced from 44% to 13% (Table 2, row *d*): **CE = $9,995 per QALY**
- Assume the effectiveness of interventions aimed at improving rates of exclusive breastfeeding at 6 months is increased from 44% to 84% (Table 2, row *d*): **CE =** Cost-saving
- Assume the effectiveness of breastfeeding in reducing overweight and obesity is reduced from 24% to 14% (Table 2, rows *hh* & *mm*): CE = Cost-saving
- Assume the effectiveness of breastfeeding in reducing overweight and obesity is increased from 24% to 33% (Table 2, rows *hh* & *mm*): CE = Cost-saving
- Assume the proportion of an office visit required for screening/referral is reduced from 50% to 33% (Table 3, row *k)*: CE = Cost-saving
- Assume the proportion of an office visit required for screening/referral is increased from 50% to 67% (Table 3, row *k)*: CE = Cost-saving

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with interventions aimed at improving rates of exclusive breastfeeding at 6 months is estimated to be 5,430 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be cost-saving (see Table 4).

Table 4: Promotion of Breastfeeding in a Birth Cohort of 40,000
Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume No Current Service			
1.5% Discount Rate	**5,430**	3,762	7,019
3% Discount Rate	3,442	2,385	4,450
0% Discount Rate	9,291	6,437	12,011
Gap between B.C. Current and Best in the World			
1.5% Discount Rate	**1,748**	1,211	3,388
3% Discount Rate	1,108	768	2,116
0% Discount Rate	2,992	2,073	5,711
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**Cost-saving**	Cost-saving	$9,995
3% Discount Rate	Cost-saving	Cost-saving	$24,290
0% Discount Rate	Cost-saving	Cost-saving	Cost-saving
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	Cost-saving	Cost-saving	Cost-saving
3% Discount Rate	Cost-saving	Cost-saving	Cost-saving
0% Discount Rate	Cost-saving	Cost-saving	Cost-saving

Canadian Task Force on Preventive Health Care Recommendations (2017)

*We recommend asking children and youth (age 5–18 yr.) or their parents about tobacco use by the child or youth and offering brief information and advice, as appropriate, during primary care visits to **prevent** tobacco smoking among children and youth (weak recommendation, low-quality evidence).*

*We recommend asking children and youth (age 5–18 yr.) or their parents about tobacco use by the child or youth and offering brief information and advice, as appropriate, during primary care visits to **treat** tobacco smoking among children and youth (weak recommendation, low-quality evidence).*[337]

United States Preventive Services Task Force Recommendations (2020)

*The USPSTF recommends that primary care clinicians provide interventions, including education or brief counseling, to **prevent** initiation of tobacco use among school-aged children and adolescents (ages 5-17 yr.) (B Recommendation)*

*The USPSTF concludes that the current evidence is insufficient to assess the balance of benefits and harms of primary care–feasible interventions for the **cessation** of tobacco use among school-aged children and adolescents (ages 5-17 yr.) (I Recommendation)*[338]

Other Approaches to Prevention

In the review of the evidence for the 2013 recommendation,[339] the USPSTF noted that the 2012 Surgeon General's Report concluded that there is a "large, robust, and consistent" evidence base that documents known effective strategies for reducing tobacco use among youth and young adults.[340] These strategies include coordinated, multi-component approaches that combine media campaigns, price increases, school-based policies and programs and community-wide changes in policies and norms. The purpose of the USPSTF review was not to reconsider the evidence covered by the Surgeon General's Report, but rather "to review the evidence for the efficacy and harms of **primary-care relevant interventions** (emphasis added) that aim to reduce tobacco use among children and adolescents."[341]

[337] Canadian Task Force on Preventive Health Care. Recommendations on behavioural interventions for the prevention and treatment of cigarette smoking among school-aged children and youth. *Canadian Medical Association Journal*. 2017; 189 (8): E310-16.

[338] US Preventive Service Task Force. Primary care interventions for prevention and cessation of tobacco use in children and adolescents: US Preventive Services Task Force recommendation statement. *JAMA*. 2020; 323(16): 1590-98.

[339] Patnode CD, O'Connor E, Whitlock EP et al. Primary care-relevant interventions for tobacco use prevention and cessation in children and adolescents: a systematic evidence review for the U.S. Preventive Services Task Force. *Annals of Internal Medicine*. 2013; 158(4): 253-60.

[340] U.S. Department of Health and Human Services. *Preventing Tobacco Use Among Youth and Young Adults: A Report of the Surgeon General*. 2012. Available at http://www.cdc.gov/tobacco/data_statistics/sgr/2012/consumer_booklet/pdfs/consumer.pdf. Accessed January 2014.

[341] Patnode CD, O'Connor E, Whitlock EP et al. Primary care-relevant interventions for tobacco use prevention and cessation in children and adolescents: a systematic evidence review for the U.S. Preventive Services Task Force. *Annals of Internal Medicine*. 2013; 158(4): 253-60.

Use of E-Cigarettes

The 2017 CTFPHC report states that "this guideline does not address smokeless tobacco or e-cigarettes".[342] They note, however, that "the number of children and youth trying e-cigarettes is increasing, and one in five youth 15-19 years of age have tried them."[343]

The 2020 USPSTF report does include the use of e-cigarettes in its updated guidelines, noting that "although conventional cigarette use has gradually declined among children in the US since the late 1990s, tobacco use via electronic cigarettes (e-cigarettes) is quickly rising and is now more common among youth than cigarette smoking. E-cigarette products usually contain nicotine, which is addictive, raising concerns about e-cigarette use and nicotine addiction in children. Exposure to nicotine during adolescence can harm the developing brain, which may affect brain function and cognition, attention, and mood; thus, minimizing nicotine exposure from any tobacco product in youth is important."[344]

Furthermore, the 2020 USPSTF report notes that "most of the evidence on behavioral counseling interventions to prevent tobacco use focused on prevention of cigarette smoking. Given the similar contextual and cultural issues currently surrounding the use of e-cigarettes in youth and the inclusion of e-cigarettes as a tobacco product by the FDA, the USPSTF concludes that the evidence on interventions to prevent cigarette smoking could be applied to prevention of e-cigarette use as well. The USPSTF also concludes that the evidence could be applied to prevention of cigar use, which includes cigarillos and little cigars."[345]

Best in the World

- In Oregon, 87.4% of adolescents ages 10-17 who visited a primary care provider between January 1, 2016 and December 31, 2017 had their smoking status assessed.[346]

- In Florida, 92.3% of adolescents ages 11-17 who visited a primary care provider between July 2016 and November 2017 were asked about their current cigarette smoking. Just over half (51.4%) were asked about their current use of smokeless tobacco but none were asked about their use of electronic nicotine delivery systems (ENDS).[347]

- In a national US sample of adolescents ages 12 to 17, 45.2% of those who screened positive for current cigarette smoking were advised by their clinician to quit smoking.[348]

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[342] Canadian Task Force on Preventive Health Care. Recommendations on behavioural interventions for the prevention and treatment of cigarette smoking among school-aged children and youth. *Canadian Medical Association Journal*. 2017; 189 (8): E310-16.
[343] Ibid.
[344] US Preventive Service Task Force. Primary care interventions for prevention and cessation of tobacco use in children and adolescents: US Preventive Services Task Force recommendation statement. *JAMA*. 2020; 323(16): 1590-98.
[345] US Preventive Service Task Force. Primary care interventions for prevention and cessation of tobacco use in children and adolescents: US Preventive Services Task Force recommendation statement. *JAMA*. 2020; 323(16): 1590-98.
[346] Bailey S, Fankhosuer K, Marino M et al. Smoking assessment and current smoking status among adolescents in primary care. *Nicotine & Tobacco Research*. 2020; 22(11): 2098-2103.
[347] LeLaurin J, Theis R, Thompson L et al. Tobacco-related counselling and documentation in adolescent primary care practice: Challenges and opportunities. *Nicotine & Tobacco Research*. 2020; 22(6): 1023-9.
[348] Merianos A, Mahabee-Gittens E. Screening, counselling, and health care utilization among a national sample of adolescent smokers. *Clinical Paediatrics*. 2020; 59(4-5): 467-75.

- In a survey of 1,050 US pediatric care providers conducted in 2021, 69.4% indicated they screen patients for e-cigarette use, 63.8% counsel e-cigarette prevention and 67% counsel e-cigarette cessation.[349]

- Matheus and colleagues managed to improve screening rates for e-cigarette use from 23% to 89% of 300 adolescents with a health maintenance or sports physical visit between October 2019 and February 2020 in the US.[350]

- For modelling purposes, we have assumed that the best rate in the world for cigarette / e-cigarette screening of children / youth is 92%[351] and 89%[352] of those with a primary health care visit in a given year. Furthermore, 45%[353] and 67%[354] of those found positive for cigarette / e-cigarette use receive counselling to quit.

Modelling the Clinically Preventable Burden

In this section, we model CPB associated with asking children and youth or their parents about tobacco use / e-cigarette use by the child or youth and offering brief information and advice, as appropriate, during primary care visits to prevent and / or treat tobacco smoking and e-cigarette use among children and youth.

Definitions

- "Tobacco products include any product made or derived from tobacco intended for human consumption (except products that meet the definition of drugs), including, but not limited to, cigarettes, cigars (including cigarillos and little cigars), dissolvable tobacco, hookah tobacco, nicotine gels, pipe tobacco, roll-your-own tobacco, smokeless tobacco products (including dip, snuff, snus, and chewing tobacco), vapes, e-cigarettes, hookah pens, and other electronic nicotine delivery systems. 'Smoking' generally refers to the inhaling and exhaling of smoke produced by combustible tobacco products such as cigarettes, cigars, and pipes. 'Vaping' refers to the inhaling and exhaling of aerosols produced by e-cigarettes."[355]

Defining and Estimating the Population at Risk

- "All youth are considered at risk of initiating tobacco use. Interventions to prevent the initiation of tobacco use should be provided to all youth who have not started using tobacco products yet, regardless of the presence or absence of other risk factors. The following risk factors may increase the risk of tobacco use in youth: being male, white race, not college-bound, from a rural area, having parents with lower levels of education, parental smoking, having childhood friends who smoke, being an older

[349] Golden T, VanFrank B, Courtney-Long E. E-cigarette screening and clinical intervention behaviours among pediatric primary care providers, DocStyles 2021. *Paediatrics*. 2022; 149: 740.
[350] Matheus C, Hein N, Narahari P et al. Improving standardized screening for e-cigarette and vaping use among adolescents. *Paediatrics*. 2021; 147 (3-Meeting Abstract): 1002.
[351] LeLaurin J, Theis R, Thompson L et al. Tobacco-related counselling and documentation in adolescent primary care practice: Challenges and opportunities. *Nicotine & Tobacco Research*. 2020; 22(6): 1023-9.
[352] Matheus C, Hein N, Narahari P et al. Improving standardized screening for e-cigarette and vaping use among adolescents. *Paediatrics*. 2021; 147 (3-Meeting Abstract): 1002.
[353] Merianos A, Mahabee-Gittens E. Screening, counselling, and health care utilization among a national sample of adolescent smokers. *Clinical Paediatrics*. 2020; 59(4-5): 467-75.
[354] Golden T, VanFrank B, Courtney-Long E. E-cigarette screening and clinical intervention behaviours among pediatric primary care providers, DocStyles 2021. *Paediatrics*. 2022; 149: 740.
[355] US Preventive Service Task Force. Primary care interventions for prevention and cessation of tobacco use in children and adolescents: US Preventive Services Task Force recommendation statement. *JAMA*. 2020; 323(16): 1590-98.

adolescent, experiencing highly stressful events, and perceiving tobacco use as low risk."[356]

- Based on data from the 2018/19 Canadian Student Tobacco, Alcohol and Drugs Survey (CSTADS), just 0.80% of BC adolescents in grades 7-9 and 4.40% of BC adolescents in grades 10-12 were current smokers. Current smokers includes occasional (smoked at least one cigarette during the past 30 days, but has not smoked every day) and daily (smoke at least one cigarette per day for each of the 30 days preceding the survey) smokers (see Table 1).[357]

Table 1: Cigarette Smoking in British Columbia
Adolescents in Grades 7 to 12
In 2018/19

Grade	Current Smoker	Current Daily Smoker	Current Occasional Smoker
Grades 7-9			
Male	0.88%	0.40%	0.48%
Female	0.72%	0.32%	0.40%
Combined	0.80%	0.36%	0.44%
Grades 10-12			
Male	5.26%	1.53%	3.73%
Female	3.35%	0.96%	2.39%
Combined	4.40%	1.24%	3.16%

Extrapolated based on data for Canada

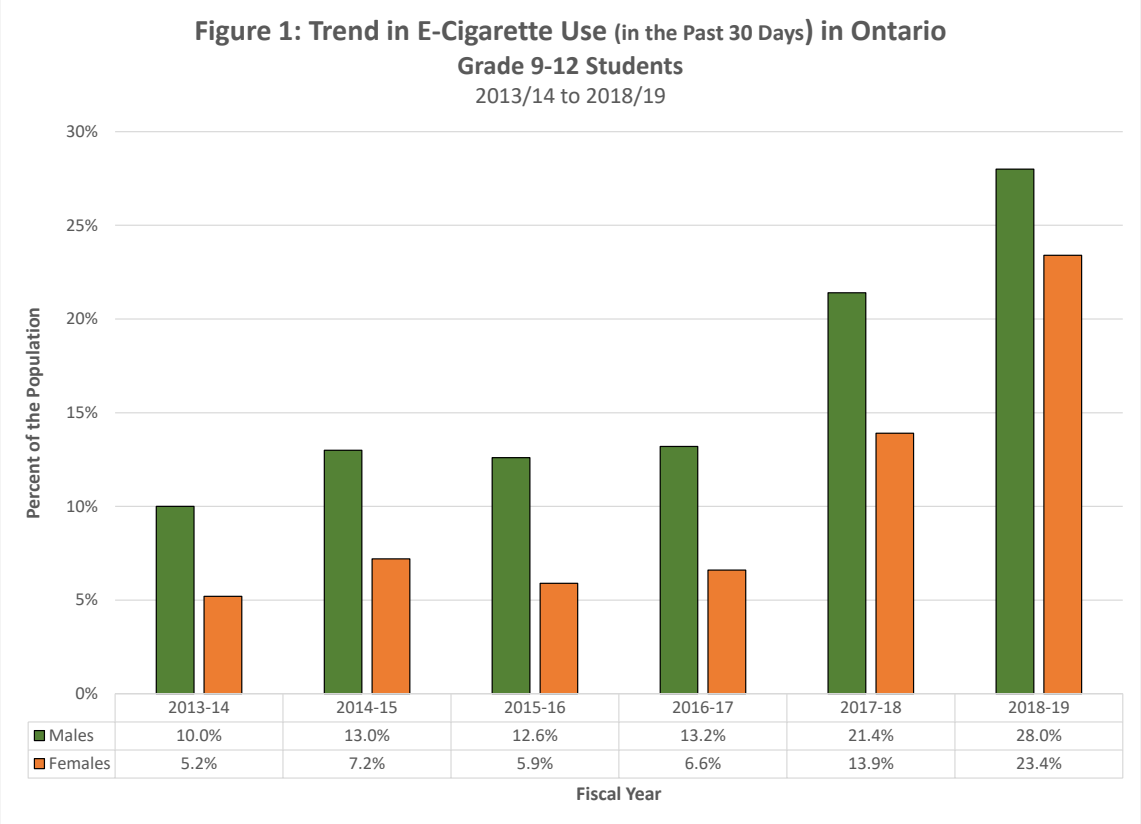
- Across Canada, the proportion of adolescent current smokers ages 12-17 has declined from 4.1% in 2015 to 1.1% in 2021 (see Table 2).[358]

Table 2: Trend in the Proportion of Daily or Occasional Smokers in Canada
Ages 12 - 17
2015 to 2021

Sex	2015	2016	2017	2018	2019	2020	2021
Males	4.3%	3.9%	2.7%	3.3%	2.5%	2.3%	1.3%
Females	4.0%	3.3%	4.3%	3.0%	2.5%	1.3%	1.0%
Total	**4.1%**	**3.6%**	**3.5%**	**3.2%**	**2.5%**	**1.8%**	**1.1%**

[356] US Preventive Service Task Force. Primary care interventions for prevention and cessation of tobacco use in children and adolescents: US Preventive Services Task Force recommendation statement. *JAMA*. 2020; 323(16): 1590-98.
[357] Canadian Student Tobacco, Alcohol and Drugs Survey 2018-2019, Table 3. Available online at https://www.canada.ca/en/health-canada/services/canadian-student-tobacco-alcohol-drugs-survey/2018-2019-detailed-tables.html#t3. Accessed September 2022.
[358] Statistics Canada, *Smokers by Age Group*. Available online at https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310009610&pickMembers%5B0%5D=1.1&pickMembers%5B1%5D=3.1&cubeTimeFrame.startYear=2015&cubeTimeFrame.endYear=2021&referencePeriods=20150101%2C20210101. Accessed September 2022.

- In 2018 in BC among the 19% of children / youth aged 12-19 who had ever smoked tobacco, the age they first tried smoking was as follows:[359]
    - Less than 9 Years old – 5%
    - 9 – 2%
    - 10 – 3%
    - 11 – 3%
    - 12 – 8%
    - 13 – 14%
    - 14 – 19%
    - 15 – 20%
    - 16 – 17%
    - 17 or older – 10%
- While cigarette smoking among adolescents has decreased, use of e-cigarettes has increased dramatically. In Ontario, for example, the rate of e-cigarette use in male adolescents increased almost 3-fold during the six year period between 2013/14 and 2018/19. In female adolescents, the rate of increase during that time was even higher, at greater than 4-fold (see Figure 1).[360]



[359] Smith A, Peled M, Poon C et al. *Understanding Tobacco Use and Vaping among BC Youth: Findings from the BC Adolescent Health Survey.* 2020. Vancouver, BC: McCreary Centre Society.
[360] Cole A, Aleyan S, Battista K et al. Trends in youth e-cigarette and cigarette use between 2013 and 2019: Insights from repeat cross-sectional data from the COMPASS study. *Canadian Journal of Public Health*. 2021; 112: 60-69.

- In BC, the proportion of adolescents in grades 10-12 who had ever tried e-cigarettes increased from 34.3% in 2016/17 to 56.6% in 2018/19. Daily or almost daily use increased even more dramatically in the cohort, from 2.5% in 2016/17 to 11.6% in 2018/19 (see Table 3).[361]

Table 3: Use of E-Cigarettes in British Columbia
Adolescents in Grades 7 - 12

	In 2016/17			*In 2018/19*		
	Ever Tried	Past 30-Day Use	Daily or Almost Daily Use	Ever Tried	Past 30-Day Use	Daily or Almost Daily Use
Grades 7-9						
Male	13.1%	6.4%	1.1%	23.9%	15.0%	2.7%
Female	10.9%	5.9%	0.3%	26.1%	15.8%	2.2%
Combined	**12.0%**	**6.1%**	**0.7%**	**25.0%**	**15.4%**	**2.5%**
Grades 10-12						
Male	38.6%	23.4%	4.0%	56.9%	40.3%	13.9%
Female	29.9%	12.6%	1.0%	56.4%	36.7%	9.3%
Combined	**34.3%**	**18.1%**	**2.5%**	**56.6%**	**38.5%**	**11.6%**

- In BC, 29% of children / youth ages 12-19 used at least one nicotine-related product in the month prior to completing the 2018 BC Adolescent Health Survey. The proportion of youth that used each product was as follows:[362]
    - Vape pen/stick – 27%
    - Cigarettes – 7%
    - Cigars/cigarillos – 3%
    - Chewing tobacco – 2%
    - A hookah – 2%

[361] Data for 2016/17 is from the Canadian Student Tobacco, Alcohol and Drugs Survey 2016-2017, Tables 5 & 6. Available online at https://www.canada.ca/en/health-canada/services/canadian-student-tobacco-alcohol-drugs-survey/2016-2017-supplementary-tables.html#t6.
Data for 2018/19 is from the Canadian Student Tobacco, Alcohol and Drugs Survey 2018-2019, Tables 5 & 6. Available online at https://www.canada.ca/en/health-canada/services/canadian-student-tobacco-alcohol-drugs-survey/2018-2019-detailed-tables.html#t3.
Accessed September 2022.

[362] Smith A, Peled M, Poon C et al. *Understanding Tobacco Use and Vaping among BC Youth: Findings from the BC Adolescent Health Survey.* 2020. Vancouver, BC: McCreary Centre Society.

- Not only are more adolescents using e-cigarettes but the intensity of use is also increasing.[363] Of US high school students who used e-cigarettes in 2019, 34.2% used them at least 20 out of the past 30 days (see Table 4).[364]

Table 4: Frequency of Tobacco Product Use During the Past 30 Days
Among US High School Students
By Product, 2019

	Days of Use		
	1-5	6-19	20-30
E-cigarettes	46.4%	19.4%	34.2%
Cigars	68.6%	14.1%	17.3%
Cigarettes	51.5%	16.0%	32.5%
Smokeless tobacco	44.0%	18.0%	37.9%
Hookahs	69.2%	13.2%	17.6%

- Among US youth, the initiation of e-cigarette use, in particular "fairly regular use", tends to peak at ages 17-18 (see Table 5).[365]

Table 5: Cumulative Proportion of US Youth Who Initiate e-Cigarette Use
By Age and e-Cigarette Use Outcome
During 2013 to 2017

Age	Ever Use	Past 30-Day Use	Fairly Regular Use *
13	3.0%	0.8%	0.45%
14	6.6%	2.3%	1.0%
15	11.7%	4.4%	2.2%
16	18.6%	7.4%	3.8%
17	30.4%	13.1%	6.6%
18	41.7%	23.5%	10.3%

** Based on the question "Have you ever used electronic nicotine products fairly regularly?"*

[363] Glantz S, Jeffers A, Winickoff J. Nicotine addiction and intensity of e-cigarette use by adolescents in the US, 2014 to 2021. *JAMA Network Open*. 2022; 5(11): e2240671.
[364] Wang T, Gentzke A, Creamer M et al. Tobacco product use and associated factors among middle and high school students – United States, 2019. *Morbidity and Mortality Weekly Report*. December 6, 2019; 68(12): 1-22.
[365] Perez A, Bluestein M, Chen B et al. Prospectively estimating the age of initiation of e-cigarettes among U.S. youth: Finding from the Population Assessment of Tobacco and Health (PATH) study, 2013-2017. *Journal of Journal of Biometrics and Biostatistics.* 2020; Volume 11(3): DOI: 10.37421/jbmbs.2020.11.44211

- Based on data from the 2019 Canadian Tobacco and Nicotine Survey,[366] the proportion of current smokers across Canada increased from 5.1% for those ages 15-19 to 13.3% for those ages 20-24, stabilizing at 13.3% between the ages of 25-45 and then declining modestly to 12.0% for those over the age of 45 (see Table 6). The proportion of the population reporting vaping during the past 30 days remained fairly constant between the ages of 15-24, dropping significantly thereafter (see Table 6).

Table 6: Smoking and Vaping Status
By Age Group and Sex
Canada, 2019

Sex	Age Group	Current Smoker	Former Smoker	Never Smoker	Vaping*
Male					
	15-19	6.0%	NA	92.6%	16.1%
	20-24	15.3%	8.6%	76.0%	18.0%
	25-44	13.7%	30.0%	69.4%	6.7%
	45+	12.9%	38.1%	49.0%	1.9%
	Total	**12.7%**	**26.0%**	**61.4%**	**5.8%**
Female					
	15-19	NA	NA	95.0%	13.6%
	20-24	10.6%	NA	88.0%	11.8%
	25-44	12.8%	17.3%	69.9%	3.3%
	45+	11.3%	32.2%	56.6%	1.3%
	Total	**11.1%**	**23.0%**	**65.9%**	**3.6%**
Total					
	15-19	5.1%	NA	93.4%	15.1%
	20-24	13.3%	5.2%	81.5%	15.2%
	25-44	13.3%	17.1%	17.1%	5.0%
	45+	12.0%	35.1%	35.1%	1.6%
	Total	**11.9%**	**24.5%**	**63.7%**	**4.7%**

*Notes: NA = not available; * Past 30-day use*

[366] Health Canada. *Canadian Tobacco and Nicotine Survey: 2019 Detailed Tables*. Available online at https://www.canada.ca/en/health-canada/services/canadian-tobacco-nicotine-survey/2019-summary/2019-detailed-tables.html#t1. Accessed September 2022.

E-Cigarette Use and Subsequent Cigarette Smoking

- Only a minority of adolescents (7.8%)[367] or young adults (12.8%)[368] who use e-cigarettes report using them for the purpose of smoking cessation.
- Among baseline adolescent never smokers, e-cigarette users have a much higher odds of subsequent **infrequent** (OR=4.27, 95% CI 2.75 – 6.62) or **frequent** (OR=3.51, 95% CI 1.97 – 6.24) cigarette use than never smokers who do not use e-cigarettes.[369]
- The probability of cigarette smoking initiation by an adolescent **ever** e-cigarette user is 30.4% vs. 7.9% by an adolescent **never** e-cigarette user, an odds ratio of 3.62 (95% CI of 2.42 to 5.41).[370]
- Soneji and co-authors suggest three possible reasons for this high level of cigarette smoking initiation by an adolescent ever e-cigarette user. First, e-cigarette use mimics the behavioral scripts of cigarette smoking. Second, adolescents and young adults who use nicotine-containing e-cigarettes may become addicted to nicotine because e-cigarette aerosol contains highly oxidizing free-base nicotine - the most addictive form of nicotine - that is easily absorbed by the body. And third, e-cigarette use may activate cognitive or behavioral processes that increase the risk of smoking.[371]

Harms Associated with E-Cigarette Use in Children and Youth

In addition to a higher risk of converting to conventional cigarette use, e-cigarette use in children and youth is also associated with a number of other harms.

- In a longitudinal study of 17,073 children with an average initial age of 9.9 years, ever-use of tobacco products, including e-cigarettes, was associated with inferior cognitive performance and reduced brain structure with sustained effects for at least two years.[372]
- Based on data from the 2016/17 US Behavioral Risk Factor Surveillance System, Obisesan and colleagues found that former e-cigarette users had a 1.60-fold (95% CI, 1.54-1.67) higher odds of reporting a history of clinical diagnosis of depression than never users, whereas current e-cigarette users had 2.10 (95% CI, 1.98-2.23) times higher odds. Additionally, higher odds of reporting depression were observed with increased frequency of use among current e-cigarette users compared with never

[367] Tsai J, Walton K, Coleman B et al. Reasons for electronic cigarette use among middle and high school students – National Youth Tobacco Survey, United States, 2016. *Morbidity and Mortality Weekly Report*. 2018; 67(6): 196-200.
[368] Hong H, Liu F, Urman R et al. Reasons for electronic cigarette use among South California young adults. In: *Proceedings of the American Thoracic Society International Conference*; May 19-24, 2017; Washington DC.
[369] Barrington-Trimis J, Komg G, Leventhal A et al. E-cigarette use and subsequent smoking frequency among adolescents. *Paediatrics*. 2018; 142(6): e20180486.
[370] Soneji S, Barrington-Trimis J, Wills T et al. Association between initial use of e-cigarettes and subsequent cigarette smoking among adolescents and young adults: A systematic review and meta-analysis. *JAMA Paediatrics*. 2017; 171(8):788-97.
[371] Soneji S, Barrington-Trimis J, Wills T et al. Association between initial use of e-cigarettes and subsequent cigarette smoking among adolescents and young adults: A systematic review and meta-analysis. *JAMA Paediatrics*. 2017; 171(8):788-97.
[372] Dai H, Doucet G, Wang Y et al. Longitudinal assessments of neurocognitive performance and brain structure associated with initiation of tobacco use in children, 2016 to 2021. *JAMA Network Open*. 2022; 5(8): e2225991.

users (**daily use**: OR, 2.39; 95% CI, 2.19-2.61; **occasional use**: OR, 1.96; 95% CI, 1.82-2.10).[373]

- Based on a study of 2,299 high school seniors, McCabe et al found that among users of e-cigarettes, lifetime cigarette smoking, alcohol use, marijuana use, nonmedical prescription drug use and illicit drug use (e.g. cocaine, LSD, heroin) are much higher compared with non-users of e-cigarettes. In particular, early onset of e-cigarette use (by grade 9 or earlier) was associated with an increased odds ratio of 14.2 for lifetime cigarette smoking, 70.6 for lifetime alcohol use, 16.4 for lifetime marijuana use, 9.5 for lifetime nonmedical prescription drug use and 19.2 for lifetime illicit drug use.[374]
- In their 2020 review of the available literature on the cardiovascular risk of e-cigarettes, Buchman and colleagues conclude that "there is growing evidence that e-cigarettes and their aerosol constituents, nicotine, carbonyl compounds, particulate matter, metals, and flavourings, can have adverse effects on the cardiovascular system" and furthermore "while there is a paucity of data, recent studies have also suggested that e-cigarette use is associated with inflammation, oxidative stress, and haemodynamic imbalance leading to increased cardiovascular diseases risk."[375]
- Dual use (combining the use of conventional cigarettes and e-cigarettes) may increase cardiovascular risk when compared with those who use only conventional cigarettes.[376]
- Based on a review of current evidence on the respiratory effects of e-cigarettes, Miyashita and Foley conclude that "e-cigarette exposure can disrupt pulmonary homeostasis, with reports of gas exchange disturbance, reduced lung function, increased airway inflammation and oxidative stress, downregulation of immunity, and increased risk of respiratory infection."[377]
- Based on a systematic review of the available literature on e-cigarette use and oral health, Yang and colleagues found that "the majority of mouth and throat symptoms experienced by e-cigarette users were relatively minor and temporary, with some evidence that conventional smokers who switched to e-cigarettes experienced mitigation of these symptoms. E-cigarette exposure increased the risk for deteriorating periodontal, dental and gingival health as well as changes to the oral microbiome. Extensive dental damage as a result of e-cigarette explosions were described in case reports."[378]
- Based on a systematic review of the available literature, Bjurlina et al found that "biomarkers of carcinogens, several with a strong link to bladder cancer, are present in the urine of e-cigarette users. Long-term implications of urothelial exposure to

[373] Obisesan O, Mirbolouk M, Osei A et al. Association between e-cigarette use and depression in the Behavioral Risk Factor Surveillance System, 2016-2017. *JAMA: Public Health*. 2019; 2(12): e1916800. doi:10.1001/jamanetworkopen.2019.16800.
[374] McCabe S, West B, McCabe V. Associations between early onset of e-cigarette use and cigarette smoking and other substance use among US adolescents: A national study. *Nicotine & Tobacco Research*. 2018; 923-30.
[375] Buchanan N, Grimmer J, Tanwar V et al. Cardiovascular risk of electronic cigarettes: A review of preclinical and clinical studies. *Cardiovascular Research*. 2020; 116: 40-50.
[376] Kim C, Paek Y, Seo H et al. Dual use of electronic and conventional cigarettes is associated with higher cardiovascular risk factors in Korean men. *Scientific Reports*. 2020; 10: 5612.
[377] Miyashital, Foley G. E-cigarettes and respiratory health: the latest evidence. *British Medical Journal*. 2019; 366: 5027-38.
[378] Yang I, Sandeep S, Rodriguez J. The oral health impact of electronic cigarette use: a systematic review. *Critical Reviews in Toxicology*. 2020; 50(2): 97-127.

these toxicants are unknown but concerning, given the similarities to tobacco smoke and its established relationship with bladder cancer."[379]

- Other potential harms include unintentional injuries due to device malfunctions, ingesting e-liquids by young children, nicotine toxicity and withdrawal symptoms.[380]

Estimating the Prevalence of Cigarette Smoking and E-Cigarette Use – No Intervention

- In estimating the number of current female and male adolescent **cigarette smokers** in a BC birth cohort of 40,000 we began with the assumption that 3.35% of females and 5.26% of males in grade 11 were current cigarette smokers (see Table 1). Furthermore, an additional 10%[381] of adolescents would take up cigarette smoking in grade 12 (age 17) for a total of 3.68% of females and 5.79% of males by the end of their 17th year (see Table 7). The % and number of cigarette smokers prior to age 17 is based on the age that BC youth first tried smoking (see Table 7).[382]
- In estimating the number of female and male adolescent **e-cigarette users** in a BC birth cohort of 40,000 we began with the assumption that 15.8% of females age 13 (Grade 8) used e-cigarettes in the past 30 days and 2.2% were daily or almost daily users. The equivalent % for males age 13 is 15.0% and 2.7% (see Table 3). By age 17 (Grade 11) 36.7% / 40.3% of females / males used e-cigarettes in the past 30 days and 9.3% / 13.9% of females / males were daily or almost daily users (see Table 3).
- A significant number of adolescents start e-cigarette use in their 18th year (see Table 5). This increase is reflected in the % and number of e-cigarette users by the end of their 18th year in Table 7.
- Hammond et al estimated that 41.9% of youth in Canada (in 2019) who smoke also vape.[383]
- We assumed that 22.5% of 18 year olds with past 30 day e-cigarette use **who did not smoke** would convert to cigarette smoking by age 24, based on the probability of cigarette smoking initiation by an adolescent **ever** e-cigarette user of 30.4% vs. 7.9% by an adolescent **never** e-cigarette user.[384] The uptake of cigarette smoking by this cohort between the ages of 18 and 24 was assumed to be linear (see Table 7).
- Of exclusive experimental e-cigarette users (past 30 day use but not regular users) at age 18, 10.6% who did not transition to conventional cigarette use would remain exclusive e-cigarette users by age 24. Of exclusive established e-cigarette users

[379] Bjurlina M, Matulewicz R, Roberts T et al. Carcinogen biomarkers in the urine of electronic cigarette users and implications for the development of bladder cancer: A systematic review. *European Urology Oncology*. 2021; 5(4): 766-783.
[380] Chadi N, Vyver E, Belanger R. Protecting children and adolescents against the risks of vaping. *Paediatrics and Child Health*. 2021; 351-65.
[381] Smith A, Peled M, Poon C et al. *Understanding Tobacco Use and Vaping among BC Youth: Findings from the BC Adolescent Health Survey.* 2020. Vancouver, BC: McCreary Centre Society.
[382] Smith A, Peled M, Poon C et al. *Understanding Tobacco Use and Vaping among BC Youth: Findings from the BC Adolescent Health Survey.* 2020. Vancouver, BC: McCreary Centre Society.
[383] Hammond D, reid J, Rynard V et al. Indicators of dependence and efforts to quit vaping among youth in Canada, England and the USA. *Tobacco Control*. 2022; 31: e25-e34.
[384] Soneji S, Barrington-Trimis J, Wills T et al. Association between initial use of e-cigarettes and subsequent cigarette smoking among adolescents and young adults: A systematic review and meta-analysis. *JAMA Paediatrics*. 2017; 171(8):788-97.

(regular use) at age 18, 62.2% who did not transition to conventional cigarette use would remain exclusive e-cigarette users by age 24 (see Table 7).[385]

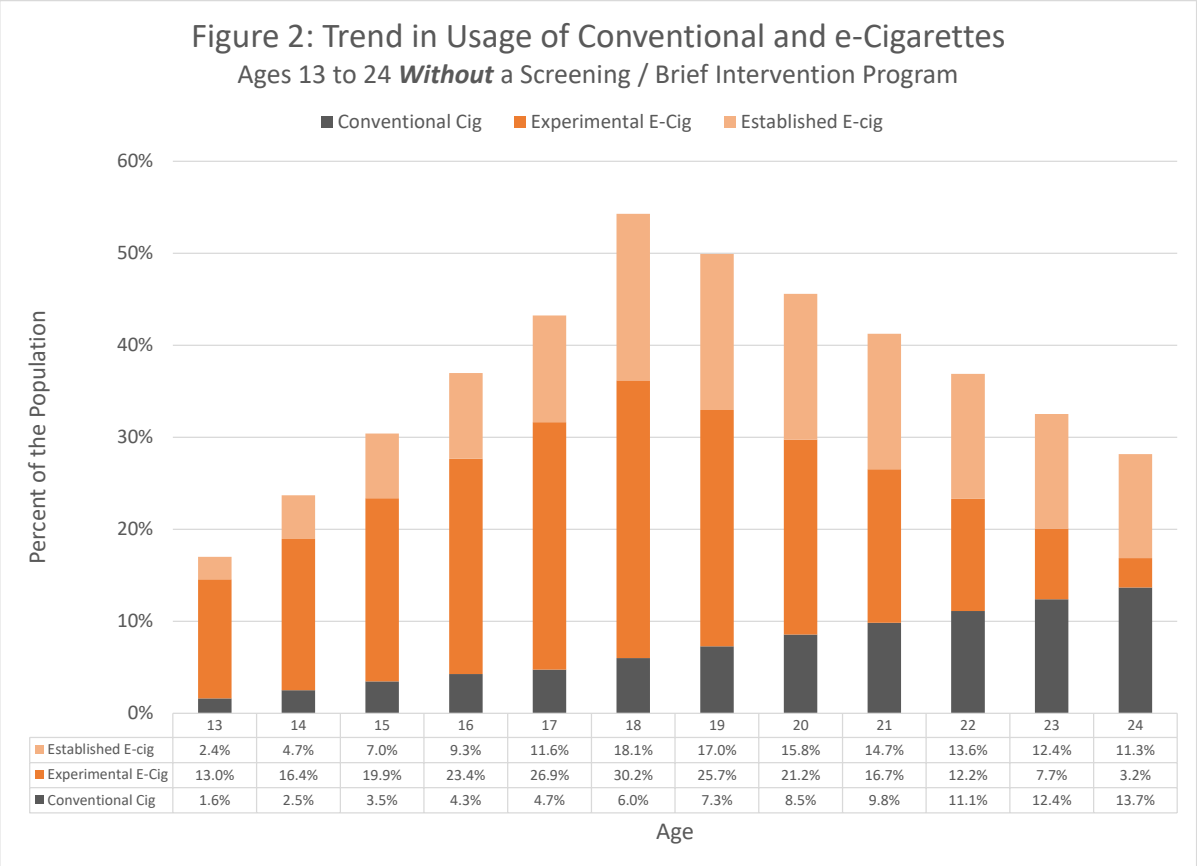
- Based on these assumptions, 5,414 (13.7%) in the BC birth cohort would be current smokers by age 24 (2,627 females [13.2%] and 2,788 males [14.1%]) while a further 5,571 (14.5%) would continue to use e-cigarettes at age 24 (2,527 females [12.7%] and 3,224 males [16.3%]) (see Table 7).

Table 7: Estimated Prevalence of Cigarette Smoking and E-cigarette Use
Between the Ages of 8 and 24
In a British Columbia Birth Cohort of 40,000
Without a Child / Youth Screening Program / Brief Intervention

	Female							*Male*							*Total Population*						
				e-Cigarette Past 30-day Use							*e-Cigarette* Past 30-day Use						*e-Cigarette* Past 30-day Use			
		Cigarette		Excl Regular Use		Regular Use			*Cigarette*		Excl Regular Use		Regular Use			*Cigarette*		Excl Regular Use		Regular Use	
Age	N	%	#	%	#	%	#	N	%	#	%	#	%	#	N	%	#	%	#	%	#
8	19,918	0.15%	29					19,907	0.23%	46					39,824	0.19%	75				
9	19,917	0.22%	44					19,906	0.35%	69					39,822	0.28%	113				
10	19,915	0.33%	66					19,904	0.52%	104					39,820	0.43%	170				
11	19,914	0.44%	88					19,903	0.69%	138					39,817	0.57%	226				
12	19,913	0.74%	147					19,902	1.16%	230					39,815	0.95%	377				
13	19,911	1.25%	249	13.6%	2,708	2.2%	438	19,900	1.97%	391	12.3%	2,448	2.7%	537	39,812	1.6%	641	13.0%	5,156	2.4%	975
14	19,910	1.95%	388	17.0%	3,394	4.0%	791	19,898	3.07%	610	15.8%	3,149	5.5%	1,094	39,808	2.5%	999	16.4%	6,543	4.7%	1,886
15	19,907	2.69%	535	20.5%	4,081	5.7%	1,145	19,896	4.22%	840	19.3%	3,850	8.3%	1,651	39,803	3.5%	1,375	19.9%	7,930	7.0%	2,796
16	19,904	3.31%	660	24.0%	4,767	7.5%	1,498	19,891	5.21%	1,036	22.9%	4,550	11.1%	2,208	39,795	4.3%	1,696	23.4%	9,318	9.3%	3,706
17	19,900	3.68%	733	27.4%	5,454	9.3%	1,851	19,885	5.79%	1,151	26.4%	5,251	13.9%	2,765	39,784	4.7%	1,884	26.9%	10,705	11.6%	4,616
18	19,894	5.04%	1,004	34.6%	6,893	14.5%	2,888	19,876	6.97%	1,385	25.7%	5,104	21.7%	4,313	39,770	6.0%	2,388	30.2%	11,997	18.1%	7,202
19	19,888	6.41%	1,274	29.5%	5,866	13.6%	2,706	19,864	8.15%	1,619	21.9%	4,343	20.3%	4,042	39,752	7.3%	2,893	25.7%	10,209	17.0%	6,748
20	19,881	7.77%	1,545	24.3%	4,839	12.7%	2,524	19,851	9.33%	1,852	18.0%	3,583	19.0%	3,770	39,732	8.5%	3,397	21.2%	8,422	15.8%	6,294
21	19,874	9.13%	1,815	19.2%	3,812	11.8%	2,342	19,835	10.52%	2,086	14.2%	2,822	17.6%	3,498	39,709	9.8%	3,901	16.7%	6,634	14.7%	5,841
22	19,867	10.50%	2,086	14.0%	2,785	10.9%	2,160	19,817	11.71%	2,320	10.4%	2,062	16.3%	3,226	39,684	11.1%	4,406	12.2%	4,847	13.6%	5,387
23	19,859	11.86%	2,356	8.9%	1,758	10.0%	1,978	19,796	12.90%	2,554	6.6%	1,301	14.9%	2,955	39,656	12.4%	4,910	7.7%	3,059	12.4%	4,933
24	19,851	13.23%	2,627	3.7%	731	9.0%	1,796	19,775	14.10%	2,788	2.7%	541	13.6%	2,683	39,626	13.7%	5,414	3.2%	1,272	11.3%	4,479

- Figure 2 provides a visual representation of the modelled transitions between conventional and e-cigarette use between the ages of 13 and 24 in the ***absence*** of a child and youth screening program and brief intervention.

[385] Wei L, Muhammad-Kah R, Hannel T et al. The impact of cigarette and e-cigarette use history on transition patterns: A longitudinal analysis of the population assessment of tobacco and health (PATH) study, 2013 – 2015. *Harm Reduction Journal*. 2020; 17(45).



	13	14	15	16	17	18	19	20	21	22	23	24
Established E-cig	2.4%	4.7%	7.0%	9.3%	11.6%	18.1%	17.0%	15.8%	14.7%	13.6%	12.4%	11.3%
Experimental E-Cig	13.0%	16.4%	19.9%	23.4%	26.9%	30.2%	25.7%	21.2%	16.7%	12.2%	7.7%	3.2%
Conventional Cig	1.6%	2.5%	3.5%	4.3%	4.7%	6.0%	7.3%	8.5%	9.8%	11.1%	12.4%	13.7%

Estimating the Number of Deaths and Life Years Lost Attributable to Cigarette Smoking – No Intervention

- We assumed that 53.7% of females and 51.6% of males would be light smokers (less than 10 cigarettes per day), 32.4% / 26.1% would be moderate smokers (10-19 cigarettes per day) and 13.9% / 22.4% would be heavy smokers (≥ 20 cigarettes per day).[386]
    - Of the 2,627 female cigarette smokers at age 24, 1,411 would be light smokers, 851 would be moderate smokers and 365 would be heavy smokers
    - Of the 2,788 male cigarette smokers at age 24, 1,437 would be light smokers, 727 would be moderate smokers and 623 would be heavy smokers
- On average, tobacco smoking is associated with 10 life years lost,[387] with 6.6, 11.9 and 18.1 life years lost associated with light, moderate and heavy smoking.[388]

[386] H. Krueger & Associates Inc. *The Economic Burden of Risk Factors in British Columbia: Excess Weight, Tobacco Smoking, Alcohol Use, Physical Inactivity and Low Fruit and Vegetable Consumption.* 2017. Vancouver, B.C.: Provincial Health Services Authority, Population and Public Health Program.

[387] Banks E, Joshy G, Weber M et al. Tobacco smoking and all-cause mortality in a large Australian cohort study: findings from a mature epidemic with current low smoking prevalence. *BioMed Central Medicine*. 2015; 13(1): 38-48.

[388] In BC in 2015, 56% of tobacco smokers were light smokers, 28% were moderate smokers and 17% were heavy smokers. The estimated annual economic burden attributable to premature mortality in 2015 is $1,346 ($891 for light, $1,607 for moderate and $2,439 for heavy smokers). H. Krueger & Associates Inc. *The Economic Burden of Risk Factors in British Columbia: Excess Weight, Tobacco Smoking, Alcohol Use, Physical Inactivity and Low Fruit and Vegetable Consumption.* 2017. Vancouver, B.C.: Provincial Health Services Authority, Population and Public Health Program. We used this data to estimate life years lost by smoking intensity as follows: $891 / $1,346 * 10 life years lost = 6.6 life years lost for light smokers; $1,607 / $1,346 * 10 life years lost = 11.9 life years lost for moderate smokers; $2,439 / $1,346 * 10 life years lost = 18.1 life years lost for heavy smokers.

- Total life years lost in the 2,627 female cigarette smokers at age 24 is expected to be 26,403 ((1,411 * 6.6) + (851*11.9) + (365*18.1)).
- Total life years lost in the 2,788 male cigarette smokers at age 24 is expected to be 29,421 ((1,437 * 6.6) + (727*11.9) + (623*18.1)).

- Based on data between 1990 to 2011 in the US, Lariscy and colleagues found an elevated relative risk ratio for all-cause mortality among current smokers by smoking intensity as follows:[389]
  - < 10 cigarettes – 1.78
  - 10-19 cigarettes – 2.04
  - 20-39 cigarettes – 2.47
  - ≥ 40 cigarettes – 3.23
- Data from the Lariscy et al study was used to estimate the distribution of excess deaths attributable to cigarette smoking by age and sex (see Table 8).[390]

Table 8: Distribution of Excess Deaths Attributable to Smoking
By Age and Sex

Age	*Female*	*Male*	*Total*
35-44	2.1%	2.7%	2.5%
45-54	10.6%	13.3%	12.3%
55-64	25.3%	30.5%	28.5%
65-74	31.1%	33.8%	32.8%
75-84	25.6%	16.9%	20.2%
85+	5.3%	2.8%	3.8%
Total	**100%**	**100%**	**100%**

- Data from the previous two bullet points was then combined to estimate the distribution of excess deaths by age, sex and smoking intensity (see Table 9).

Table 9: Distribution of Excess Deaths Attributable to Smoking
By Age, Sex and Smoking Intensity

	Females				***Males***			
	Smoking Intensity				*Smoking Intensity*			
Age	Light	Moderate	Heavy	Total	Light	Moderate	Heavy	Total
35-44	0.6%	0.7%	0.8%	2.1%	0.8%	0.9%	1.0%	2.7%
45-54	3.0%	3.4%	4.2%	10.6%	3.8%	4.3%	5.2%	13.3%
55-64	7.2%	8.2%	9.9%	25.3%	8.6%	9.9%	12.0%	30.5%
65-74	8.8%	10.1%	12.2%	31.1%	9.6%	11.0%	13.3%	33.8%
75-84	7.2%	8.3%	10.0%	25.6%	4.8%	5.5%	6.6%	16.9%
85+	1.5%	1.7%	2.1%	5.3%	0.8%	0.9%	1.1%	2.8%
Total	**28.3%**	**32.4%**	**39.3%**	**100%**	**28.3%**	**32.4%**	**39.3%**	**100%**

[389] Lariscy J, Hummer R, Rogers R. Cigarette smoking and all-cause and cause-specific adult mortality in the United States. *Demography*. 2018; 55(5): 1855-85.
[390] Lariscy J, Hummer R, Rogers R. Cigarette smoking and all-cause and cause-specific adult mortality in the United States. *Demography*. 2018; 55(5): 1855-85.

- Lariscy et al calculated that 18% of female deaths and 26% of male deaths ages 35+ in the US between 1990 and 2011 were attributable to tobacco smoking.[391]
- For modelling purposes we assumed no smoking-attributable deaths in the cohort until age 36. We then distributed smoking-attributable deaths in the cohort by age, sex and smoking intensity (as per Table 9) and then adjusted the results so that total life years lost in the female cohort of smokers would be 27,730 and in males it would be 34,518 (see above). After this adjustment, our model indicated that 25.8% of female deaths and 23.6% of male deaths in the cohort between the ages of 36 and 84 would be attributable to cigarette smoking.
- While long-term use of e-cigarettes is associated a number of harms (see section on *Harms Associated with E-Cigarette Use in Children and Youth*) it is not yet known whether such long-term use is associated with premature death and life years lost. The outbreak of vaping-associated lung illness in 2019 and 2020 resulted in at least 2,807 cases and 64 deaths in the US.[392] In Canada, however, just 20 cases have been identified with no deaths.[393]
- Based on these assumptions, 3,320 (61.3%) of the cohort who were smoking at age 24 (5,414) would die prematurely due to a smoking-attributable cause (see Table 10).
    - 1,519 of 2,627 female smokers (57.8%) (see Table 10).
    - 1,801 of 2,788 male smokers (64.6%) (see Table 10).

[391] Lariscy J, Hummer R, Rogers R. Cigarette smoking and all-cause and cause-specific adult mortality in the United States. *Demography*. 2018; 55(5): 1855-85.
[392] Baker M, Procter T, Belzak L et al. Vaping-associated lung illness (VALI) in Canada: A descriptive analysis of VALI cases reported from September 2019 to December 2020. *Health Promotion and Chronic Disease Prevention in Canada: Research, Policy and Practice.* 2022; 42(1): 37-44.
[393] Ibid.

Table 10: Estimated Deaths and Life Years Lost Attributable to Cigarette Smoking

Between the Ages of 35 and 84

In a British Columbia Birth Cohort of 40,000

Without a Child / Youth Screening Program / Brief Intervention

	Female								*Male*								*Total Population*					
		Deaths								Deaths								Deaths Attributable to Smoking				
Age	Pop.	In Cohort	Att to Smoking	By Smoking Intensity Light	Moderate	Heavy	LYL / Death	LYL	Pop.	In Cohort	Att to Smoking	By Smoking Intensity Light	Moderate	Heavy	LYL / Death	LYL	Pop.	Light	Moderate	Heavy	Total	LYL
35	19,749								19,505								39,254					
36	19,736	13	3.1	0.9	1.0	1.2	50.8	160	19,474	31	6.3	1.8	2.0	2.5	46.5	292	39,210	2.7	3.1	3.7	9	452
37	19,722	14	3.3	0.9	1.1	1.3	49.9	164	19,442	32	6.4	1.8	2.1	2.5	45.6	294	39,164	2.8	3.2	3.8	10	458
38	19,708	14	3.4	1.0	1.1	1.4	48.9	168	19,409	33	6.6	1.9	2.2	2.6	44.7	297	39,117	2.9	3.3	4.0	10	465
39	19,693	15	3.6	1.0	1.2	1.4	47.9	174	19,375	34	6.9	2.0	2.2	2.7	43.7	301	39,068	3.0	3.4	4.1	11	475
40	19,677	16	3.8	1.1	1.2	1.5	47.0	177	19,339	35	7.1	2.0	2.3	2.8	42.8	305	39,017	3.1	3.5	4.3	11	483
41	19,661	16	4.0	1.1	1.3	1.6	46.0	183	19,303	37	7.4	2.1	2.4	2.9	41.9	309	38,964	3.2	3.7	4.5	11	492
42	19,643	18	4.3	1.2	1.4	1.7	45.1	192	19,264	38	7.7	2.2	2.5	3.0	41.0	315	38,908	3.4	3.9	4.7	12	507
43	19,625	19	4.5	1.3	1.5	1.8	44.1	199	19,225	40	8.0	2.3	2.6	3.1	40.1	321	38,849	3.5	4.1	4.9	13	520
44	19,605	20	4.8	1.4	1.6	1.9	43.1	207	19,183	41	8.3	2.4	2.7	3.3	39.1	327	38,788	3.7	4.3	5.2	13	533
45	19,584	21	5.1	1.5	1.7	2.0	42.2	217	19,140	43	8.7	2.5	2.8	3.4	38.2	333	38,724	3.9	4.5	5.4	14	549
46	19,561	23	5.5	1.5	1.8	2.1	41.2	226	19,094	46	9.2	2.6	3.0	3.6	37.3	343	38,656	4.1	4.8	5.8	15	568
47	19,537	24	5.9	1.7	1.9	2.3	40.3	236	19,047	48	9.6	2.7	3.1	3.8	36.4	351	38,584	4.4	5.0	6.1	15	587
48	19,511	26	6.2	1.8	2.0	2.5	39.3	246	18,996	50	10.1	2.9	3.3	4.0	35.5	359	38,508	4.6	5.3	6.4	16	605
49	19,484	28	6.7	1.9	2.2	2.6	38.4	257	18,943	53	10.8	3.0	3.5	4.2	34.6	372	38,427	4.9	5.7	6.9	17	629
50	19,454	30	7.2	2.0	2.3	2.8	37.4	268	18,887	56	11.4	3.2	3.7	4.5	33.7	383	38,341	5.2	6.0	7.3	19	651
51	19,422	32	7.7	2.2	2.5	3.0	36.5	281	18,827	60	12.0	3.4	3.9	4.7	32.8	395	38,249	5.6	6.4	7.8	20	676
52	19,388	34	8.2	2.3	2.7	3.2	35.6	293	18,763	64	12.9	3.6	4.2	5.0	31.9	410	38,151	6.0	6.8	8.3	21	703
53	19,352	37	8.9	2.5	2.9	3.5	34.6	307	18,695	68	13.7	3.9	4.5	5.4	31.0	426	38,046	6.4	7.3	8.9	23	733
54	19,312	39	9.5	2.7	3.1	3.7	33.7	322	18,622	73	14.6	4.1	4.7	5.7	30.2	441	37,934	6.8	7.8	9.5	24	763
55	19,270	43	10.3	2.9	3.3	4.1	32.8	338	18,545	78	15.6	4.4	5.1	6.1	29.3	458	37,814	7.3	8.4	10.2	26	796
56	19,224	46	11.1	3.1	3.6	4.4	31.9	353	18,461	83	16.8	4.7	5.4	6.6	28.4	476	37,685	7.9	9.0	10.9	28	829
57	19,174	49	12.0	3.4	3.9	4.7	30.9	370	18,372	89	17.9	5.1	5.8	7.0	27.5	494	37,547	8.5	9.7	11.7	30	864
58	19,121	53	12.9	3.7	4.2	5.1	30.0	388	18,277	95	19.2	5.4	6.2	7.5	26.7	513	37,398	9.1	10.4	12.6	32	901
59	19,063	58	14.0	4.0	4.6	5.5	29.1	409	18,175	102	20.6	5.8	6.7	8.1	25.8	532	37,238	9.8	11.2	13.6	35	941
60	19,000	63	15.2	4.3	4.9	6.0	28.2	429	18,065	110	22.1	6.3	7.2	8.7	25.0	553	37,065	10.6	12.1	14.7	37	982
61	18,932	68	16.5	4.7	5.4	6.5	27.3	451	17,947	118	23.8	6.7	7.7	9.3	24.1	574	36,879	11.4	13.1	15.8	40	1,025
62	18,858	74	18.0	5.1	5.8	7.1	26.4	475	17,820	127	25.6	7.2	8.3	10.0	23.3	596	36,678	12.3	14.1	17.1	44	1,070
63	18,777	81	19.5	5.5	6.3	7.7	25.5	498	17,684	136	27.5	7.8	8.9	10.8	22.5	618	36,461	13.3	15.2	18.5	47	1,116
64	18,689	88	21.3	6.0	6.9	8.4	24.6	525	17,537	147	29.6	8.4	9.6	11.6	21.7	642	36,226	14.4	16.5	20.0	51	1,167
65	18,593	96	23.2	6.6	7.5	9.1	23.8	551	17,379	158	31.9	9.0	10.3	12.5	20.9	665	35,972	15.6	17.9	21.6	55	1,216
66	18,489	105	25.3	7.2	8.2	9.9	22.9	580	17,208	171	34.4	9.7	11.1	13.5	20.1	690	35,697	16.9	19.4	23.4	60	1,270
67	18,375	114	27.7	7.8	9.0	10.9	22.0	609	17,024	184	37.1	10.5	12.0	14.6	19.3	715	35,399	18.3	21.0	25.4	65	1,324
68	18,250	125	30.3	8.6	9.8	11.9	21.2	641	16,826	198	39.9	11.3	13.0	15.7	18.5	739	35,075	19.9	22.8	27.6	70	1,380
69	18,113	137	33.1	9.4	10.7	13.0	20.3	674	16,612	214	43.1	12.2	14.0	16.9	17.7	765	34,725	21.6	24.7	29.9	76	1,438
70	17,963	150	36.3	10.3	11.8	14.2	19.5	707	16,381	231	46.5	13.2	15.1	18.3	17.0	790	34,344	23.4	26.9	32.5	83	1,497
71	17,799	164	39.8	11.3	12.9	15.6	18.7	743	16,132	249	50.2	14.2	16.3	19.7	16.2	815	33,930	25.5	29.2	35.3	90	1,558
72	17,619	180	43.6	12.4	14.2	17.1	17.9	779	15,863	269	54.2	15.3	17.6	21.3	15.5	839	33,481	27.7	31.7	38.4	98	1,618
73	17,421	198	47.9	13.5	15.5	18.8	17.1	816	15,573	290	58.4	16.5	19.0	22.9	14.8	863	32,994	30.1	34.5	41.7	106	1,680
74	17,204	217	52.6	14.9	17.0	20.6	16.3	855	15,260	313	63.0	17.8	20.4	24.8	14.1	887	32,464	32.7	37.5	45.4	116	1,742
75	16,966	238	57.7	16.3	18.7	22.7	15.5	894	14,923	337	67.9	19.2	22.0	26.7	13.4	908	31,889	35.5	40.7	49.3	126	1,802
76	16,704	261	63.3	17.9	20.5	24.9	14.7	933	14,560	363	73.1	20.7	23.7	28.7	12.7	928	31,265	38.6	44.2	53.6	136	1,860
77	16,417	287	69.6	19.7	22.6	27.3	14.0	972	14,170	390	78.6	22.3	25.5	30.9	12.0	946	30,587	41.9	48.1	58.2	148	1,918
78	16,102	315	76.3	21.6	24.7	30.0	13.2	1,010	13,751	419	84.5	23.9	27.4	33.2	11.4	961	29,853	45.5	52.1	63.1	161	1,971
79	15,757	346	83.7	23.7	27.1	32.9	12.5	1,048	13,301	450	90.6	25.6	29.4	35.6	10.8	974	29,058	49.3	56.5	68.4	174	2,022
80	15,378	379	91.7	26.0	29.8	36.0	11.8	1,083	12,820	481	97.0	27.4	31.4	38.1	10.1	982	28,198	53.4	61.2	74.1	189	2,066
81	14,963	415	100.4	28.4	32.6	39.4	11.1	1,118	12,306	514	103.5	29.3	33.6	40.7	9.5	987	27,269	57.7	66.1	80.1	204	2,104
82	14,510	453	109.7	31.0	35.6	43.1	10.5	1,148	11,759	547	110.2	31.2	35.7	43.3	9.0	986	26,269	62.2	71.3	86.4	220	2,134
83	14,016	494	119.7	33.9	38.8	47.0	9.8	1,174	11,179	580	117.0	33.1	37.9	45.9	8.4	981	25,195	67.0	76.7	92.9	237	2,155
84	13,478	538	130.2	36.9	42.2	51.1	9.2	1,196	10,565	614	123.6	35.0	40.1	48.6	7.9	971	24,043	71.8	82.3	99.7	254	2,166
Total		***6,271***	***1,519***	***430***	***493***	***596***	***17.1***	***26,043***		***8,940***	***1,801***	***510***	***584***	***707***	***16.3***	***29,421***		***940***	***1,077***	***1,304***	***3,320***	***55,464***

- A UK study used a community-based sample ≥ 16 years of age of 14,117 to assess the effect of tobacco smoking on QoL.[394] After adjusting for age, sex, alcohol use, physical activity, fruit and vegetable consumption, excess weight, ethnicity, marital status, educational attainment, and income, they found a utility of -0.031 (95%CI of -0.018 to -0.045) associated with light tobacco smoking (less than 10 cigarettes per day), -0.033 (95% CI of -0.019 to -0.047) for moderate tobacco smoking (10 to 19 cigarettes per day) and -0.062 (95% CI of -0.042 to -0.082) for heavy tobacco smoking (20 or more cigarettes per day). We used the upper and lower bounds of the 95% CI in the sensitivity analysis.
- We applied the relevant QoL reductions to current smokers in the cohort (starting at age 19) who were alive at a given age (i.e. current smokers less those who died in the previous year due to smoking-attributable causes).
- Based on these assumptions, 13,805 QALYs would be lost between the ages of 19 and 84 by those living with cigarette smoking, 6,602 in females and 7,202 in males (see Table 11).

[394] Maheswaran H, Petrou S, Rees K et al. Estimating EQ-5D utility values for major health behavioural risk factors in England. *Journal of Epidemiology and Community Health*. 2013; 67(1): 172-80.

Table 11: Estimated Quality-Adjusted Life Years Lost Attributable to Cigarette Smoking

Between the Ages of 19 and 84

In a British Columbia Birth Cohort of 40,000

Without a Child / Youth Screening Program / Brief Intervention

	Females							***Males***							***Total Population***			
	Smokers Alive			QALYs Lost				Smokers Alive			QALYs Lost				QALYs Lost			
	Smoking Intensity			Smoking Intensity				Smoking Intensity			Smoking Intensity				Smoking Intensity			
Age	Light	Mod	Heavy	Light	Mod	Heavy	**Total**	Light	Mod	Heavy	Light	Mod	Heavy	**Total**	Light	Mod	Heavy	**Total**
19	1,411	851	365	48	31	25	**103**	1,437	727	623	49	26	42	**117**	97	57	67	**221**
20	1,411	851	365	48	31	25	**103**	1,437	727	623	49	26	42	**117**	97	57	67	**221**
21	1,411	851	365	48	31	25	**103**	1,437	727	623	49	26	42	**117**	97	57	67	**221**
22	1,411	851	365	48	31	25	**103**	1,437	727	623	49	26	42	**117**	97	57	67	**221**
23	1,411	851	365	48	31	25	**103**	1,437	727	623	49	26	42	**117**	97	57	67	**221**
24	1,411	851	365	48	31	25	**103**	1,437	727	623	49	26	42	**117**	97	57	67	**221**
25	1,411	851	365	48	31	25	**103**	1,437	727	623	49	26	42	**117**	97	57	67	**221**
26	1,411	851	365	48	31	25	**103**	1,437	727	623	49	26	42	**117**	97	57	67	**221**
27	1,411	851	365	48	31	25	**103**	1,437	727	623	49	26	42	**117**	97	57	67	**221**
28	1,411	851	365	48	31	25	**103**	1,437	727	623	49	26	42	**117**	97	57	67	**221**
29	1,411	851	365	48	31	25	**103**	1,437	727	623	49	26	42	**117**	97	57	67	**221**
30	1,411	851	365	49	32	25	**106**	1,437	727	623	50	27	43	**120**	99	59	69	**227**
31	1,411	851	365	49	32	25	**106**	1,437	727	623	50	27	43	**120**	99	59	69	**227**
32	1,411	851	365	49	32	25	**106**	1,437	727	623	50	27	43	**120**	99	59	69	**227**
33	1,411	851	365	49	32	25	**106**	1,437	727	623	50	27	43	**120**	99	59	69	**227**
34	1,411	851	365	49	32	25	**106**	1,437	727	623	50	27	43	**120**	99	59	69	**227**
35	1,411	851	365	49	32	25	**106**	1,437	727	623	50	27	43	**120**	99	59	69	**227**
36	1,410	850	364	49	32	25	**106**	1,435	725	621	50	27	43	**120**	99	58	69	**226**
37	1,409	849	362	49	31	25	**106**	1,434	723	618	50	27	43	**120**	99	58	68	**226**
38	1,408	848	361	49	31	25	**106**	1,432	721	616	50	27	43	**119**	99	58	68	**225**
39	1,407	847	360	49	31	25	**105**	1,430	719	613	50	27	43	**119**	99	58	68	**225**
40	1,406	846	358	51	33	26	**110**	1,428	716	610	52	28	44	**124**	103	60	70	**234**
41	1,405	844	356	51	33	26	**109**	1,426	714	607	52	28	44	**123**	103	60	70	**233**
42	1,403	843	355	51	33	26	**109**	1,423	711	604	52	27	44	**123**	103	60	70	**232**
43	1,402	841	353	51	33	26	**109**	1,421	709	601	52	27	44	**123**	102	60	69	**232**
44	1,401	840	351	51	32	25	**109**	1,419	706	598	52	27	43	**122**	102	60	69	**231**
45	1,399	838	349	51	32	25	**109**	1,416	703	594	51	27	43	**122**	102	60	69	**230**
46	1,398	836	347	51	32	25	**108**	1,414	700	591	51	27	43	**121**	102	59	68	**230**
47	1,396	835	345	51	32	25	**108**	1,411	697	587	51	27	43	**121**	102	59	68	**229**
48	1,394	833	342	51	32	25	**108**	1,408	694	583	51	27	42	**120**	102	59	67	**228**
49	1,392	830	340	51	32	25	**107**	1,405	690	579	51	27	42	**120**	102	59	67	**227**
50	1,390	828	337	53	33	25	**111**	1,402	687	574	53	28	43	**124**	106	61	69	**235**
51	1,388	826	334	52	33	25	**111**	1,398	683	570	53	27	43	**123**	105	61	68	**234**
52	1,386	823	331	52	33	25	**111**	1,395	679	565	53	27	43	**123**	105	60	68	**233**
53	1,383	820	327	52	33	25	**110**	1,391	674	559	53	27	42	**122**	105	60	67	**232**
54	1,381	817	323	52	33	24	**110**	1,387	670	553	52	27	42	**121**	105	60	66	**231**
55	1,378	814	319	52	33	24	**109**	1,382	664	547	52	27	41	**120**	104	59	66	**229**
56	1,375	810	315	52	33	24	**108**	1,378	659	541	52	27	41	**119**	104	59	65	**228**
57	1,371	806	310	52	32	23	**108**	1,373	653	534	52	26	40	**119**	104	59	64	**226**
58	1,368	802	305	52	32	23	**107**	1,367	647	526	52	26	40	**118**	103	58	63	**225**
59	1,364	797	300	52	32	23	**106**	1,361	640	518	51	26	39	**116**	103	58	62	**223**
60	1,359	792	294	53	33	23	**108**	1,355	633	509	53	26	40	**118**	105	59	62	**226**
61	1,355	787	287	53	33	22	**107**	1,348	625	500	52	26	39	**117**	105	58	61	**224**
62	1,350	781	280	52	32	22	**106**	1,341	617	490	52	25	38	**116**	104	58	60	**222**
63	1,344	775	272	52	32	21	**105**	1,333	608	479	52	25	37	**114**	104	57	58	**219**
64	1,338	768	264	52	32	20	**104**	1,325	599	468	51	25	36	**112**	103	56	57	**217**
65	1,331	760	255	52	31	20	**103**	1,316	588	455	51	24	35	**111**	103	56	55	**214**
66	1,324	752	245	51	31	19	**101**	1,306	577	442	51	24	34	**109**	102	55	53	**210**
67	1,316	743	234	51	31	18	**100**	1,296	565	427	50	23	33	**107**	101	54	51	**207**
68	1,308	733	222	51	30	17	**98**	1,284	552	411	50	23	32	**105**	101	53	49	**203**
69	1,298	723	209	50	30	16	**96**	1,272	538	394	49	22	31	**102**	100	52	47	**199**
70	1,288	711	195	53	31	16	**100**	1,259	523	376	52	23	31	**105**	104	54	47	**205**
71	1,277	698	179	52	30	15	**97**	1,245	507	356	51	22	29	**102**	103	53	44	**200**
72	1,265	684	162	52	30	13	**95**	1,229	489	335	50	21	27	**99**	102	51	41	**194**
73	1,251	668	143	51	29	12	**92**	1,213	470	312	50	20	26	**96**	101	50	37	**188**
74	1,236	651	123	51	28	10	**89**	1,195	450	287	49	20	24	**92**	100	48	34	**181**
75	1,220	633	100	50	28	8	**86**	1,176	428	261	48	19	21	**88**	98	46	30	**174**
76	1,202	612	75	49	27	6	**82**	1,155	404	232	47	18	19	**84**	97	44	25	**166**
77	1,182	590	48	48	26	4	**78**	1,133	379	201	46	17	16	**79**	95	42	20	**157**
78	1,161	565	18	48	25	1	**74**	1,109	351	168	45	15	14	**74**	93	40	15	**148**
79	1,137	538		47	23		**70**	1,083	322	132	44	14	11	**69**	91	37	11	**139**
80	1,111	508		49	24		**73**	1,056	290	94	47	14	8	**69**	96	38	8	**143**
81	1,083	475		48	23		**71**	1,027	257	54	46	12	5	**63**	94	35	5	**133**
82	1,052	440		47	21		**68**	995	221	10	44	10	1	**56**	91	31	1	**123**
83	1,018	401		45	19		**64**	962	183		43	9		**51**	88	28		**116**
84	981	359		44	17		**61**	927	143		41	7		**48**	85	24		**109**
Total				***3,297***	***2,000***	***1,306***	***6,602***				***3,289***	***1,582***	***2,332***	***7,202***	***6,586***	***3,581***	***3,638***	***13,805***

- Despite the evolving evidence linking e-cigarette use to a variety of harms (see *Harms Associated with E-Cigarette Use in Children and Youth* above), little evidence currently exists quantifying the harms of e-cigarettes in terms of quality-adjusted life expectancy.
- To begin to address the gap in evidence quantifying the harms of e-cigarettes in terms of quality-adjusted life expectancy, Nutt and colleagues gathered a group of experts in 2013 and used a multi-criteria decision analysis approach in a 2-day facilitated workshop to estimate the harms of a variety of nicotine-containing products, including e-cigarettes. While not explicitly stated, it appears that the group of experts consisted of 11 authors of the subsequent publication.[395] Using this process, they determined that e-cigarettes where just 5% as harmful as smoking conventional cigarettes.[396]
- In 2020, Allcot and Rafkin surveyed 137 public health experts whose responses indicated that e-cigarettes where 37% as harmful as smoking conventional cigarettes, when considered in terms of quality-adjusted life expectancy.[397] There was substantial disagreement between experts, with the interquartile range of beliefs about relative harms ranging from 10% to 60%. When the experts were asked why they disagreed with the prior assessment by Nutt et al they gave three main explanations: "they disagree with how researchers interpreted the evidence available at the time, new research evidence is becoming available, and e-cigarette products have changed."[398] In addition, three of the authors of the Nutt et al study had financial ties with e-cigarette producers.[399] In particular, the consultant who facilitated the group process for the Nutt et al paper had financial ties with British American Tobacco and a number of other companies that produce smoking cessation products.[400] Indeed, the editors of the publishing journal took the extraordinary step of justifying why they accepted the paper for publication despite the consultant's financial ties.[401] By comparison, the research by Allcot and Rafkin explicitly excluded "people with tobacco industry affiliations."[402]
- Based on the available evidence, we have assumed that e-cigarettes use is 37% as harmful as smoking conventional cigarettes, when considered in terms of quality-adjusted life expectancy. This estimate was varied from 10% to 60% in the sensitivity analysis.
- Based on this assumption, e-cigarette use in the birth cohort would result in 1,695 premature deaths and a loss of 31,943 QALYs (see Table 12).

[395] Nutt D, Phillips L, Balfour D et al. Estimating the harms of nicotine-containing products using the MCDA approach. *European Addiction Research*. 2014; 20: 218-25.
[396] Ibid.
[397] Allcott H, Rafkin C. *Optimal Regulation of e-Cigarettes: Theory and Evidence*. National Bureau of Economic Research Working Paper Series, August 2021. Available online at https://www.nber.org/system/files/working_papers/w27000/w27000.pdf. Accessed November 2022.
[398] Ibid.
[399] Nutt D, Phillips L, Balfour D et al. Estimating the harms of nicotine-containing products using the MCDA approach. *European Addiction Research*. 2014; 20: 218-25.
[400] Ibid.
[401] Ibid.
[402] Allcott H, Rafkin C. *Optimal Regulation of e-Cigarettes: Theory and Evidence*. National Bureau of Economic Research Working Paper Series, August 2021. Available online at https://www.nber.org/system/files/working_papers/w27000/w27000.pdf. Accessed November 2022.

Table 12: Estimated Deaths and QALYs Lost Due to e-Cigarette Use

Between the Ages of 19 and 84

In a British Columbia Birth Cohort of 40,000

Without a Child / Youth Screening Program / Brief Intervention

	Females							*Males*							*Total Population*				
	c-Cig		e-Cig					c-Cig		e-Cig					e-Cig				Total
Age	Alive	Deaths	Alive	Deaths	LE	LYL	QALYs	Alive	Deaths	Alive	Deaths	LE	LYL	QALYs	Alive	Deaths	LYL	QALYs	QALYs
19	1,274	0.0	8,572	0.0	66.4	0	257	1,619	0.0	8,385	0.0	61.4	0	225	16,957	0	0	482	482
20	1,545	0.0	7,363	0.0	65.4	0	182	1,852	0.0	7,353	0.0	60.5	0	172	14,716	0	0	354	354
21	1,815	0.0	6,154	0.0	64.4	0	130	2,086	0.0	6,321	0.0	59.5	0	131	12,475	0	0	261	261
22	2,086	0.0	4,945	0.0	63.5	0	91	2,320	0.0	5,288	0.0	58.6	0	99	10,234	0	0	190	190
23	2,356	0.0	3,736	0.0	62.5	0	61	2,554	0.0	4,256	0.0	57.7	0	72	7,992	0	0	133	133
24	2,627	0.0	2,527	0.0	61.5	0	37	2,788	0.0	3,224	0.0	56.7	0	50	5,751	0	0	87	87
25	2,627	0.0	2,527	0.0	60.5	0	37	2,788	0.0	3,224	0.0	55.8	0	50	5,751	0	0	87	87
26	2,627	0.0	2,527	0.0	59.6	0	37	2,788	0.0	3,224	0.0	54.8	0	50	5,751	0	0	87	87
27	2,627	0.0	2,527	0.0	58.6	0	37	2,788	0.0	3,224	0.0	53.9	0	50	5,751	0	0	87	87
28	2,627	0.0	2,527	0.0	57.6	0	37	2,788	0.0	3,224	0.0	53.0	0	50	5,751	0	0	87	87
29	2,627	0.0	2,527	0.0	56.6	0	37	2,788	0.0	3,224	0.0	52.1	0	50	5,751	0	0	87	87
30	2,627	0.0	2,527	0.0	55.7	0	38	2,788	0.0	3,224	0.0	51.1	0	52	5,751	0	0	89	89
31	2,627	0.0	2,527	0.0	54.7	0	38	2,788	0.0	3,224	0.0	50.2	0	52	5,751	0	0	89	89
32	2,627	0.0	2,527	0.0	53.7	0	38	2,788	0.0	3,224	0.0	49.3	0	52	5,751	0	0	89	89
33	2,627	0.0	2,527	0.0	52.8	0	38	2,788	0.0	3,224	0.0	48.4	0	52	5,751	0	0	89	89
34	2,627	0.0	2,527	0.0	51.8	0	38	2,788	0.0	3,224	0.0	47.4	0	52	5,751	0	0	89	89
35	2,627	0.0	2,527	0.0	50.8	0	38	2,788	0.0	3,224	0.0	46.5	0	52	5,751	0	0	89	89
36	2,623	3.1	2,526	1.1	49.9	56	38	2,781	6.3	3,221	2.7	45.6	123	51	5,747	4	178	89	268
37	2,620	3.3	2,525	1.2	48.9	57	38	2,775	6.4	3,219	2.8	44.7	123	51	5,743	4	181	89	270
38	2,617	3.4	2,524	1.2	47.9	59	38	2,768	6.6	3,216	2.9	43.7	125	51	5,739	4	184	89	273
39	2,613	3.6	2,522	1.3	47.0	61	38	2,761	6.9	3,213	3.0	42.8	127	51	5,735	4	188	89	277
40	2,609	3.8	2,521	1.3	46.0	62	39	2,754	7.1	3,210	3.1	41.9	129	53	5,731	4	191	93	283
41	2,605	4.0	2,520	1.4	45.1	64	39	2,747	7.4	3,206	3.2	41.0	130	53	5,726	5	194	92	287
42	2,601	4.3	2,518	1.5	44.1	67	39	2,739	7.7	3,203	3.3	40.1	133	53	5,721	5	200	92	293
43	2,597	4.5	2,516	1.6	43.1	70	39	2,731	8.0	3,200	3.5	39.1	136	53	5,716	5	205	92	298
44	2,592	4.8	2,515	1.7	42.2	73	39	2,723	8.3	3,196	3.6	38.2	138	53	5,711	5	211	92	303
45	2,587	5.1	2,513	1.8	41.2	76	39	2,714	8.7	3,192	3.8	37.3	141	53	5,705	6	217	92	309
46	2,581	5.5	2,511	2.0	40.3	79	39	2,705	9.2	3,188	4.0	36.4	146	53	5,699	6	225	92	317
47	2,575	5.9	2,509	2.1	39.3	83	39	2,695	9.6	3,184	4.2	35.5	149	53	5,693	6	232	92	324
48	2,569	6.2	2,506	2.3	38.4	86	39	2,685	10.1	3,180	4.4	34.6	153	53	5,686	7	239	92	331
49	2,562	6.7	2,504	2.4	37.4	90	39	2,674	10.8	3,175	4.7	33.7	159	53	5,679	7	249	91	341
50	2,555	7.2	2,501	2.6	36.5	95	40	2,663	11.4	3,170	5.0	32.8	164	55	5,671	8	258	95	353
51	2,548	7.7	2,499	2.8	35.6	99	40	2,651	12.0	3,165	5.3	31.9	169	55	5,663	8	269	95	363
52	2,539	8.2	2,496	3.0	34.6	103	40	2,638	12.9	3,159	5.7	31.0	176	54	5,655	9	280	95	374
53	2,530	8.9	2,492	3.2	33.7	109	40	2,624	13.7	3,153	6.1	30.2	184	54	5,645	9	292	94	387
54	2,521	9.5	2,489	3.5	32.8	114	40	2,610	14.6	3,146	6.5	29.3	190	54	5,635	10	304	94	398
55	2,511	10.3	2,485	3.8	31.9	120	40	2,594	15.6	3,139	7.0	28.4	198	54	5,625	11	318	94	412
56	2,499	11.1	2,481	4.1	30.9	126	40	2,577	16.8	3,132	7.5	27.5	207	54	5,613	12	332	94	426
57	2,488	12.0	2,477	4.4	30.0	132	40	2,559	17.9	3,124	8.1	26.7	215	54	5,601	12	347	93	440
58	2,475	12.9	2,472	4.8	29.1	139	40	2,540	19.2	3,115	8.7	25.8	224	53	5,587	13	363	93	456
59	2,461	14.0	2,467	5.2	28.2	146	39	2,520	20.6	3,106	9.3	25.0	233	53	5,573	15	380	93	472
60	2,445	15.2	2,461	5.6	27.3	154	40	2,497	22.1	3,096	10.1	24.1	244	54	5,557	16	398	95	492
61	2,429	16.5	2,455	6.2	26.4	162	40	2,474	23.8	3,085	10.9	23.3	254	54	5,540	17	417	94	511
62	2,411	18.0	2,448	6.7	25.5	172	40	2,448	25.6	3,073	11.8	22.5	265	54	5,521	19	437	94	530
63	2,391	19.5	2,441	7.3	24.6	181	40	2,421	27.5	3,060	12.8	21.7	277	53	5,501	20	457	93	550
64	2,370	21.3	2,433	8.0	23.8	191	40	2,391	29.6	3,046	13.9	20.9	289	53	5,479	22	480	93	573
65	2,347	23.2	2,424	8.8	22.9	202	39	2,359	31.9	3,031	15.0	20.1	302	53	5,455	24	503	92	595
66	2,321	25.3	2,414	9.7	22.0	213	39	2,325	34.4	3,015	16.3	19.3	315	52	5,429	26	528	91	620
67	2,294	27.7	2,404	10.6	21.2	225	39	2,288	37.1	2,997	17.8	18.5	329	52	5,401	28	555	90	645
68	2,264	30.3	2,392	11.7	20.3	239	38	2,248	39.9	2,978	19.4	17.7	343	51	5,370	31	582	90	672
69	2,230	33.1	2,379	13.0	19.5	253	38	2,205	43.1	2,957	21.1	17.0	359	51	5,336	34	611	89	700
70	2,194	36.3	2,365	14.3	18.7	267	40	2,158	46.5	2,934	23.1	16.2	375	53	5,298	37	642	93	735
71	2,154	39.8	2,349	15.9	17.9	283	39	2,108	50.2	2,908	25.3	15.5	391	52	5,257	41	674	91	766
72	2,111	43.6	2,331	17.6	17.1	300	39	2,054	54.2	2,881	27.7	14.8	408	51	5,212	45	709	90	799
73	2,063	47.9	2,312	19.6	16.3	318	38	1,995	58.4	2,850	30.3	14.1	427	51	5,162	50	745	89	834
74	2,010	52.6	2,290	21.8	15.5	338	38	1,932	63.0	2,817	33.3	13.4	445	50	5,107	55	783	87	870
75	1,953	57.7	2,266	24.3	14.7	358	37	1,864	67.9	2,780	36.6	12.7	465	49	5,046	61	823	85	908
76	1,889	63.3	2,238	27.2	14.0	380	36	1,791	73.1	2,740	40.3	12.0	485	48	4,979	68	865	83	948
77	1,820	69.6	2,208	30.5	13.2	404	35	1,713	78.6	2,696	44.5	11.4	506	46	4,904	75	910	81	991
78	1,743	76.3	2,174	34.2	12.5	429	34	1,628	84.5	2,646	49.2	10.8	529	45	4,820	83	958	79	1,036
79	1,660	83.7	2,135	38.6	11.8	456	33	1,538	90.6	2,592	54.5	10.1	552	43	4,727	93	1,008	77	1,084
80	1,568	91.7	2,091	43.7	11.1	486	36	1,441	97.0	2,531	60.5	9.5	576	45	4,623	104	1,062	81	1,144
81	1,468	100.4	2,042	49.6	10.5	518	36	1,337	103.5	2,464	67.3	9.0	602	43	4,506	117	1,121	79	1,200
82	1,358	109.7	1,985	56.5	9.8	554	37	1,227	110.2	2,389	75.2	8.4	631	40	4,374	132	1,185	77	1,261
83	1,238	119.7	1,921	64.7	9.2	594	37	1,110	117.0	2,305	84.3	7.9	661	40	4,225	149	1,256	76	1,332
84	1,108	130.2	1,846	74.8	8.6	641	37	986	123.6	2,210	95.0	7.3	696	40	4,056	170	1,337	77	1,414
Total		***1,519***		***681***	***15.4***	***10,484***	***3,053***		***1,801***		***1,014***	***14.4***	***14,600***	***3,806***		***1,695***	***25,084***	***6,859***	***31,943***

Annual Visits to a General Practitioner

- As noted earlier, a key variable in the effectiveness of screening and brief intervention is the proportion of children and youth that make contact with a primary care provider.
- Using data provided by the BC Ministry of Health, Health Sector Information, Analysis and Reporting Division[403] we were able to generate BC-specific rates of primary care visits and average visits per year for the fiscal years ending in 2012/13 to 2016/17, in total and by sex, as shown in Table 13 below.
- For the five years considered, the average proportion of children and youth ages 10-19 visiting a GP is 70%, and the average number of GP visits per adolescent is 2.07 per year (see Table 13). The proportion of males visiting a GP was 65.4% (see Table 13a) and for females it was 75.0% (see Table 13b). The average number of visits per male in the population was 1.75 and for females was 2.42.

Table 13: General Practitioner Visits by Children and Youth
British Columbia, 2012/13 to 2016/17

Age Group	2012/13	2013/14	2014/15	2015/16	2016/17	Total
	Population in Each Age Group					
10 - 14	234,780	231,544	230,178	230,177	232,010	1,158,689
15 - 19	284,482	282,214	279,997	276,909	272,677	1,396,279
Total	519,262	513,758	510,175	507,086	504,687	2,554,968
	Number of Unique Individuals with GP Visit					
10 - 14	163,332	160,912	158,653	160,260	159,826	802,983
15 - 19	205,821	200,410	196,629	192,566	189,547	984,973
Total	369,153	361,322	355,282	352,826	349,373	1,787,956
	Proportion of Individuals with a GP Visit					
10 - 14	69.6%	69.5%	68.9%	69.6%	68.9%	69.3%
15 - 19	72.3%	71.0%	70.2%	69.5%	69.5%	70.5%
Total	71.1%	70.3%	69.6%	69.6%	69.2%	70.0%
	Number of GP Visits					
10 - 14	429,881	422,188	412,182	413,411	407,442	2,085,104
15 - 19	681,806	659,038	641,316	619,790	601,925	3,203,875
Total	1,111,687	1,081,226	1,053,498	1,033,201	1,009,367	5,288,979
	GP Visits per Individual in Total Population					
10 - 14	1.83	1.82	1.79	1.80	1.76	1.80
15 - 19	2.40	2.34	2.29	2.24	2.21	2.29
Total	2.14	2.10	2.06	2.04	2.00	2.07

[403] Aciemme (Sam) Ospan, Senior Manager, Lifetime Prevention Schedule, Healthy Living and Health Promotion Branch, BC Ministry of Health. January 30, 2019. Personal communication.

Table 13a: General Practitioner Visits by Children and Youth

British Columbia, 2012/13 to 2016/17

Males

Age Group	2012/13	2013/14	2014/15	2015/16	2016/17	Total
	Population in Each Age Group					
10 - 14	121,031	119,378	118,720	118,572	119,586	597,287
15 - 19	149,279	147,563	145,417	143,117	140,451	725,827
Total	270,310	266,941	264,137	261,689	260,037	1,323,114
	Number of Unique Males with GP Visit					
10 - 14	82,970	81,960	80,756	81,067	80,862	407,615
15 - 19	95,992	93,224	91,170	89,118	87,596	457,100
Total	178,962	175,184	171,926	170,185	168,458	864,715
	Proportion of Males with a GP Visit					
10 - 14	68.6%	68.7%	68.0%	68.4%	67.6%	68.2%
15 - 19	64.3%	63.2%	62.7%	62.3%	62.4%	63.0%
Total	66.2%	65.6%	65.1%	65.0%	64.8%	65.4%
	Number of GP Visits					
10 - 14	215,841	211,444	206,909	206,013	202,386	1,042,593
15 - 19	270,303	259,637	253,874	244,381	238,257	1,266,452
Total	486,144	471,081	460,783	450,394	440,643	2,309,045
	GP Visits per Male in Total Population					
10 - 14	1.78	1.77	1.74	1.74	1.69	1.75
15 - 19	1.81	1.76	1.75	1.71	1.70	1.74
Total	1.80	1.76	1.74	1.72	1.69	1.75

Table 13b: General Practitioner Visits by Children and Youth

British Columbia, 2012/13 to 2016/17

Females

Age Group	2012/13	2013/14	2014/15	2015/16	2016/17	Total
	Population in Each Age Group					
10 - 14	113,749	112,166	111,458	111,605	112,424	561,402
15 - 19	135,203	134,651	134,580	133,792	132,226	670,452
Total	248,952	246,817	246,038	245,397	244,650	1,231,854
	Number of Unique Females with GP Visit					
10 - 14	80,381	78,955	77,909	79,202	78,985	395,432
15 - 19	109,865	107,210	105,496	103,488	101,995	528,054
Total	190,246	186,165	183,405	182,690	180,980	923,486
	Proportion of Females with a GP Visit					
10 - 14	70.7%	70.4%	69.9%	71.0%	70.3%	70.4%
15 - 19	81.3%	79.6%	78.4%	77.3%	77.1%	78.8%
Total	76.4%	75.4%	74.5%	74.4%	74.0%	75.0%
	Number of GP Visits					
10 - 14	214,033	210,738	205,270	207,393	205,052	1,042,486
15 - 19	411,487	399,386	387,411	375,393	363,660	1,937,337
Total	625,520	610,124	592,681	582,786	568,712	2,979,823
	GP Visits per Female in Total Population					
10 - 14	1.88	1.88	1.84	1.86	1.82	1.86
15 - 19	3.04	2.97	2.88	2.81	2.75	2.89
Total	2.51	2.47	2.41	2.37	2.32	2.42

Source: BC Ministry of Health, Health Sector Information, Analysis and Reporting Division

Calculations by H. Krueger & Associates, Inc.

Effectiveness of the Intervention(s)

- The USPSTF found that behavioural interventions led to an 18% (95% CI of 8% to 27%) **reduction in smoking initiation** in adolescents, based on a meta-analysis of 13 studies (RR 0.82, 95% CI of 0.73 – 0.92).[404]
- This effectiveness is almost identical to that observed by the CTFPHC who found that interventions aimed at reducing smoking initiation among non-smoking children and adolescents had an effectiveness of 18% (RR 0.82, 95% CI of 0.72 to 0.94).[405]
- The USPSTF found that behavioural interventions did not lead to an **increase in smoking cessation** in adolescents, based on a **meta-analysis of 9 studies** (RR 0.97, 95% CI of 0.93 – 1.01).[406]
- The CTFPHC, on the other hand, found that behavioural interventions aimed at smoking cessation among children and adolescents have an effectiveness of 34% (RR 1.34, 95% CI of 1.05 to 1.69), based on a **meta-analysis of 3 randomized controlled trials** (RCTs).[407]
- A significant effect was observed in 2 of the 3 RCTs included by the CTFPHC. In the study by Hollis et al, the interventions consisted of an individually tailored intervention based on the smoking status and stage of change of the individual. It included a 30-second clinician advice message, a 10-minute interactive computer program, a 5-minute motivational interview, and up to two 10-minute telephone or in person booster sessions.[408] In the study by Pbert and colleagues, the intervention consisted of brief counselling by the paediatric provider followed by one visit and four telephone calls by older peer counsellors (aged 21 to 25 years).[409]
- Based on a limited number of studies with small sample sizes, the USPSTF found no beneficial intervention effect associated with medication on the likelihood of smoking cessation in adolescents.[410]

- For modelling purposes we assumed an 18% (95% CI of 8% to 27%) **reduction in smoking initiation** and a 34% (95% CI of 5% to 69%) **increase in smoking cessation** in children and youth associated with screening and a behavioural intervention. We used the upper and lower bounds of the 95% CI in the sensitivity analysis.

[404] Selph S, Patnode C, Bailey S et al. Primary care-relevant interventions for tobacco and nicotine use prevention and cessation in children and adolescents: Updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2020; 323(16): 1599-608.
[405] Canadian Task Force on Preventive Health Care. Recommendations on behavioural interventions for the prevention and treatment of smoking among school-aged children and youth. *Canadian Medical Association Journal*. 2017; 189(8): e310-16.
[406] Selph S, Patnode C, Bailey S et al. Primary care-relevant interventions for tobacco and nicotine use prevention and cessation in children and adolescents: Updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2020; 323(16): 1599-608.
[407] Canadian Task Force on Preventive Health Care. Recommendations on behavioural interventions for the prevention and treatment of smoking among school-aged children and youth. *Canadian Medical Association Journal*. 2017; 189(8): e310-16.
[408] Hollis J, Polen M, Whitlock E et al. Teen Reach: Outcomes from a randomized, controlled trial of a tobacco reduction program for teens seen in primary medical care. *Pediatrics*. 2005; 115(4): 981-9.
[409] Pberrt L, Flint A, Fletcher K et al. Effect of a pediatric-based smoking prevention and cessation intervention for adolescents: A randomized, controlled trial. *Pediatrics*. 2008; 121(4): e738-47.
[410] Selph S, Patnode C, Bailey S et al. Primary care-relevant interventions for tobacco and nicotine use prevention and cessation in children and adolescents: Updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2020; 323(16): 1599-608.

- Based on the above assumptions, an intervention in which all screened children / youth ages 5 – 17 would receive a brief intervention re: cigarette smoking / e-cigarette use initiation and 45% of screened cigarette smokers and 67% of screened e-cigarette users receive a brief cessation intervention every two years would reduce the number of current smokers at age 24 in the birth cohort from 5,414 (see Table 7) to 4,316 (see Table 14), a reduction of 1,099 (20.3%). The number of e-cigarette users at age 24 would also be reduced from 5,751 (see Table 7) to 4,510 (see Table 14), a reduction of 1,241 (21.6%).

Table 14: Estimated Prevalence of Cigarette Smoking and E-Cigarette Use

Between the Ages of 8 and 24

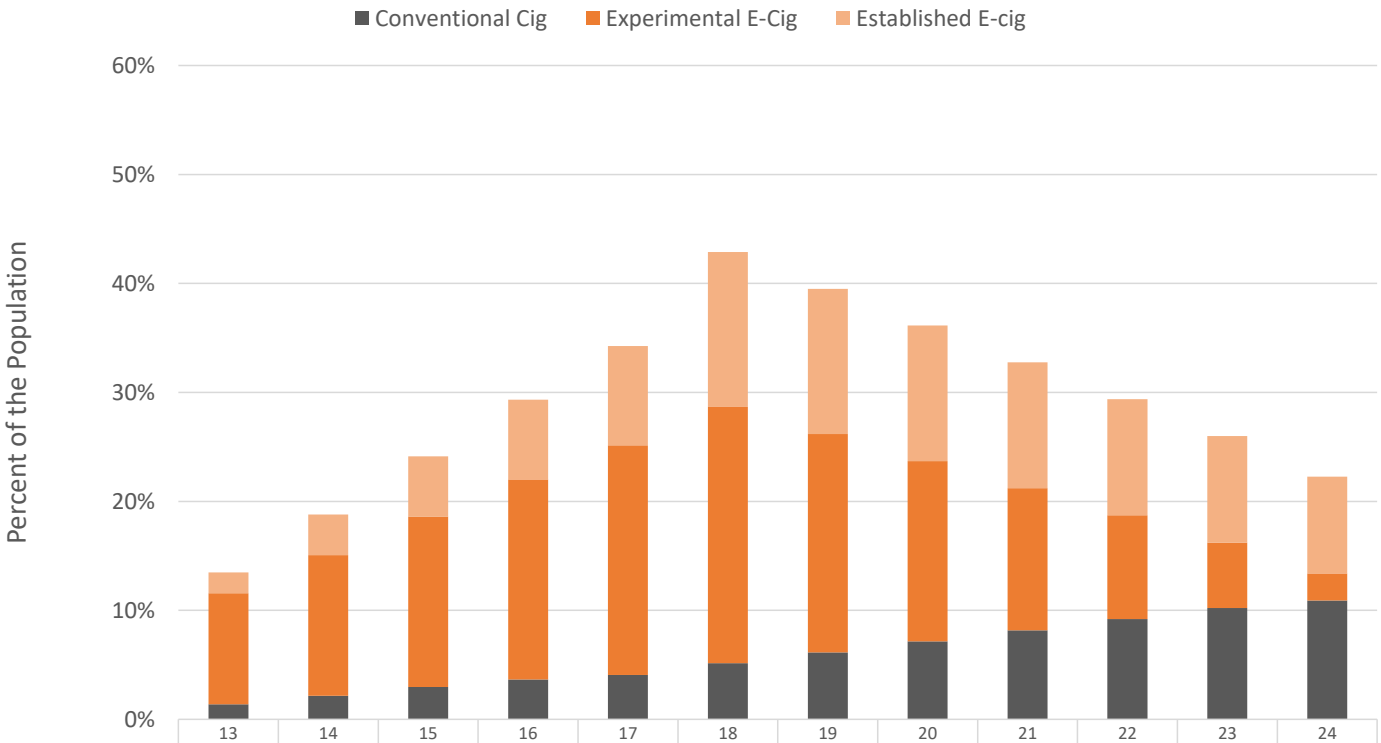
In a British Columbia Birth Cohort of 40,000

With a Child / Youth Screening Program / Brief Intervention

	Females							Males							Total Population						
	No Intervention (Table 7)				With Intervention			No Intervention (Table 7)				With Intervention			No Intervention (Table 7)				With Intervention		
			e-Cig			e-Cig				e-Cig			e-Cig				e-Cig			e-Cig	
Age	**Pop.**	Cig	Exp	Est	Cig	Exp	Est	**Pop.**	Cig	Exp	Est	Cig	Exp	Est	**Pop.**	Cig	Exp	Est	Cig	Exp	Est
8	19,918	29			25			19,907	46			40			39,824	75			65		
9	19,917	44			38			19,906	69			59			39,822	113			97		
10	19,915	66			56			19,904	104			89			39,820	170			145		
11	19,914	88			75			19,903	138			119			39,817	226			194		
12	19,913	147			125			19,902	230			198			39,815	377			323		
13	19,911	249	2,708	438	213	2,120	343	19,900	391	2,448	537	336	1,932	424	39,812	641	5,156	975	549	4,052	767
14	19,910	388	3,394	791	332	2,658	620	19,898	610	3,149	1,094	524	2,485	863	39,808	999	6,543	1,886	856	5,142	1,483
15	19,907	535	4,081	1,145	455	3,176	886	19,896	840	3,850	1,651	724	3,049	1,312	39,803	1,375	7,930	2,796	1,178	6,225	2,198
16	19,904	660	4,767	1,498	559	3,694	1,153	19,891	1,036	4,550	2,208	894	3,613	1,760	39,795	1,696	9,318	3,706	1,452	7,307	2,913
17	19,900	733	5,454	1,851	620	4,212	1,420	19,885	1,151	5,251	2,765	994	4,177	2,208	39,784	1,884	10,705	4,616	1,614	8,389	3,628
18	19,894	1,004	6,893	2,888	846	5,299	2,203	19,876	1,385	5,104	4,313	1,197	4,058	3,454	39,770	2,388	11,997	7,202	2,043	9,357	5,657
19	19,888	1,274	5,866	2,706	1,047	4,510	2,064	19,864	1,619	4,343	4,042	1,397	3,453	3,236	39,752	2,893	10,209	6,748	2,444	7,963	5,300
20	19,881	1,545	4,839	2,524	1,247	3,720	1,925	19,851	1,852	3,583	3,770	1,597	2,849	3,019	39,732	3,397	8,422	6,294	2,844	6,569	4,944
21	19,874	1,815	3,812	2,342	1,447	2,930	1,786	19,835	2,086	2,822	3,498	1,798	2,244	2,801	39,709	3,901	6,634	5,841	3,245	5,174	4,588
22	19,867	2,086	2,785	2,160	1,648	2,141	1,648	19,817	2,320	2,062	3,226	1,998	1,639	2,584	39,684	4,406	4,847	5,387	3,646	3,780	4,231
23	19,859	2,356	1,758	1,978	1,848	1,351	1,509	19,796	2,554	1,301	2,955	2,198	1,035	2,366	39,656	4,910	3,059	4,933	4,046	2,386	3,875
24	19,851	2,627	731	1,796	2,048	562	1,370	19,775	2,788	541	2,683	2,267	430	2,148	39,626	5,414	1,272	4,479	4,316	992	3,518

- Figure 3 provides a visual representation of the modelled transitions between conventional and e-cigarette use between the ages of 13 and 24 with a child and youth screening program and brief intervention.

Figure 3: Trend in Usage of Conventional and e-Cigarettes
Ages 13 to 24 ***With*** a Screening / Brief Intervention Program



	13	14	15	16	17	18	19	20	21	22	23	24
Established E-cig	1.9%	3.7%	5.5%	7.3%	9.1%	14.2%	13.3%	12.4%	11.6%	10.7%	9.8%	8.9%
Experimental E-Cig	10.2%	12.9%	15.6%	18.4%	21.1%	23.5%	20.0%	16.5%	13.0%	9.5%	6.0%	2.5%
Conventional Cig	1.4%	2.1%	3.0%	3.6%	4.1%	5.1%	6.1%	7.2%	8.2%	9.2%	10.2%	10.9%

- Based on the above assumptions, an intervention in which all screened children / youth ages 5 – 17 would receive a brief intervention re: cigarette smoking / e-cigarette use initiation and 45% of screened cigarette smokers and 67% of screened e-cigarette users receive a brief cessation intervention every two years would reduce the number of deaths and life years lost attributable to cigarette smoking between the ages of 36 and 84 from 3,320 / 55,464 (see Table 10) to 2,649 / 44,239 (see Table 15), a reduction of 671 deaths (20.2%) and 11,225 life years lost (20.2%).

Table 15: Estimated Deaths and Life Years Lost Attributable to Cigarette Smoking
Between the Ages of 35 and 84
In a British Columbia Birth Cohort of 40,000
With a Child / Youth Screening Program / Brief Intervention

	Female								***Male***								***Total Population***					
		Deaths								Deaths								Deaths Attributable to Smoking					
		In	Att to	By Smoking Intensity			LYL /			In	Att to	By Smoking Intensity			LYL /							
Age	**Pop.**	Cohort	Smoking	Light	Moderate	Heavy	Death	LYL	**Pop.**	Cohort	Smoking	Light	Moderate	Heavy	Death	LYL	**Pop.**	Light	Moderate	Heavy	Total	LYL
35	19,749								19,505								39,254					
36	19,736	13	2.5	0.7	0.8	1.0	50.8	125	19,474	31	5.1	1.4	1.7	2.0	46.5	238	39,210	2.1	2.5	3.0	8	363
37	19,722	14	2.6	0.7	0.8	1.0	49.9	128	19,442	32	5.2	1.5	1.7	2.1	45.6	239	39,164	2.2	2.5	3.1	8	367
38	19,708	14	2.7	0.8	0.9	1.1	48.9	131	19,409	33	5.4	1.5	1.8	2.1	44.7	242	39,117	2.3	2.6	3.2	8	373
39	19,693	15	2.8	0.8	0.9	1.1	47.9	136	19,375	34	5.6	1.6	1.8	2.2	43.7	245	39,068	2.4	2.7	3.3	8	381
40	19,677	16	2.9	0.8	1.0	1.2	47.0	138	19,339	35	5.8	1.6	1.9	2.3	42.8	248	39,017	2.5	2.8	3.4	9	387
41	19,661	16	3.1	0.9	1.0	1.2	46.0	143	19,303	37	6.0	1.7	1.9	2.4	41.9	251	38,964	2.6	3.0	3.6	9	394
42	19,643	18	3.3	0.9	1.1	1.3	45.1	150	19,264	38	6.3	1.8	2.0	2.5	41.0	257	38,908	2.7	3.1	3.8	10	406
43	19,625	19	3.5	1.0	1.1	1.4	44.1	155	19,225	40	6.5	1.8	2.1	2.6	40.1	261	38,849	2.8	3.3	3.9	10	416
44	19,605	20	3.7	1.1	1.2	1.5	43.1	161	19,183	41	6.8	1.9	2.2	2.7	39.1	266	38,788	3.0	3.4	4.1	11	427
45	19,584	21	4.0	1.1	1.3	1.6	42.2	169	19,140	43	7.1	2.0	2.3	2.8	38.2	271	38,724	3.1	3.6	4.4	11	439
46	19,561	23	4.3	1.2	1.4	1.7	41.2	176	19,094	46	7.5	2.1	2.4	2.9	37.3	279	38,656	3.3	3.8	4.6	12	455
47	19,537	24	4.6	1.3	1.5	1.8	40.3	184	19,047	48	7.8	2.2	2.5	3.1	36.4	285	38,584	3.5	4.0	4.9	12	469
48	19,511	26	4.9	1.4	1.6	1.9	39.3	192	18,996	50	8.2	2.3	2.7	3.2	35.5	292	38,508	3.7	4.2	5.1	13	484
49	19,484	28	5.2	1.5	1.7	2.0	38.4	200	18,943	53	8.8	2.5	2.8	3.4	34.6	303	38,427	4.0	4.5	5.5	14	503
50	19,454	30	5.6	1.6	1.8	2.2	37.4	209	18,887	56	9.2	2.6	3.0	3.6	33.7	312	38,341	4.2	4.8	5.8	15	521
51	19,422	32	6.0	1.7	1.9	2.4	36.5	219	18,827	60	9.8	2.8	3.2	3.8	32.8	322	38,249	4.5	5.1	6.2	16	541
52	19,388	34	6.4	1.8	2.1	2.5	35.6	228	18,763	64	10.5	3.0	3.4	4.1	31.9	334	38,151	4.8	5.5	6.6	17	562
53	19,352	37	6.9	2.0	2.2	2.7	34.6	239	18,695	68	11.2	3.2	3.6	4.4	31.0	347	38,046	5.1	5.9	7.1	18	586
54	19,312	39	7.4	2.1	2.4	2.9	33.7	251	18,622	73	11.9	3.4	3.9	4.7	30.2	359	37,934	5.5	6.3	7.6	19	610
55	19,270	43	8.0	2.3	2.6	3.2	32.8	264	18,545	78	12.7	3.6	4.1	5.0	29.3	372	37,814	5.9	6.7	8.2	21	636
56	19,224	46	8.6	2.4	2.8	3.4	31.9	275	18,461	83	13.6	3.9	4.4	5.4	28.4	387	37,685	6.3	7.2	8.8	22	663
57	19,174	49	9.3	2.6	3.0	3.7	30.9	289	18,372	89	14.6	4.1	4.7	5.7	27.5	402	37,547	6.8	7.8	9.4	24	690
58	19,121	53	10.1	2.9	3.3	4.0	30.0	303	18,277	95	15.6	4.4	5.1	6.1	26.7	417	37,398	7.3	8.3	10.1	26	720
59	19,063	58	11.0	3.1	3.6	4.3	29.1	319	18,175	102	16.8	4.7	5.4	6.6	25.8	433	37,238	7.8	9.0	10.9	28	752
60	19,000	63	11.9	3.4	3.8	4.7	28.2	334	18,065	110	18.0	5.1	5.8	7.1	25.0	450	37,065	8.4	9.7	11.7	30	784
61	18,932	68	12.9	3.6	4.2	5.1	27.3	352	17,947	118	19.3	5.5	6.3	7.6	24.1	467	36,879	9.1	10.4	12.7	32	818
62	18,858	74	14.0	4.0	4.5	5.5	26.4	370	17,820	127	20.8	5.9	6.7	8.2	23.3	484	36,678	9.8	11.3	13.7	35	855
63	18,777	81	15.2	4.3	4.9	6.0	25.5	388	17,684	136	22.4	6.3	7.3	8.8	22.5	503	36,461	10.6	12.2	14.8	38	891
64	18,689	88	16.6	4.7	5.4	6.5	24.6	409	17,537	147	24.1	6.8	7.8	9.5	21.7	522	36,226	11.5	13.2	16.0	41	932
65	18,593	96	18.1	5.1	5.9	7.1	23.8	430	17,379	158	25.9	7.3	8.4	10.2	20.9	541	35,972	12.5	14.3	17.3	44	971
66	18,489	105	19.8	5.6	6.4	7.8	22.9	452	17,208	171	28.0	7.9	9.1	11.0	20.1	561	35,697	13.5	15.5	18.7	48	1,013
67	18,375	114	21.6	6.1	7.0	8.5	22.0	475	17,024	184	30.2	8.5	9.8	11.8	19.3	581	35,399	14.6	16.8	20.3	52	1,057
68	18,250	125	23.6	6.7	7.7	9.3	21.2	500	16,826	198	32.5	9.2	10.5	12.8	18.5	601	35,075	15.9	18.2	22.0	56	1,101
69	18,113	137	25.8	7.3	8.4	10.1	20.3	525	16,612	214	35.1	9.9	11.4	13.8	17.7	622	34,725	17.2	19.8	23.9	61	1,147
70	17,963	150	28.3	8.0	9.2	11.1	19.5	552	16,381	231	37.9	10.7	12.3	14.9	17.0	643	34,344	18.7	21.5	26.0	66	1,194
71	17,799	164	31.0	8.8	10.1	12.2	18.7	579	16,132	249	40.8	11.6	13.2	16.0	16.2	663	33,930	20.3	23.3	28.2	72	1,242
72	17,619	180	34.0	9.6	11.0	13.4	17.9	608	15,863	269	44.1	12.5	14.3	17.3	15.5	682	33,481	22.1	25.3	30.7	78	1,290
73	17,421	198	37.3	10.6	12.1	14.7	17.1	637	15,573	290	47.5	13.5	15.4	18.7	14.8	702	32,994	24.0	27.5	33.3	85	1,339
74	17,204	217	41.0	11.6	13.3	16.1	16.3	667	15,260	313	51.3	14.5	16.6	20.1	14.1	721	32,464	26.1	29.9	36.2	92	1,388
75	16,966	238	45.0	12.7	14.6	17.7	15.5	697	14,923	337	55.2	15.6	17.9	21.7	13.4	738	31,889	28.4	32.5	39.4	100	1,435
76	16,704	261	49.4	14.0	16.0	19.4	14.7	727	14,560	363	59.5	16.8	19.3	23.4	12.7	755	31,265	30.8	35.3	42.7	109	1,482
77	16,417	287	54.2	15.3	17.6	21.3	14.0	758	14,170	390	64.0	18.1	20.7	25.1	12.0	769	30,587	33.4	38.3	46.4	118	1,527
78	16,102	315	59.5	16.8	19.3	23.4	13.2	788	13,751	419	68.7	19.4	22.3	27.0	11.4	782	29,853	36.3	41.6	50.3	128	1,570
79	15,757	346	65.3	18.5	21.2	25.6	12.5	817	13,301	450	73.7	20.9	23.9	28.9	10.8	792	29,058	39.3	45.1	54.6	139	1,609
80	15,378	379	71.5	20.2	23.2	28.1	11.8	845	12,820	481	78.9	22.3	25.6	31.0	10.1	799	28,198	42.6	48.8	59.1	150	1,644
81	14,963	415	78.3	22.2	25.4	30.7	11.1	871	12,306	514	84.2	23.8	27.3	33.1	9.5	803	27,269	46.0	52.7	63.8	163	1,674
82	14,510	453	85.6	24.2	27.7	33.6	10.5	895	11,759	547	89.7	25.4	29.1	35.2	9.0	802	26,269	49.6	56.8	68.8	175	1,697
83	14,016	494	93.3	26.4	30.3	36.6	9.8	916	11,179	580	95.1	26.9	30.9	37.4	8.4	798	25,195	53.3	61.1	74.0	188	1,714
84	13,478	538	101.6	28.7	32.9	39.9	9.2	932	10,565	614	100.6	28.5	32.6	39.5	7.9	789	24,043	57.2	65.6	79.4	202	1,722
Total		***6,271***	***1,184***	***335***	***384***	***465***	***17.1***	***20,308***		***8,940***	***1,465***	***415***	***475***	***575***	***16.3***	***23,931***		***750***	***859***	***1,040***	***2,649***	***44,239***

- Based on the above assumptions, an intervention in which all screened children / youth ages 5 – 17 would receive a brief intervention re: cigarette smoking / e-cigarette use initiation and 45% of screened cigarette smokers and 67% of screened e-cigarette users receive a brief cessation intervention every two years would reduce the QALYs lost between the ages of 19 and 84 by those living with cigarette smoking from 13,805 (see Table 11) to 11,007 (see Table 16), a reduction of 2,798 QALYs lost (20.3%).

Table 16: Estimated Quality-Adjusted Life Years Lost Attributable to Cigarette Smoking
Between the Ages of 19 and 84
In a British Columbia Birth Cohort of 40,000
With a Child / Youth Screening Program / Brief Intervention

	Females							***Males***							***Total Population***			
	Smokers Alive			QALYs Lost				Smokers Alive			QALYs Lost				QALYs Lost			
	Smoking Intensity			Smoking Intensity				Smoking Intensity			Smoking Intensity				Smoking Intensity			
Age	Light	Mod	Heavy	Light	Mod	Heavy	**Total**	Light	Mod	Heavy	Light	Mod	Heavy	**Total**	Light	Mod	Heavy	**Total**
19	1,100	664	284	37	24	19	**81**	1,169	592	507	40	21	34	**95**	77	45	54	**176**
20	1,100	664	284	37	24	19	**81**	1,169	592	507	40	21	34	**95**	77	45	54	**176**
21	1,100	664	284	37	24	19	**81**	1,169	592	507	40	21	34	**95**	77	45	54	**176**
22	1,100	664	284	37	24	19	**81**	1,169	592	507	40	21	34	**95**	77	45	54	**176**
23	1,100	664	284	37	24	19	**81**	1,169	592	507	40	21	34	**95**	77	45	54	**176**
24	1,100	664	284	37	24	19	**81**	1,169	592	507	40	21	34	**95**	77	45	54	**176**
25	1,100	664	284	37	24	19	**81**	1,169	592	507	40	21	34	**95**	77	45	54	**176**
26	1,100	664	284	37	24	19	**81**	1,169	592	507	40	21	34	**95**	77	45	54	**176**
27	1,100	664	284	37	24	19	**81**	1,169	592	507	40	21	34	**95**	77	45	54	**176**
28	1,100	664	284	37	24	19	**81**	1,169	592	507	40	21	34	**95**	77	45	54	**176**
29	1,100	664	284	37	24	19	**81**	1,169	592	507	40	21	34	**95**	77	45	54	**176**
30	1,100	664	284	38	25	20	**83**	1,169	592	507	41	22	35	**98**	79	47	55	**181**
31	1,100	664	284	38	25	20	**83**	1,169	592	507	41	22	35	**98**	79	47	55	**181**
32	1,100	664	284	38	25	20	**83**	1,169	592	507	41	22	35	**98**	79	47	55	**181**
33	1,100	664	284	38	25	20	**83**	1,169	592	507	41	22	35	**98**	79	47	55	**181**
34	1,100	664	284	38	25	20	**83**	1,169	592	507	41	22	35	**98**	79	47	55	**181**
35	1,100	664	284	38	25	20	**83**	1,169	592	507	41	22	35	**98**	79	47	55	**181**
36	1,099	663	284	38	25	20	**83**	1,167	590	505	41	22	35	**98**	79	46	55	**180**
37	1,099	662	283	38	25	20	**82**	1,166	588	503	41	22	35	**97**	79	46	55	**180**
38	1,098	661	281	38	25	20	**82**	1,164	586	501	41	22	35	**97**	79	46	54	**180**
39	1,097	660	280	38	24	20	**82**	1,163	585	499	41	22	35	**97**	79	46	54	**179**
40	1,096	659	279	40	25	20	**86**	1,161	583	496	42	23	36	**101**	82	48	56	**186**
41	1,095	658	278	40	25	20	**85**	1,160	581	494	42	22	36	**100**	82	48	56	**186**
42	1,094	657	277	40	25	20	**85**	1,158	579	492	42	22	36	**100**	82	48	56	**185**
43	1,093	656	275	40	25	20	**85**	1,156	577	489	42	22	35	**100**	82	48	55	**185**
44	1,092	655	274	40	25	20	**85**	1,154	574	486	42	22	35	**99**	82	48	55	**184**
45	1,091	654	272	40	25	20	**85**	1,152	572	484	42	22	35	**99**	81	47	55	**184**
46	1,090	652	271	40	25	20	**84**	1,150	570	481	42	22	35	**99**	81	47	55	**183**
47	1,089	651	269	40	25	20	**84**	1,148	567	478	42	22	35	**98**	81	47	54	**182**
48	1,087	649	267	39	25	19	**84**	1,145	564	474	42	22	34	**98**	81	47	54	**182**
49	1,086	648	265	39	25	19	**84**	1,143	562	471	41	22	34	**97**	81	47	53	**181**
50	1,084	646	263	41	26	20	**87**	1,140	559	467	43	22	35	**101**	84	48	55	**188**
51	1,083	644	260	41	26	20	**87**	1,137	555	463	43	22	35	**100**	84	48	55	**187**
52	1,081	642	258	41	26	19	**86**	1,135	552	459	43	22	35	**100**	84	48	54	**186**
53	1,079	639	255	41	26	19	**86**	1,131	548	455	43	22	34	**99**	84	48	54	**185**
54	1,077	637	252	41	26	19	**85**	1,128	545	450	43	22	34	**99**	83	48	53	**184**
55	1,074	634	249	41	26	19	**85**	1,124	540	445	43	22	34	**98**	83	47	52	**183**
56	1,072	632	246	41	25	19	**85**	1,121	536	440	42	22	33	**97**	83	47	52	**182**
57	1,069	629	242	40	25	18	**84**	1,116	531	434	42	21	33	**96**	83	47	51	**180**
58	1,066	625	238	40	25	18	**83**	1,112	526	428	42	21	32	**96**	82	46	50	**179**
59	1,063	622	234	40	25	18	**83**	1,107	521	421	42	21	32	**95**	82	46	50	**178**
60	1,060	618	229	41	26	18	**84**	1,102	515	414	43	21	32	**96**	84	47	50	**181**
61	1,056	614	224	41	25	17	**84**	1,097	509	407	43	21	32	**95**	84	46	49	**179**
62	1,052	609	218	41	25	17	**83**	1,091	502	399	42	21	31	**94**	83	46	48	**177**
63	1,048	604	212	41	25	16	**82**	1,084	495	390	42	20	30	**93**	83	45	47	**175**
64	1,043	599	206	40	25	16	**81**	1,078	487	380	42	20	30	**91**	82	45	45	**173**
65	1,038	593	199	40	24	15	**80**	1,070	478	370	42	20	29	**90**	82	44	44	**170**
66	1,033	587	191	40	24	15	**79**	1,062	469	359	41	19	28	**88**	81	44	43	**168**
67	1,027	580	183	40	24	14	**78**	1,054	460	347	41	19	27	**87**	81	43	41	**165**
68	1,020	572	173	40	24	13	**77**	1,045	449	335	41	19	26	**85**	80	42	39	**162**
69	1,013	564	163	39	23	13	**75**	1,035	438	321	40	18	25	**83**	79	41	38	**158**
70	1,005	554	152	41	24	12	**78**	1,024	425	306	42	19	25	**86**	83	43	38	**163**
71	996	544	140	41	24	11	**76**	1,012	412	290	41	18	24	**83**	82	42	35	**159**
72	986	533	127	40	23	10	**74**	1,000	398	273	41	17	22	**81**	81	41	33	**155**
73	976	521	112	40	23	9	**72**	987	382	254	40	17	21	**78**	80	39	30	**150**
74	964	508	96	39	22	8	**69**	972	366	234	40	16	19	**75**	79	38	27	**144**
75	951	493	78	39	22	6	**67**	956	348	212	39	15	17	**72**	78	37	24	**139**
76	937	477	59	38	21	5	**64**	940	329	189	38	14	15	**68**	77	35	20	**132**
77	922	460	37	38	20	3	**61**	921	308	164	38	13	13	**65**	75	33	16	**125**
78	905	440	14	37	19	1	**57**	902	286	137	37	12	11	**61**	74	32	12	**118**
79	887	419		36	18		**55**	881	262	108	36	11	9	**56**	72	30	9	**111**
80	866	396		39	19		**57**	859	236	77	38	11	7	**56**	77	30	7	**113**
81	844	371		38	18		**55**	835	209	44	37	10	4	**51**	75	27	4	**106**
82	820	343		36	16		**53**	810	180	8	36	9	1	**45**	72	25	1	**98**
83	794	313		35	15		**50**	783	149		35	7		**42**	70	22		**92**
84	765	280		34	13		**47**	754	116		34	6		**39**	68	19		**86**
Total				***2,571***	***1,559***	***1,018***	***5,148***				***2,675***	***1,287***	***1,897***	***5,858***	***5,246***	***2,846***	***2,915***	***11,007***

- Based on the above assumptions, an intervention in which all screened children / youth ages 5 – 17 would receive a brief intervention re: cigarette smoking / e-cigarette use initiation and 45% of screened cigarette smokers and 67% of screened e-cigarette users receive a brief cessation intervention every two years would reduce the number of deaths and QALYs lost between the ages of 19 and 84 attributable to e-cigarette use from 1,695 / 31,943 (see Table 12) to 1,136 / 23,031 (see Table 17), a reduction of 559 deaths (33.0%) and 8,912 QALYs lost (27.9%).

Table 17: Estimated Deaths and QALYs Lost Due to e-Cigarette Use
Between the Ages of 19 and 84
In a British Columbia Birth Cohort of 40,000
With a Child / Youth Screening Program / Brief Intervention

	Females							***Males***							***Total Population***				
	c-Cig		e-Cig					c-Cig		e-Cig					e-Cig				Total
Age	Alive	Deaths	Alive	Deaths	LE	LYL	QALYs	Alive	Deaths	Alive	Deaths	LE	LYL	QALYs	Alive	Deaths	LYL	QALYs	QALYs
19	1,047	0.0	6,574	0.0	66.4	0	240	1,619	0.0	6,690	0.0	61.4	0	179	13,263	0	0	419	419
20	1,247	0.0	5,645	0.0	65.4	0	173	1,852	0.0	5,867	0.0	60.5	0	137	11,513	0	0	311	311
21	1,447	0.0	4,717	0.0	64.4	0	125	2,086	0.0	5,045	0.0	59.5	0	105	9,762	0	0	230	230
22	1,648	0.0	3,789	0.0	63.5	0	88	2,320	0.0	4,223	0.0	58.6	0	79	8,011	0	0	167	167
23	1,848	0.0	2,860	0.0	62.5	0	59	2,554	0.0	3,401	0.0	57.7	0	58	6,261	0	0	117	117
24	2,048	0.0	1,932	0.0	61.5	0	36	2,788	0.0	2,578	0.0	56.7	0	40	4,510	0	0	76	76
25	2,048	0.0	1,932	0.0	60.5	0	36	2,788	0.0	2,578	0.0	55.8	0	40	4,510	0	0	76	76
26	2,048	0.0	1,932	0.0	59.6	0	36	2,788	0.0	2,578	0.0	54.8	0	40	4,510	0	0	76	76
27	2,048	0.0	1,932	0.0	58.6	0	36	2,788	0.0	2,578	0.0	53.9	0	40	4,510	0	0	76	76
28	2,048	0.0	1,932	0.0	57.6	0	36	2,788	0.0	2,578	0.0	53.0	0	40	4,510	0	0	76	76
29	2,048	0.0	1,932	0.0	56.6	0	36	2,788	0.0	2,578	0.0	52.1	0	40	4,510	0	0	76	76
30	2,048	0.0	1,932	0.0	55.7	0	37	2,788	0.0	2,578	0.0	51.1	0	41	4,510	0	0	78	78
31	2,048	0.0	1,932	0.0	54.7	0	37	2,788	0.0	2,578	0.0	50.2	0	41	4,510	0	0	78	78
32	2,048	0.0	1,932	0.0	53.7	0	37	2,788	0.0	2,578	0.0	49.3	0	41	4,510	0	0	78	78
33	2,048	0.0	1,932	0.0	52.8	0	37	2,788	0.0	2,578	0.0	48.4	0	41	4,510	0	0	78	78
34	2,048	0.0	1,932	0.0	51.8	0	37	2,788	0.0	2,578	0.0	47.4	0	41	4,510	0	0	78	78
35	2,048	0.0	1,932	0.0	50.8	0	37	2,788	0.0	2,578	0.0	46.5	0	41	4,510	0	0	78	78
36	2,046	2.5	1,931	0.9	49.9	43	37	2,783	5.1	2,577	1.8	45.6	80	41	4,508	3	122	78	201
37	2,043	2.6	1,930	0.9	48.9	44	37	2,777	5.2	2,575	1.8	44.7	80	41	4,505	3	124	78	202
38	2,041	2.7	1,929	0.9	47.9	45	37	2,772	5.4	2,573	1.9	43.7	81	41	4,502	3	126	78	204
39	2,038	2.8	1,928	1.0	47.0	47	37	2,766	5.6	2,571	1.9	42.8	82	41	4,499	3	129	78	207
40	2,035	2.9	1,927	1.0	46.0	47	38	2,760	5.8	2,569	2.0	41.9	84	43	4,496	3	131	81	212
41	2,032	3.1	1,926	1.1	45.1	49	38	2,754	6.0	2,567	2.1	41.0	85	43	4,493	3	134	81	214
42	2,028	3.3	1,925	1.2	44.1	51	38	2,748	6.3	2,565	2.2	40.1	86	42	4,490	3	138	81	219
43	2,025	3.5	1,924	1.2	43.1	53	38	2,742	6.5	2,563	2.3	39.1	88	42	4,486	3	141	81	222
44	2,021	3.7	1,922	1.3	42.2	55	38	2,735	6.8	2,560	2.3	38.2	90	42	4,483	4	145	81	226
45	2,017	4.0	1,921	1.4	41.2	58	38	2,728	7.1	2,558	2.5	37.3	92	42	4,479	4	150	80	230
46	2,013	4.3	1,919	1.5	40.3	61	38	2,720	7.5	2,555	2.6	36.4	94	42	4,475	4	155	80	235
47	2,008	4.6	1,918	1.6	39.3	63	38	2,713	7.8	2,553	2.7	35.5	97	42	4,470	4	160	80	240
48	2,003	4.9	1,916	1.7	38.4	66	38	2,704	8.2	2,550	2.9	34.6	99	42	4,466	5	165	80	245
49	1,998	5.2	1,914	1.8	37.4	69	38	2,696	8.8	2,547	3.1	33.7	103	42	4,461	5	172	80	252
50	1,993	5.6	1,912	2.0	36.5	72	40	2,686	9.2	2,543	3.2	32.8	106	43	4,456	5	178	83	261
51	1,987	6.0	1,910	2.1	35.6	76	39	2,676	9.8	2,540	3.4	31.9	110	43	4,450	6	185	83	268
52	1,980	6.4	1,908	2.3	34.6	79	39	2,666	10.5	2,536	3.7	31.0	114	43	4,444	6	193	83	276
53	1,973	6.9	1,905	2.5	33.7	83	39	2,655	11.2	2,532	3.9	30.2	119	43	4,438	6	202	82	284
54	1,966	7.4	1,903	2.7	32.8	87	39	2,643	11.9	2,528	4.2	29.3	123	43	4,431	7	210	82	292
55	1,958	8.0	1,900	2.9	31.9	92	39	2,630	12.7	2,524	4.5	28.4	128	43	4,423	7	220	82	301
56	1,949	8.6	1,897	3.1	30.9	96	39	2,617	13.6	2,519	4.8	27.5	133	43	4,416	8	229	82	311
57	1,940	9.3	1,893	3.4	30.0	101	39	2,602	14.6	2,514	5.2	26.7	139	42	4,407	9	239	81	321
58	1,930	10.1	1,890	3.6	29.1	106	39	2,586	15.6	2,508	5.6	25.8	144	42	4,398	9	250	81	331
59	1,919	11.0	1,886	4.0	28.2	112	39	2,570	16.8	2,502	6.0	25.0	150	42	4,388	10	262	81	343
60	1,907	11.9	1,881	4.3	27.3	118	40	2,552	18.0	2,496	6.5	24.1	157	43	4,377	11	274	82	357
61	1,894	12.9	1,877	4.7	26.4	124	39	2,532	19.3	2,489	7.0	23.3	163	43	4,365	12	287	82	369
62	1,880	14.0	1,872	5.1	25.5	131	39	2,512	20.8	2,481	7.6	22.5	170	42	4,353	13	301	81	382
63	1,865	15.2	1,866	5.6	24.6	138	39	2,489	22.4	2,473	8.2	21.7	177	42	4,339	14	315	81	396
64	1,848	16.6	1,860	6.2	23.8	146	39	2,465	24.1	2,464	8.9	20.9	185	42	4,324	15	331	80	411
65	1,830	18.1	1,853	6.7	22.9	154	39	2,439	25.9	2,454	9.6	20.1	192	41	4,307	16	347	80	426
66	1,810	19.8	1,846	7.4	22.0	163	38	2,411	28.0	2,444	10.4	19.3	201	41	4,290	18	364	79	443
67	1,789	21.6	1,838	8.1	21.2	172	38	2,381	30.2	2,433	11.3	18.5	209	40	4,270	19	382	78	460
68	1,765	23.6	1,829	9.0	20.3	183	38	2,349	32.5	2,420	12.3	17.7	218	40	4,249	21	400	78	478
69	1,739	25.8	1,819	9.9	19.5	193	37	2,313	35.1	2,407	13.4	17.0	227	39	4,226	23	420	77	497
70	1,711	28.3	1,808	10.9	18.7	204	39	2,276	37.9	2,392	14.6	16.2	237	41	4,200	26	441	80	521
71	1,680	31.0	1,796	12.1	17.9	217	39	2,235	40.8	2,377	15.9	15.5	246	40	4,172	28	463	79	541
72	1,646	34.0	1,782	13.5	17.1	230	38	2,191	44.1	2,359	17.3	14.8	256	39	4,141	31	486	78	563
73	1,609	37.3	1,767	15.0	16.3	243	37	2,143	47.5	2,340	18.9	14.1	266	39	4,107	34	510	76	586
74	1,568	41.0	1,751	16.7	15.5	258	37	2,092	51.3	2,320	20.7	13.4	277	38	4,070	37	535	75	610
75	1,523	45.0	1,732	18.6	14.7	274	36	2,037	55.2	2,297	22.7	12.7	288	37	4,029	41	561	73	634
76	1,473	49.4	1,711	20.8	14.0	290	35	1,977	59.5	2,272	24.8	12.0	298	36	3,983	46	589	71	660
77	1,419	54.2	1,688	23.3	13.2	309	34	1,913	64.0	2,245	27.2	11.4	309	34	3,933	51	618	69	687
78	1,360	59.5	1,662	26.2	12.5	328	33	1,845	68.7	2,215	29.8	10.8	321	33	3,877	56	648	66	715
79	1,294	65.3	1,632	29.5	11.8	349	33	1,771	73.7	2,182	32.7	10.1	332	32	3,814	62	680	64	744
80	1,223	71.5	1,599	33.4	11.1	372	36	1,692	78.9	2,146	36.0	9.5	343	32	3,745	69	714	68	782
81	1,144	78.3	1,561	37.9	10.5	396	36	1,608	84.2	2,107	39.5	9.0	354	30	3,668	77	750	66	816
82	1,059	85.6	1,518	43.2	9.8	424	36	1,518	89.7	2,063	43.5	8.4	365	28	3,581	87	788	64	852
83	966	93.3	1,468	49.5	9.2	454	36	1,423	95.1	2,016	47.8	7.9	376	27	3,484	97	830	63	893
84	864	101.6	1,411	57.1	8.6	490	37	1,322	100.6	1,963	52.7	7.3	386	26	3,374	110	876	63	939
Total		***1,184***		***521***	***15.4***	***8,015***	***2,972***		***1,465***		***616***	***14.7***	***9,058***	***2,987***		***1,136***	***17,072***	***5,959***	***23,031***

- Other assumptions used in assessing the clinically preventable burden are detailed in the Reference Document.

Summary of CPB – Males and Females

Based on these assumptions, the CPB associated with an intervention in which all screened children and youth ages 5 – 17 would receive a brief intervention re: cigarette smoking / e-cigarette use initiation and 45% of screened cigarette smokers and 67% of screened e-cigarette users receive a brief cessation intervention every two years is 22,935 QALYs (Table 18, row *aw*). The CPB of 22,935 represents the gap between no coverage and the 'best in the world' coverage.

Table 18: CPB of Interventions for Tobacco Use Prevention and Cessation in Children and Youth in a B.C. Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
a	Age to start screening	5	√
b	Age to stop screening / brief intervention	17	√
	Without an Adolescent Screening Program / Brief Intervention		
	Prevalence of **female cigarette smokers** at age 24, by smoking intensity		
c	Light	1,411	Table 7
d	Moderate	851	Table 7
e	Heavy	365	Table 7
f	Total	2,627	= c + d + e
	Prevalence of **male cigarette smokers** at age 24, by smoking intensity		
g	Light	1,437	Table 7
h	Moderate	727	Table 7
i	Heavy	623	Table 7
j	Total	2,788	= g + h + i
k	Premature deaths in **female cigarette** smokers	1,519	Table 10
l	Life years lost due to premature deaths	26,043	Table 10
m	Premature deaths in **male cigarette** smokers	1,801	Table 10
n	Life years lost due to premature deaths	29,421	Table 10
o	QALYs lost due to **cigarette smoking** while alive (**females)**	6,602	Table 11
p	QALYs lost due to **cigarette smoking** while alive (**males)**	7,202	Table 11
q	Premature deaths in **female e-cigarette** users	681	Table 12
r	Life years lost due to premature deaths	10,484	Table 12
s	Premature deaths in **male e-cigarette** users	1,014	Table 12
t	Life years lost due to premature deaths	14,600	Table 12
u	QALYs lost due to **e-cigarette** use while alive (**females)**	3,053	Table 12
v	QALYs lost due to **e-cigarette** smoking while alive (**males)**	3,806	Table 12
w	Total QALYs Lost - **Females**	46,183	= l + o + r + u
x	Total QALYs Lost - **Males**	55,029	= n + p + t + v
	With an Adolescent Screening Program / Brief Intervention		
	Prevalence of **female smokers** at age 24, by smoking intensity		
y	Light	1,100	Table 14
z	Moderate	664	Table 14
aa	Heavy	284	Table 14
ab	Total	2,048	= y + z + aa
	Prevalence of **male smokers** at age 24, by smoking intensity		
ac	Light	1,169	Table 14
ad	Moderate	592	Table 14
ae	Heavy	507	Table 14
af	Total	2,267	= ac + ad + ae
ag	Premature deaths in **female cigarette** smokers	1,184	Table 15
ah	Life years lost due to premature deaths	20,308	Table 15
ai	Premature deaths in **male cigarette** smokers	1,465	Table 15
aj	Life years lost due to premature deaths	23,931	Table 15
ak	QALYs lost due to **cigarette smoking** while alive (**females)**	5,148	Table 16
al	QALYs lost due to **cigarette smoking** while alive (**males)**	5,858	Table 16
am	Premature deaths in **female e-cigarette** users	521	Table 17
an	Life years lost due to premature deaths	8,015	Table 17
ao	Premature deaths in **male e-cigarette** users	616	Table 17
ap	Life years lost due to premature deaths	9,058	Table 17
aq	QALYs lost due to **e-cigarette** use while alive (**females)**	2,972	Table 17
ar	QALYs lost due to **e-cigarette** smoking while alive (**males)**	2,987	Table 17
as	Total QALYs Lost - **Females**	36,443	= ah + ak + an + aq
at	Total QALYs Lost - **Males**	41,834	= aj + al + ap + ar
	QALYs Gained With Screening / Brief Intervention		
au	**Total QALYs gained - Females (CPB)**	9,740	= w - as
av	**Total QALYs gained - Males (CPB)**	13,195	= x - at
aw	**Total QALYs gained (CPB)**	**22,935**	= au + av

√ = Estimates from the literature

We also modified a number of major assumptions and recalculated the CPB as follows:

- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is reduced from 18% to 8% and the effectiveness of interventions aimed at smoking cessation are reduced from 34% to 5%: **CPB = 5,910**.
- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is increased from 18% to 27% and the effectiveness of interventions aimed at smoking cessation are increased from 34% to 69%: **CPB = 41,077.**
- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is reduced from 18% to 8%: CPB = 18,681.
- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is increased from 18% to 27%: CPB = 26,719.
- Assume the effectiveness of interventions aimed at smoking cessation are reduced from 34% to 5%: CPB = 10,377.
- Assume the effectiveness of interventions aimed smoking cessation are increased from 34% to 69%: CPB = 37,486.
- Assume the QoL reduction associated with light/moderate/heavy smoking is reduced from 0.031 / 0.033 / 0.062 to 0.018 / 0.019 / 0.042: CPB = 21,476.
- Assume the QoL reduction associated with light/moderate/heavy smoking is increased from 0.031 / 0.033 / 0.062 to 0.045 / 0.047 / 0.082: CPB = 24,452.
- Assume the harms attributable to e-cigarette use are reduced from being 37% as harmful as smoking conventional cigarettes to being 10% as harmful: CPB = 16,707.
- Assume the harms attributable to e-cigarette use are increased from being 37% as harmful as smoking conventional cigarettes to being 60% as harmful: CPB = 27,266.

Summary of CPB – Females Only

Based on these assumptions, the CPB associated with an intervention in which female screened children and youth ages 5 – 17 would receive a brief intervention re: cigarette smoking / e-cigarette use initiation and 45% of screened cigarette smokers and 67% of screened e-cigarette users receive a brief cessation intervention every two years is 9,740 QALYs (Table 18, row *au*). The CPB of 9,740 represents the gap between no coverage and the 'best in the world' coverage.

We also modified a number of major assumptions and recalculated the CPB as follows:

- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is reduced from 18% to 8% and the effectiveness of interventions aimed at smoking cessation are reduced from 34% to 5%: **CPB = 2,438**.
- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is increased from 18% to 27% and the effectiveness of interventions aimed at smoking cessation are increased from 34% to 69%: **CPB = 17,995**.
- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is reduced from 18% to 8%: CPB = 7,873.
- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is increased from 18% to 27%: CPB = 11,423.

- Assume the effectiveness of interventions aimed at smoking cessation are reduced from 34% to 5%: CPB = 4,311.
- Assume the effectiveness of interventions aimed smoking cessation are increased from 34% to 69%: CPB = 16,316.
- Assume the QoL reduction associated with light/moderate/heavy smoking is reduced from 0.031 / 0.033 / 0.062 to 0.018 / 0.019 / 0.042: CPB = 9,123.
- Assume the QoL reduction associated with light/moderate/heavy smoking is increased from 0.031 / 0.033 / 0.062 to 0.045 / 0.047 / 0.082: CPB = 10,381.
- Assume the harms attributable to e-cigarette use are reduced from being 37% as harmful as smoking conventional cigarettes to being 10% as harmful: CPB = 7,932.
- Assume the harms attributable to e-cigarette use are increased from being 37% as harmful as smoking conventional cigarettes to being 60% as harmful: CPB = 11,078.

Summary of CPB – Males Only

Based on these assumptions, the CPB associated with an intervention in which male screened children and youth ages 5 – 17 would receive a brief intervention re: cigarette smoking / e-cigarette use initiation and 45% of screened cigarette smokers and 67% of screened e-cigarette users receive a brief cessation intervention every two years is 13,195 QALYs (Table 18, row *av*). The CPB of 13,195 represents the gap between no coverage and the 'best in the world' coverage.

We also modified a number of major assumption and recalculated the CPB as follows:

- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is reduced from 18% to 8% and the effectiveness of interventions aimed at smoking cessation are reduced from 34% to 5%: **CPB = 3,473.**
- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is increased from 18% to 27% and the effectiveness of interventions aimed at smoking cessation are increased from 34% to 69%: **CPB = 23,083.**
- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is reduced from 18% to 8%: CPB = 10,808.
- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is increased from 18% to 27%: CPB = 15,297.
- Assume the effectiveness of interventions aimed at smoking cessation are reduced from 34% to 5%: CPB = 6,066.
- Assume the effectiveness of interventions aimed smoking cessation are increased from 34% to 69%: CPB = 21,171.
- Assume the QoL reduction associated with light/moderate/heavy smoking is reduced from 0.031 / 0.033 / 0.062 to 0.018 / 0.019 / 0.042: CPB = 12,353.
- Assume the QoL reduction associated with light/moderate/heavy smoking is increased from 0.031 / 0.033 / 0.062 to 0.045 / 0.047 / 0.082: CPB = 14,071.
- Assume the harms attributable to e-cigarette use are reduced from being 37% as harmful as smoking conventional cigarettes to being 10% as harmful: CPB = 8,774.
- Assume the harms attributable to e-cigarette use are increased from being 37% as harmful as smoking conventional cigarettes to being 60% as harmful: CPB = 16,188.

Modelling Cost-Effectiveness

In this section, we model CE associated with asking children and youth or their parents about tobacco use by the child or youth and offering brief information and advice, as appropriate, during primary care visits to prevent and/or treat tobacco smoking and e-cigarette use among children and youth.

In calculating CE, we made the following assumptions:

Screening and Brief Behavioural Interventions to Reduce the Initiation of Tobacco Smoking

- We assumed that screening for cigarette smoking / e-cigarette use in children / youth would take place annually in 92%[411] and 89%[412] of those with a primary health care visit in a given year. Furthermore, we have assumed that the screening would require 20% of a PCP office visit.

- The USPSTF reviewed 14 studies assessing the effectiveness of a brief intervention to **reduce the initiation of tobacco smoking**. Follow-up for these studies ranged from 6 to 36 months with the majority (57%) at 12 months.[413]
- In the 14 studies, three interventions took place in primary care clinics, two in dental clinics, 10 in homes and one in a school. Eight trials targeted the youth to receive the intervention, two targeted the parent and four targeted both child and parent. Print materials were used most commonly to deliver part or all of the intervention followed by face-to-face encounters with a counselor, health educator, or primary care medical or dental provider. The duration of the interventions ranged from 7 weeks to 25 months with a mean number of six contacts (ranging from 3-15).[414]

- We have assumed that an intervention to **reduce the initiation of tobacco smoking** would be required seven times between the ages of 5 and 17 for maximum effect, approximately once every two years. Furthermore, we have assumed that the intervention would require 50% of a PCP office visit for the first four interventions between the ages of 5 and 12 and then a full PCP office visit for the final three interventions between the ages of 13 and 17.

- The cost of an office visit to a General Practitioner (GP) in BC is estimated at $35.97.[415]

[411] LeLaurin J, Theis R, Thompson L et al. Tobacco-related counselling and documentation in adolescent primary care practice: Challenges and opportunities. *Nicotine & Tobacco Research*. 2020; 22(6): 1023-9.
[412] Matheus C, Hein N, Narahari P et al. Improving standardized screening for e-cigarette and vaping use among adolescents. *Paediatrics*. 2021; 147 (3-Meeting Abstract): 1002.
[413] Selph S, Patnode C, Bailey S et al. *Primary Care Interventions for Prevention and Cessation of Tobacco Use in Children and Adolescents: A Systematic Review for the U.S. Preventive Services Task Force*. Evidence Synthesis No. 185. AHRQ Publication No. 19-05254-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; 2020.
[414] Selph S, Patnode C, Bailey S et al. *Primary Care Interventions for Prevention and Cessation of Tobacco Use in Children and Adolescents: A Systematic Review for the U.S. Preventive Services Task Force*. Evidence Synthesis No. 185. AHRQ Publication No. 19-05254-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; 2020.
[415] Ministry of Health. *Medical Services Commission Payment Schedule*. 2021. Available at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msc-payment-schedule-may-2021.pdf. Accessed September 2022.

- Patient time costs resulting from receiving, as well as travelling to and from, a service are valued based on the average hourly wage rate in BC in 2022 ($31.49[416]) plus 18% benefits for an average cost per hour of $37.16. In the absence of specific data on the amount of time required, we assume two hours per service.
- Based on these assumptions, the cost of asking children and youth between the ages of 5 and 17 (or their parents) about tobacco use by the child or youth and offering brief information and advice, as appropriate, during primary care visits to prevent tobacco smoking and e-cigarette use among children and youth in a BC cohort of 40,000 is $21.4 million, $11.2 million in females and $10.2 million in males (see Table 19).

Table 19: Estimated Cost of Interventions to Reduce Initiation of Cigarette Smoking and E-Cigarette Use
Between the Ages of 5 and 17
In a British Columbia Birth Cohort of 40,000

	Females										Males									
Age	Pop.	See PHP	Cig Screened	E-Cig Screened	# of Screens	# of Interventions	PCP Visits	PCP	Cost Patient	Total	Pop.	See PHP	Cig Screened	E-Cig Screened	# of Screens	# of Interventions	PCP Visits	PCP	Cost Patient	Total
5	19,922	70%	92%	89%	12,830	12,830	8,981	$ 323,041	$ 667,456	$ 990,497	19,911	68%	92%	89%	12,456	12,456	8,719	$ 313,635	$ 648,021	$ 961,656
6	19,920	70%	92%	89%	12,829		2,566	$ 92,290	$ 190,686	$ 282,976	19,909	68%	92%	89%	12,455		2,491	$ 89,604	$ 185,136	$ 274,739
7	19,919	70%	92%	89%	12,828	12,828	8,979	$ 322,992	$ 667,355	$ 990,347	19,908	68%	92%	89%	12,454	12,454	8,718	$ 313,590	$ 647,930	$ 961,521
8	19,918	70%	92%	89%	12,827		2,565	$ 92,278	$ 190,661	$ 282,939	19,907	68%	92%	89%	12,454		2,491	$ 89,591	$ 185,110	$ 274,701
9	19,917	70%	92%	89%	12,826	12,826	8,978	$ 322,953	$ 667,275	$ 990,228	19,906	68%	92%	89%	12,453	12,453	8,717	$ 313,553	$ 647,852	$ 961,405
10	19,915	70%	92%	89%	12,826		2,565	$ 92,267	$ 190,638	$ 282,905	19,904	68%	92%	89%	12,452		2,490	$ 89,581	$ 185,089	$ 274,670
11	19,914	70%	92%	89%	12,825	12,825	8,977	$ 322,914	$ 667,195	$ 990,109	19,903	68%	92%	89%	12,451	12,451	8,716	$ 313,515	$ 647,774	$ 961,289
12	19,913	70%	92%	89%	12,824		2,565	$ 92,256	$ 190,616	$ 282,871	19,902	68%	92%	89%	12,451		2,490	$ 89,570	$ 185,067	$ 274,637
13	19,911	70%	92%	89%	12,823	12,823	15,388	$ 553,489	$1,143,601	$ 1,697,091	19,900	68%	92%	89%	12,450	12,450	14,940	$ 537,378	$1,110,313	$ 1,647,692
14	19,910	70%	92%	89%	12,822		2,564	$ 92,240	$ 190,583	$ 282,823	19,898	68%	92%	89%	12,448		2,490	$ 89,554	$ 185,034	$ 274,588
15	19,907	79%	92%	89%	14,469	14,469	17,362	$ 624,527	$1,290,376	$ 1,914,903	19,896	63%	92%	89%	11,531	11,531	13,838	$ 497,745	$1,028,424	$ 1,526,170
16	19,904	79%	92%	89%	14,466		2,893	$ 104,070	$ 215,026	$ 319,096	19,891	63%	92%	89%	11,529		2,306	$ 82,939	$ 171,366	$ 254,305
17	19,900	79%	92%	89%	14,463	14,463	17,356	$ 624,282	$1,289,871	$ 1,914,153	19,885	63%	92%	89%	11,525	11,525	13,830	$ 497,475	$1,027,866	$ 1,525,341
Total					**171,657**	**93,063**	**101,740**	**$3,659,599**	**$7,561,340**	**$11,220,939**					**159,111**	**85,321**	**92,236**	**$3,317,730**	**$6,854,983**	**$10,172,713**

Screening and Brief Behavioural Interventions to Increase Tobacco Smoking Cessation

- For modelling purposes, we have assumed that 45%[417] and 67%[418] of those found positive for cigarette / e-cigarette use would receive counselling to quit.

- In the systematic review by the CTFPHC on the effectiveness of a brief intervention to **increase smoking cessation**, a significant effect was observed in 2 of the 3 RCTs included. In the study by Hollis et al, the interventions consisted of an individually tailored intervention based on the smoking status and stage of change of the individual. It included a 30-second clinician advice message, a 10-minute interactive computer program, a 5-minute motivational interview, and up to two 10-minute telephone or in person booster sessions.[419] In the study by Pbert and colleagues, the

[416] BC Stats. *Earning & Employment Trends – August 2022*. Available at https://www2.gov.bc.ca/assets/gov/data/statistics/people-population-community/income/earnings_and_employment_trends_data_tables.pdf. Accessed September 2022.
[417] Merianos A, Mahabee-Gittens E. Screening, counselling, and health care utilization among a national sample of adolescent smokers. *Clinical Paediatrics*. 2020; 59(4-5): 467-75.
[418] Golden T, VanFrank B, Courtney-Long E. E-cigarette screening and clinical intervention behaviours among pediatric primary care providers, DocStyles 2021. *Paediatrics*. 2022; 149: 740.
[419] Hollis J, Polen M, Whitlock E et al. Teen Reach: Outcomes from a randomized, controlled trial of a tobacco reduction program for teens seen in primary medical care. *Pediatrics*. 2005; 115(4): 981-9.

intervention consisted of brief counselling by the paediatric provider followed by one visit and four telephone calls by older peer counsellors (aged 21 to 25 years).[420]

- In their model of the cost-effectiveness of brief clinician tobacco counselling for youth, Maciosek and colleagues estimated a cost of $35 per person (in 2012 USD). We converted this to $36 in 2022 CAD. These costs include 1 minute for a brief anti-tobacco message by a physician, 20 minutes with a health educator, parent time to accompany the youth and $5 for print materials.[421]
- In estimating the cost of the intervention, we have assumed the equivalent of two visits to a PCP (at a cost of 2*$35.97 = $71.94) plus four ten minute follow-up telephone calls by a nurse. The value of the nursing time is estimated based on the wage rate for a Level 3 RN with four years of experience ($40.41 / hour).[422] The total nursing costs are based on the wage rate plus 18% for benefits and 40% for non-productive time (i.e. vacation, education leave, statutory holidays, coffee breaks, etc.) for 40 (0.67 of an hour) minutes of time (($40.41+$7.27+ $16.16) * 0.67) or $42.77). The total cost of the brief intervention would thus be **$114.71** ($71.94 + $42.77).
- Patient time costs are based on receiving as well as travelling to and from the two visits, assuming two hours per visit plus the 40 minutes of interaction time with the nurse.
- Based on these assumptions, the cost of offering brief information and advice to increase tobacco smoking cessation and e-cigarette use among children and youth in a BC cohort of 40,000 is $5.4 million, $2.9 million in females and $2.5 million in males (see Table 20).

Table 20: Estimated Cost of Interventions to Increase Cigarette Smoking and E-Cigarette Use Cessation
Between the Ages of 5 and 17
In a British Columbia Birth Cohort of 40,000

	Females											Males										
		Table7		See	Cig	E-Cig	Cig	E-Cig	# of		Cost		Table 7		See	Cig	E-Cig	Cig	E-Cig	# of		Cost
Age	Pop.	Cig	e-Cig	PHP	Screened		Intervention		Interventions		Patient	Total	Pop.	Cig	e-Cig	PHP	Screened		Intervention		Interventions		Patient	Total
5	19,922			70%	92%	89%	45%	67%					19,911			68%	92%	89%	45%	67%				
6	19,920			70%	92%	89%	45%	67%					19,909			68%	92%	89%	45%	67%				
7	19,919			70%	92%	89%	45%	67%					19,908			68%	92%	89%	45%	67%				
8	19,918	29		70%	92%	89%	45%	67%	8	$ 975	$ 1,471	$ 2,446	19,907	46		68%	92%	89%	45%	67%	13	$ 1,487	$ 2,245	$ 3,732
9	19,917	44		70%	92%	89%	45%	67%	13	$ 1,462	$ 2,207	$ 3,669	19,906	69		68%	92%	89%	45%	67%	19	$ 2,230	$ 3,367	$ 5,597
10	19,915	66		70%	92%	89%	45%	67%	19	$ 2,193	$ 3,311	$ 5,504	19,904	104		68%	92%	89%	45%	67%	29	$ 3,346	$ 5,050	$ 8,396
11	19,914	88		70%	92%	89%	45%	67%	25	$ 2,924	$ 4,414	$ 7,338	19,903	138		68%	92%	89%	45%	67%	39	$ 4,461	$ 6,734	$ 11,195
12	19,913	147		70%	92%	89%	45%	67%	42	$ 4,873	$ 7,357	$ 12,230	19,902	230		68%	92%	89%	45%	67%	65	$ 7,434	$ 11,223	$ 18,658
13	19,911	249	2,708	70%	92%	89%	45%	67%	1,203	$ 137,944	$ 208,240	$ 346,184	19,900	391	2,448	68%	92%	89%	45%	67%	1,103	$ 126,491	$ 190,950	$ 317,441
14	19,910	388	3,394	70%	92%	89%	45%	67%	1,529	$ 175,441	$ 264,845	$ 440,287	19,898	610	3,149	68%	92%	89%	45%	67%	1,448	$ 166,154	$ 250,825	$ 416,979
15	19,907	535	4,081	79%	92%	89%	45%	67%	2,097	$ 240,591	$ 363,195	$ 603,786	19,896	840	3,850	63%	92%	89%	45%	67%	1,665	$ 191,028	$ 288,374	$ 479,402
16	19,904	660	4,767	79%	92%	89%	45%	67%	2,462	$ 282,359	$ 426,248	$ 708,607	19,891	1,036	4,550	63%	92%	89%	45%	67%	1,980	$ 227,085	$ 342,807	$ 569,892
17	19,900	733	5,454	79%	92%	89%	45%	67%	2,809	$ 322,202	$ 486,395	$ 808,597	19,885	1,151	5,251	63%	92%	89%	45%	67%	2,273	$ 260,732	$ 393,600	$ 654,333
Total									**10,208**	**$1,170,965**	**$1,767,682**	**$2,938,647**									**8,634**	**$ 990,448**	**$1,495,176**	**$ 2,485,624**

[420] Pberrt L, Flint A, Fletcher K et al. Effect of a pediatric-based smoking prevention and cessation intervention for adolescents: A randomized, controlled trial. *Pediatrics*. 2008; 121(4): e738-47.
[421] Maciosek M, LaFrance A, Dehmer S et al. Health benefits and cost-effectiveness of brief clinician tobacco counseling for youth and adults. *Annals of Family Medicine*. 2017; 15(1): 37-47.
[422] *2019 - 2022 Provincial Collective Bargaining Agreement between the Health Employers Association of BC and the Nurses' Bargaining Association*. Available online at https://www.bcnu.org/Contracts-Bargaining/Documents/nba-pca_2019-2022.pdf. Accessed October 2022.

Costs Avoided Due to Reduced Tobacco Smoking

- Tobacco smoking is associated with excess *annual medical care costs* (e.g., hospitalization, physician, drug, etc.). Research in BC identified these costs average $1,358 per year: $893 per year for light tobacco smoking (less than 10 cigarettes per day), $1,576 per year for moderate tobacco smoking (10 to 19 cigarettes per day) and $2,332 per year for heavy tobacco smoking (20 or more cigarettes per day). The equivalent costs for females are $1,199 / $803 / $1,367 / $2,359 and for males are $1,466 / $956 / $1,752 / $2,321.[423] All costs are in 2022 Canadian dollars.
- We multiplied these excess annual medical care costs by the number of male or female light, moderate or heavy smokers who were alive between the ages of 19 and 84 assuming no child/youth screening and brief intervention program. This total cost over the lifetime of the cohort was then redistributed by age and sex based on the fact that excess annual medical care costs increase substantially as a current smoker ages.[424] As per Maciosek and colleagues, we also assumed that these excess costs would only start at age 35.[425] This latter assumption is likely conservative as there is evidence that adolescent smokers use more health services than adolescent never-smokers. For example, Merianos et al suggest that adolescent current smokers are 80% more likely (aOR = 1.80, 95% CI = 1.47-2.22) and 2.95 times more likely (95% CI = 2.15-4.05) to have had an ED visit or an overnight hospital stay within the past 12 months than adolescent never smokers.[426]
- Wang and colleagues have estimated the annual excess medical care costs of exclusive e-cigarette use in adults ages 18 and older in the US to be $1,796 (in 2018 USD). They compare this with the estimated annual excess medical care costs of $5,602 (in 2018 USD) attributed to conventional cigarette smoking in the US.[427] That is, in the US, annual medical care costs associated with exclusive e-cigarettes use are approximately one-third (32.1%) that associated with conventional cigarette use. For modelling purposes, we have assumed that annual medical care costs associated with exclusive e-cigarette use in BC would be 32.1% of the $1,358 (see first bullet point above) attributable to conventional cigarette smoking, or $436. These costs would begin at age 19.
- Based on these assumptions, lifetime total excess medical care costs attributable to conventional and e-cigarette use in a BC birth cohort of 40,000 ***without*** a child/youth screening and brief intervention program would be $576.4 million, $258.2 million in females and $318.2 million in males (see Table 21).

[423] H. Krueger & Associates Inc. *The Economic Burden of Risk Factors in British Columbia: Excess Weight, Tobacco Smoking, Alcohol Use, Physical Inactivity and Low Fruit and Vegetable Consumption.* 2017. Vancouver, B.C.: Provincial Health Services Authority, Population and Public Health Program.
[424] Maciosek M, Xu X, Butani A et al. Smoking-attributable medical expenditures by age, sex, and smoking status estimated using a relative risk approach. *Preventive Medicine*. 2015; 77: 162-7.
[425] Maciosek M, Xu X, Butani A et al. Smoking-attributable medical expenditures by age, sex, and smoking status estimated using a relative risk approach. *Preventive Medicine*. 2015; 77: 162-7.
[426] Merianos A, Mahabee-Gittens E. Screening, counseling, and health care utilization among a national sample of adolescent smokers. *Clinical Pediatrics*. 2020; 59(4-5): 467 - 75.
[427] Wang Y, Sung H, Lightwood J et al. Healthcare utilization and expenditures attributable to current e-cigarette use among US adults. *Tobacco Control*. 2022; doi:10.1136/tobaccocontrol-2021-057058.

Table 21: Estimated Excess Medical Care Costs

Attributable to Conventional and e-Cigarette Use

In a British Columbia Birth Cohort of 40,000

Without a Child / Youth Screening Program / Brief Intervention

	Females					***Males***				
	Annual Costs by Smoking Intensity					*Annual Costs by Smoking Intensity*				
Age	Light	Mod	Heavy	*E-CigUse*	Total $	Light	Mod	Heavy	*E-CigUse*	Total $
19 - 34				$25,506,905	$25,506,905				$29,140,035	$29,140,035
35	$317,933	$310,222	$275,260	$1,095,408	$1,998,823	$359,008	$300,702	$349,098	$1,384,276	$2,393,084
36	$317,933	$310,222	$275,260	$1,094,653	$1,998,068	$359,008	$300,702	$349,098	$1,382,001	$2,390,810
37	$317,933	$310,222	$275,260	$1,093,865	$1,997,280	$359,008	$300,702	$349,098	$1,379,656	$2,388,464
38	$317,933	$310,222	$275,260	$1,093,032	$1,996,448	$359,008	$300,702	$349,098	$1,377,225	$2,386,033
39	$317,933	$310,222	$275,260	$1,092,166	$1,995,582	$359,008	$300,702	$349,098	$1,374,708	$2,383,516
40	$317,933	$310,222	$275,260	$1,091,256	$1,994,671	$359,008	$300,702	$349,098	$1,372,106	$2,380,915
41	$317,933	$310,222	$275,260	$1,090,279	$1,993,695	$359,008	$300,702	$349,098	$1,369,391	$2,378,199
42	$317,933	$310,222	$275,260	$1,089,247	$1,992,662	$359,008	$300,702	$349,098	$1,366,562	$2,375,370
43	$317,933	$310,222	$275,260	$1,088,148	$1,991,563	$359,008	$300,702	$349,098	$1,363,619	$2,372,427
44	$317,933	$310,222	$275,260	$1,086,971	$1,990,387	$359,008	$300,702	$349,098	$1,360,548	$2,369,356
45	$317,933	$310,222	$275,260	$1,085,717	$1,989,132	$359,008	$300,702	$349,098	$1,357,307	$2,366,115
46	$317,933	$310,222	$275,260	$1,084,374	$1,987,789	$359,008	$300,702	$349,098	$1,353,909	$2,362,717
47	$317,933	$310,222	$275,260	$1,082,942	$1,986,357	$359,008	$300,702	$349,098	$1,350,341	$2,359,149
48	$317,933	$310,222	$275,260	$1,081,410	$1,984,825	$359,008	$300,702	$349,098	$1,346,545	$2,355,353
49	$317,933	$310,222	$275,260	$1,079,767	$1,983,182	$359,008	$300,702	$349,098	$1,342,536	$2,351,344
50	$317,933	$310,222	$275,260	$1,078,002	$1,981,417	$359,008	$300,702	$349,098	$1,338,285	$2,347,093
51	$317,933	$310,222	$275,260	$1,076,115	$1,979,530	$359,008	$300,702	$349,098	$1,333,750	$2,342,558
52	$317,933	$310,222	$275,260	$1,074,083	$1,977,499	$359,008	$300,702	$349,098	$1,328,902	$2,337,710
53	$317,933	$310,222	$275,260	$1,071,897	$1,975,312	$359,008	$300,702	$349,098	$1,323,741	$2,332,549
54	$317,933	$310,222	$275,260	$1,069,532	$1,972,947	$359,008	$300,702	$349,098	$1,318,225	$2,327,033
55	$906,408	$884,424	$784,751	$1,066,990	$3,642,573	$1,214,334	$1,017,118	$1,180,816	$1,312,311	$4,724,577
56	$906,408	$884,424	$784,751	$1,064,248	$3,639,831	$1,214,334	$1,017,118	$1,180,816	$1,305,984	$4,718,251
57	$906,408	$884,424	$784,751	$1,061,284	$3,636,868	$1,214,334	$1,017,118	$1,180,816	$1,299,203	$4,711,469
58	$906,408	$884,424	$784,751	$1,058,065	$3,633,648	$1,214,334	$1,017,118	$1,180,816	$1,291,938	$4,704,204
59	$906,408	$884,424	$784,751	$1,054,579	$3,630,163	$1,214,334	$1,017,118	$1,180,816	$1,284,133	$4,696,399
60	$906,408	$884,424	$784,751	$1,050,794	$3,626,377	$1,214,334	$1,017,118	$1,180,816	$1,275,745	$4,688,012
61	$906,408	$884,424	$784,751	$1,046,676	$3,622,259	$1,214,334	$1,017,118	$1,180,816	$1,266,732	$4,678,998
62	$906,408	$884,424	$784,751	$1,042,202	$3,617,785	$1,214,334	$1,017,118	$1,180,816	$1,257,036	$4,669,302
63	$906,408	$884,424	$784,751	$1,037,318	$3,612,901	$1,214,334	$1,017,118	$1,180,816	$1,246,586	$4,658,853
64	$906,408	$884,424	$784,751	$1,032,001	$3,607,584	$1,214,334	$1,017,118	$1,180,816	$1,235,341	$4,647,607
65	$1,889,193	$1,843,374	$1,635,629	$1,026,195	$6,394,390	$2,449,642	$2,051,803	$2,382,027	$1,223,214	$8,106,686
66	$1,889,193	$1,843,374	$1,635,629	$1,019,856	$6,388,052	$2,449,642	$2,051,803	$2,382,027	$1,210,134	$8,093,606
67	$1,889,193	$1,843,374	$1,635,629	$1,012,918	$6,381,114	$2,449,642	$2,051,803	$2,382,027	$1,196,046	$8,079,517
68	$1,889,193	$1,843,374	$1,635,629	$1,005,325	$6,373,521	$2,449,642	$2,051,803	$2,382,027	$1,180,834	$8,064,305
69	$1,889,193	$1,843,374	$1,635,629	$997,011	$6,365,206	$2,449,642	$2,051,803	$2,382,027	$1,164,413	$8,047,885
70	$1,889,193	$1,843,374	$1,635,629	$987,897	$6,356,093	$2,449,642	$2,051,803	$2,382,027	$1,146,699	$8,030,171
71	$1,889,193	$1,843,374	$1,635,629	$977,896	$6,346,091	$2,449,642	$2,051,803	$2,382,027	$1,127,592	$8,011,063
72	$1,889,193	$1,843,374	$1,635,629	$966,928	$6,335,124	$2,449,642	$2,051,803	$2,382,027	$1,106,977	$7,990,449
73	$1,889,193	$1,843,374	$1,635,629	$954,884	$6,323,079	$2,449,642	$2,051,803	$2,382,027	$1,084,742	$7,968,214
74	$1,889,193	$1,843,374	$1,635,629	$941,663	$6,309,858	$2,449,642	$2,051,803	$2,382,027	$1,060,787	$7,944,259
75	$3,649,326	$3,560,818	$3,159,520	$927,154	$11,296,819	$4,041,031	$3,384,740	$3,929,490	$1,034,998	$12,390,259
76	$3,649,326	$3,560,818	$3,159,520	$911,214	$11,280,878	$4,041,031	$3,384,740	$3,929,490	$1,007,261	$12,362,522
77	$3,649,326	$3,560,818	$3,159,520	$893,730	$11,263,394	$4,041,031	$3,384,740	$3,929,490	$977,462	$12,332,723
78	$3,649,326	$3,560,818	$3,159,520	$874,548	$11,244,212	$4,041,031	$3,384,740	$3,929,490	$945,503	$12,300,764
79	$3,649,326	$3,560,818		$853,523	$8,063,667	$4,041,031	$3,384,740	$3,929,490	$911,297	$12,266,558
80	$3,649,326	$3,560,818		$830,511	$8,040,656	$4,041,031	$3,384,740	$3,929,490	$874,774	$12,230,035
81	$3,649,326	$3,560,818		$805,368	$8,015,512	$4,041,031	$3,384,740	$3,929,490	$835,891	$12,191,152
82	$3,649,326	$3,560,818		$777,938	$7,988,083	$4,041,031	$3,384,740	$3,929,490	$794,634	$12,149,895
83	$3,649,326	$3,560,818		$748,089	$7,958,233	$4,041,031	$3,384,740		$751,017	$8,176,788
84	$3,649,326	$3,560,818		$715,708	$7,925,852	$4,041,031	$3,384,740		$705,111	$8,130,882
Total	***$70,807,922***	***$69,090,601***	***$42,347,092***	***$75,948,282***	***$258,193,897***	***$84,230,211***	***$70,550,654***	***$74,046,311***	***$89,378,059***	***$318,205,235***

- We then used the same approach but this time multiplied the excess annual medical care costs by the number of male or female light, moderate or heavy smokers and e-cigarette users who were alive between the ages of 19 and 84 assuming a child/youth screening and brief intervention program was in place.
- Based on these assumptions, lifetime total excess medical care costs attributable to tobacco smoking in a BC birth cohort of 40,000 ***with*** a child/youth screening and brief intervention program would be $457.8 million, $200.2 million in females and $257.6 million in males (see Table 22).
- Total costs avoided would therefore be $118.6 million ($576.4 - $457.8), $58.0 million in females ($258.2 - $200.2) and $60.6 million ($318.2 - $257.6) in males.

Table 22: Estimated Excess Medical Care Costs

Attributable to Conventional and e-Cigarette Use

In a British Columbia Birth Cohort of 40,000

With a Child / Youth Screening Program / Brief Intervention

	Females					***Males***				
	Annual Costs by Smoking Intensity					*Annual Costs by Smoking Intensity*				
Age	Light	Mod	Heavy	*E-CigUse*	Total $	Light	Mod	Heavy	*E-CigUse*	Total $
19 - 34				$19,525,730	$19,525,730				$23,283,819	$23,283,819
35	$247,922	$241,909	$214,647	$837,383	$1,541,861	$292,012	$244,587	$283,951	$1,107,108	$1,927,659
36	$247,922	$241,909	$214,647	$836,806	$1,541,284	$292,012	$244,587	$283,951	$1,105,289	$1,925,840
37	$247,922	$241,909	$214,647	$836,203	$1,540,681	$292,012	$244,587	$283,951	$1,103,413	$1,923,964
38	$247,922	$241,909	$214,647	$835,567	$1,540,045	$292,012	$244,587	$283,951	$1,101,469	$1,922,019
39	$247,922	$241,909	$214,647	$834,905	$1,539,383	$292,012	$244,587	$283,951	$1,099,456	$1,920,007
40	$247,922	$241,909	$214,647	$834,209	$1,538,687	$292,012	$244,587	$283,951	$1,097,375	$1,917,926
41	$247,922	$241,909	$214,647	$833,462	$1,537,940	$292,012	$244,587	$283,951	$1,095,204	$1,915,754
42	$247,922	$241,909	$214,647	$832,673	$1,537,151	$292,012	$244,587	$283,951	$1,092,941	$1,913,492
43	$247,922	$241,909	$214,647	$831,833	$1,536,311	$292,012	$244,587	$283,951	$1,090,587	$1,911,138
44	$247,922	$241,909	$214,647	$830,934	$1,535,412	$292,012	$244,587	$283,951	$1,088,131	$1,908,682
45	$247,922	$241,909	$214,647	$829,975	$1,534,453	$292,012	$244,587	$283,951	$1,085,539	$1,906,090
46	$247,922	$241,909	$214,647	$828,948	$1,533,426	$292,012	$244,587	$283,951	$1,082,821	$1,903,372
47	$247,922	$241,909	$214,647	$827,853	$1,532,331	$292,012	$244,587	$283,951	$1,079,968	$1,900,518
48	$247,922	$241,909	$214,647	$826,682	$1,531,160	$292,012	$244,587	$283,951	$1,076,932	$1,897,483
49	$247,922	$241,909	$214,647	$825,426	$1,529,904	$292,012	$244,587	$283,951	$1,073,725	$1,894,276
50	$247,922	$241,909	$214,647	$824,077	$1,528,555	$292,012	$244,587	$283,951	$1,070,326	$1,890,876
51	$247,922	$241,909	$214,647	$822,634	$1,527,112	$292,012	$244,587	$283,951	$1,066,699	$1,887,249
52	$247,922	$241,909	$214,647	$821,082	$1,525,559	$292,012	$244,587	$283,951	$1,062,821	$1,883,372
53	$247,922	$241,909	$214,647	$819,410	$1,523,888	$292,012	$244,587	$283,951	$1,058,694	$1,879,245
54	$247,922	$241,909	$214,647	$817,602	$1,522,080	$292,012	$244,587	$283,951	$1,054,282	$1,874,833
55	$706,811	$689,669	$611,945	$815,659	$2,824,084	$987,723	$827,309	$960,458	$1,049,552	$3,825,043
56	$706,811	$689,669	$611,945	$813,563	$2,821,988	$987,723	$827,309	$960,458	$1,044,492	$3,819,983
57	$706,811	$689,669	$611,945	$811,297	$2,819,722	$987,723	$827,309	$960,458	$1,039,069	$3,814,560
58	$706,811	$689,669	$611,945	$808,836	$2,817,261	$987,723	$827,309	$960,458	$1,033,259	$3,808,749
59	$706,811	$689,669	$611,945	$806,172	$2,814,597	$987,723	$827,309	$960,458	$1,027,016	$3,802,507
60	$706,811	$689,669	$611,945	$803,278	$2,811,703	$987,723	$827,309	$960,458	$1,020,308	$3,795,799
61	$706,811	$689,669	$611,945	$800,130	$2,808,555	$987,723	$827,309	$960,458	$1,013,099	$3,788,590
62	$706,811	$689,669	$611,945	$796,710	$2,805,135	$987,723	$827,309	$960,458	$1,005,345	$3,780,836
63	$706,811	$689,669	$611,945	$792,976	$2,801,401	$987,723	$827,309	$960,458	$996,988	$3,772,478
64	$706,811	$689,669	$611,945	$788,911	$2,797,336	$987,723	$827,309	$960,458	$987,994	$3,763,485
65	$1,473,181	$1,437,452	$1,275,455	$784,473	$4,970,561	$1,992,507	$1,668,908	$1,937,506	$978,295	$6,577,216
66	$1,473,181	$1,437,452	$1,275,455	$779,628	$4,965,715	$1,992,507	$1,668,908	$1,937,506	$967,834	$6,566,756
67	$1,473,181	$1,437,452	$1,275,455	$774,324	$4,960,412	$1,992,507	$1,668,908	$1,937,506	$956,566	$6,555,488
68	$1,473,181	$1,437,452	$1,275,455	$768,520	$4,954,607	$1,992,507	$1,668,908	$1,937,506	$944,400	$6,543,322
69	$1,473,181	$1,437,452	$1,275,455	$762,164	$4,948,251	$1,992,507	$1,668,908	$1,937,506	$931,268	$6,530,189
70	$1,473,181	$1,437,452	$1,275,455	$755,197	$4,941,284	$1,992,507	$1,668,908	$1,937,506	$917,100	$6,516,022
71	$1,473,181	$1,437,452	$1,275,455	$747,551	$4,933,639	$1,992,507	$1,668,908	$1,937,506	$901,819	$6,500,740
72	$1,473,181	$1,437,452	$1,275,455	$739,167	$4,925,254	$1,992,507	$1,668,908	$1,937,506	$885,332	$6,484,253
73	$1,473,181	$1,437,452	$1,275,455	$729,960	$4,916,047	$1,992,507	$1,668,908	$1,937,506	$867,549	$6,466,470
74	$1,473,181	$1,437,452	$1,275,455	$719,853	$4,905,941	$1,992,507	$1,668,908	$1,937,506	$848,390	$6,447,311
75	$2,845,722	$2,776,705	$2,463,777	$708,762	$8,794,966	$3,286,923	$2,753,100	$3,196,190	$827,764	$10,063,978
76	$2,845,722	$2,776,705	$2,463,777	$696,576	$8,782,780	$3,286,923	$2,753,100	$3,196,190	$805,581	$10,041,795
77	$2,845,722	$2,776,705	$2,463,777	$683,211	$8,769,415	$3,286,923	$2,753,100	$3,196,190	$781,749	$10,017,963
78	$2,845,722	$2,776,705	$2,463,777	$668,547	$8,754,751	$3,286,923	$2,753,100	$3,196,190	$756,189	$9,992,402
79	$2,845,722	$2,776,705		$652,475	$6,274,901	$3,286,923	$2,753,100	$3,196,190	$728,832	$9,965,046
80	$2,845,722	$2,776,705		$634,883	$6,257,310	$3,286,923	$2,753,100	$3,196,190	$699,622	$9,935,836
81	$2,845,722	$2,776,705		$615,663	$6,238,089	$3,286,923	$2,753,100	$3,196,190	$668,524	$9,904,738
82	$2,845,722	$2,776,705		$594,694	$6,217,121	$3,286,923	$2,753,100	$3,196,190	$635,528	$9,871,742
83	$2,845,722	$2,776,705		$571,875	$6,194,302	$3,286,923	$2,753,100		$600,644	$6,640,667
84	$2,845,722	$2,776,705		$547,122	$6,169,549	$3,286,923	$2,753,100		$563,929	$6,603,953
Total	***$55,215,577***	***$53,876,444***	***$33,022,041***	***$58,085,571***	***$200,199,632***	***$68,511,783***	***$57,384,920***	***$60,228,193***	***$71,460,638***	***$257,585,534***

Summary of CE – Males and Females

- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the CE associated with interventions to prevent and/or treat tobacco use among children and youth is cost-saving (Table 23, row *al*).

Table 23: CE of Interventions for Tobacco Use Prevention and Cessation in Children and Youth in a B.C. Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
	Cost of Screening / Brief Intervention		
	Reduce Initiation of Tobacco Smoking / E-cigarette Use		
a	Primary care provider costs (in millions) - Females	$3.66	Table 19
b	Patient time costs (in millions) - Females	$7.56	Table 19
c	Primary care provider costs (in millions) - Males	$3.32	Table 19
d	Patient time costs (in millions) - Males	$6.85	Table 19
	Increase Cessation of Tobacco Smoking / E-cigarette Use		
e	Primary care provider costs (in millions) - Females	$1.17	Table 20
f	Patient time costs (in millions) - Females	$1.77	Table 20
g	Primary care provider costs (in millions) - Males	$0.99	Table 20
h	Patient time costs (in millions) - Males	$1.50	Table 20
	Total Cost of Screening / Brief Intervention		
i	Females	$14.16	= a + b + e + f
j	Males	$12.66	= c + d + g + h
k	**Total Cost** of Screening / Brief Intervention	**$26.82**	= i + j
	Treatment Costs Avoided with a Screening / Brief Intervention Program		
	Excess Medical Care Costs Attributable to Tobacco Use ***Without*** a Child / Youth Screening Program / Brief Intervention		
l	Females (in millions)	$258.19	Table 21
m	Males (in millions)	$318.21	Table 21
n	Total (in millions)	$576.40	Table 21
	Excess Medical Care Costs Attributable to Tobacco Use ***With*** a Child / Youth Screening Program / Brief Intervention		
o	Females (in millions)	$200.20	Table 22
p	Males (in millions)	$257.59	Table 22
q	Total (in millions)	$457.79	Table 22
	Excess Medical Care Costs Attributable to Tobacco Use ***Avoided***		
r	Females (in millions)	$57.99	= l - o
s	Males (in millions)	$60.62	= m - p
t	**Total (in millions)**	**$118.61**	= r + s
	CE per QALY Gained		
u	Net cost of screening and brief intervention (in millions) - Females	-$43.83	= i - r
v	Total QALYs gained - Females	9,740	Table 18
w	CE ($/QALY gained) - Females	-$4,501	(u / v) * 1,000,000
x	Net cost of screening and brief intervention (in millions) - Males	-$47.96	= j - s
y	Total QALYs gained - Males	13,195	Table 18
z	CE ($/QALY gained) - Males	-$3,635	(x / y) * 1,000,000
aa	Net cost of screening and brief intervention (in millions) - Total	-$91.80	= k - t
ab	Total QALYs gained - Total	22,935	Table 18
ac	CE ($/QALY gained) - Total	-$4,002	(aa / ab) * 1,000,000
ad	Net cost of screening and brief intervention (in millions, 1.5% discount) - Females	-$19.80	Calculated
ae	Total QALYs gained, 1.5% Discount - Females	4,223	Calculated
af	**CE ($/QALY gained), 1.5% Discount - Females**	**-$4,688**	Calculated
ag	Net cost of screening and brief intervention (in millions, 1.5% discount) - Males	-$22.76	Calculated
ah	Total QALYs gained, 1.5% Discount - Males	5,859	Calculated
ai	**CE ($/QALY gained), 1.5% Discount - Males**	**-$3,885**	Calculated
aj	Net cost of screening and brief intervention (in millions, 1.5% discount) - Total	-$42.56	Calculated
ak	Total QALYs gained, 1.5% Discount - Total	10,082	Calculated
al	**CE ($/QALY gained), 1.5% Discount - Total**	**-$4,221**	Calculated

V = Estimates from the literature

We also modified several major assumptions and recalculated the cost per QALY as follows:

- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is reduced from 18% to 8% and the effectiveness of interventions aimed at smoking cessation are reduced from 34% to 5%: **CE = $2,835**
- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is increased from 18% to 27% and the effectiveness of interventions aimed at smoking cessation are increased from 34% to 69%: CE = Cost-saving
- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is reduced from 18% to 8%: CE = Cost-saving
- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is increased from 18% to 27%: CE = Cost-saving
- Assume the effectiveness of interventions aimed at smoking cessation are reduced from 34% to 5%: CE = Cost-saving
- Assume the effectiveness of interventions aimed smoking cessation are increased from 34% to 69%: CE = Cost-saving
- Assume the QoL reduction associated with light/moderate/heavy smoking is reduced from 0.031 / 0.033 / 0.062 to 0.018 / 0.019 / 0.042: CE = Cost-saving
- Assume the QoL reduction associated with light/moderate/heavy smoking is increased from 0.031 / 0.033 / 0.062 to 0.045 / 0.047 / 0.082: CE = Cost-saving
- Assume the harms attributable to e-cigarette use are reduced from being 37% as harmful as smoking conventional cigarettes to being 10% as harmful: CE = Cost-saving
- Assume the harms attributable to e-cigarette use are increased from being 37% as harmful as smoking conventional cigarettes to being 60% as harmful: CE = Cost-saving

Summary of CE – Females Only

Based on these assumptions, the CE associated with interventions to prevent and/or treat tobacco smoking among female children and youth is cost-saving (Table 23, row *af*).

We also modified several major assumptions and recalculated the cost per QALY as follows:

- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is reduced from 18% to 8% and the effectiveness of interventions aimed at smoking cessation are reduced from 34% to 5%: **CE = $4,290**
- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is increased from 18% to 27% and the effectiveness of interventions aimed at smoking cessation are increased from 34% to 69%: CE = Cost-saving
- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is reduced from 18% to 8%: CE = Cost-saving
- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is increased from 18% to 27%: CE = Cost-saving
- Assume the effectiveness of interventions aimed at smoking cessation are reduced from 34% to 5%: CE = Cost-saving

- Assume the effectiveness of interventions aimed smoking cessation are increased from 34% to 69%: CE = Cost-saving
- Assume the QoL reduction associated with light/moderate/heavy smoking is reduced from 0.031 / 0.033 / 0.062 to 0.018 / 0.019 / 0.042: CE = Cost-saving
- Assume the QoL reduction associated with light/moderate/heavy smoking is increased from 0.031 / 0.033 / 0.062 to 0.045 / 0.047 / 0.082: CE = Cost-saving
- Assume the harms attributable to e-cigarette use are reduced from being 37% as harmful as smoking conventional cigarettes to being 10% as harmful: CE = Cost-saving
- Assume the harms attributable to e-cigarette use are increased from being 37% as harmful as smoking conventional cigarettes to being 60% as harmful: CE = Cost-saving

Summary of CE – Males Only

Based on these assumptions, the CE associated with interventions to prevent and/or treat tobacco smoking among male children and youth is cost-saving (Table 23, row *ai*).

We also modified several major assumptions and recalculated the cost per QALY as follows:

- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is reduced from 18% to 8% and the effectiveness of interventions aimed at smoking cessation are reduced from 34% to 5%: **CE = $1,833**
- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is increased from 18% to 27% and the effectiveness of interventions aimed at smoking cessation are increased from 34% to 69%: CE = Cost-saving
- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is reduced from 18% to 8%: CE = Cost-saving
- Assume the effectiveness of interventions aimed at smoking initiation among children and youth is increased from 18% to 27%: CE = Cost-saving
- Assume the effectiveness of interventions aimed at smoking cessation are reduced from 34% to 5%: CE = Cost-saving
- Assume the effectiveness of interventions aimed smoking cessation are increased from 34% to 69%: CE = Cost-saving
- Assume the QoL reduction associated with light/moderate/heavy smoking is reduced from 0.031 / 0.033 / 0.062 to 0.018 / 0.019 / 0.042: CE = Cost-saving
- Assume the QoL reduction associated with light/moderate/heavy smoking is increased from 0.031 / 0.033 / 0.062 to 0.045 / 0.047 / 0.082: CE = Cost-saving
- Assume the harms attributable to e-cigarette use are reduced from being 37% as harmful as smoking conventional cigarettes to being 10% as harmful: CE = Cost-saving
- Assume the harms attributable to e-cigarette use are increased from being 37% as harmful as smoking conventional cigarettes to being 60% as harmful: CE = Cost-saving

Summary

Males and Females

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with interventions to prevent and/or treat tobacco smoking among children and youth ages 5 to 17 in a British Columbia birth cohort of 40,000 is estimated to be 10,082 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be cost-saving (see Table 24).

Table 24: Interventions for Tobacco Use Prevention and Cessation in Children and Youth

In a B.C. Birth Cohort of 40,000

Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
1.5% Discount Rate	**10,082**	2,590	18,112
3% Discount Rate	4,419	1,131	7,970
0% Discount Rate	22,935	5,910	41,077
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**Cost-saving**	Cost-saving	$2,835
3% Discount Rate	Cost-saving	Cost-saving	$10,538
0% Discount Rate	Cost-saving	Cost-saving	Cost-saving
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	Cost-saving	Cost-saving	Cost-saving
3% Discount Rate	Cost-saving	Cost-saving	Cost-saving
0% Discount Rate	Cost-saving	Cost-saving	Cost-saving

Females Only

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with interventions to prevent and/or treat tobacco smoking among female children and youth ages 5 to 17 in a British Columbia birth cohort of 40,000 is estimated to be 4,223 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be cost-saving (see Table 25).

Table 25: Interventions for Tobacco Use Prevention and Cessation in Children and Youth
In a B.C. Birth Cohort of 40,000
Summary - Females Only

	Base Case	Range	
CPB (Potential QALYs Gained)			
1.5% Discount Rate	**4,223**	1,056	7,812
3% Discount Rate	1,820	455	3,374
0% Discount Rate	9,740	3,473	17,995
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**Cost-saving**	Cost-saving	$4,290
3% Discount Rate	Cost-saving	Cost-saving	$14,625
0% Discount Rate	Cost-saving	Cost-saving	Cost-saving
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	Cost-saving	Cost-saving	Cost-saving
3% Discount Rate	Cost-saving	Cost-saving	Cost-saving
0% Discount Rate	Cost-saving	Cost-saving	Cost-saving

Males Only

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with interventions to prevent and/or treat tobacco smoking among male children and youth ages 5 to 17 in a British Columbia birth cohort of 40,000 is estimated to be 5,859 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be cost-saving (see Table 26).

Table 26: Interventions for Tobacco Use Prevention and Cessation in Children and Youth
In a B.C. Birth Cohort of 40,000
Summary - Males Only

	Base Case	Range	
CPB (Potential QALYs Gained)			
1.5% Discount Rate	**5,859**	**1,534**	**10,300**
3% Discount Rate	2,598	676	4,596
0% Discount Rate	13,195	3,473	23,083
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**Cost-saving**	Cost-saving	**$1,833**
3% Discount Rate	Cost-saving	Cost-saving	$7,791
0% Discount Rate	Cost-saving	Cost-saving	Cost-saving
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	Cost-saving	Cost-saving	Cost-saving
3% Discount Rate	Cost-saving	Cost-saving	Cost-saving
0% Discount Rate	Cost-saving	Cost-saving	Cost-saving

Preventive Medication / Devices

Fissure Sealants for Dental Health in Children

The Cochrane Oral Health Group (2017)

> *Resin-based sealants applied on occlusal surfaces of permanent molars are effective for preventing caries in children and adolescents. Our review found moderate-quality evidence that resin-based sealants reduced caries by between 11% and 51% compared to no sealant, when measured at 24 months.*[428]

Dental Sealants - Modelling the Clinically Preventable Burden

While the focus of the USPSTF is on improving dental health in preschool children, there is also a body of evidence indicating that the use of dental sealants is effective in preventing decayed, missing and filled teeth in children six years of age and older with permanent teeth.[429]

In this section, we model the CPB associated with applying dental sealants for the prevention of dental caries in children and youth with permanent teeth.

In modelling CPB, we made the following assumptions:

- A study in Portugal based on a sample of 447 adolescents aged 12 to 18 found that 59% (Table 1, row *b*) had at least one fissure sealant applied.[430]
- Dental sealants would be placed on the 1st molars at age six, the 1st and 2nd bicuspids at age 10 and the 2nd molars at age 12.
- The effectiveness of dental sealants in reducing decayed, missing and filled teeth is 84% at year 1, decreasing to 55% at year 9. Effectiveness beyond nine years is unknown.[431]
- An estimated 12.2% of Canadians avoid certain foods because of problems with their teeth or mouth, and 11.6% of Canadians sometimes or always have pain in their mouth.[432] Based on this information, we assumed that 12% of children/youth with caries would have significant enough pain to reduce their quality of life (Table 1, row *j*).
- The Global Burden of Disease Study found that symptomatic dental caries ("has a toothache, which causes some difficulty in eating") is associated with a disability weight of 0.01 (95% CI of 0.005 to 0.019) (Table 1, row *l*). Severe tooth loss ("has lost more than 20 teeth including front and back, and has great difficulty eating meat,

[428] Cochrane Oral Health Group. *Pit and fissure sealants for preventing dental decay in permanent teeth*. The Cochrane Library. July 31, 2017. Available online at http://www.cochrane.org/CD001830/ORAL_sealants-preventing-tooth-decay-permanent-teeth. Accessed September 2017.
[429] Cochrane Oral Health Group. *Pit and fissure sealants for preventing dental decay in permanent teeth*. The Cochrane Library. July 31, 2017. Available online at http://www.cochrane.org/CD001830/ORAL_sealants-preventing-tooth-decay-permanent-teeth. Accessed September 2017.
[430] Veiga N, Pereira C, Ferreira P et al. Prevalence of dental caries and fissure sealants in a Portuguese sample of adolescents. *PloS ONE*. 2015; 10(3): 1-12.
[431] Ahovuo-Saloranta A, Forss H, Walsh T et al. Sealants for preventing dental decay in the permanent teeth. *Cochrane Database of Systematic Reviews.* 2013.
[432] Canadian Dental Association. *Dental Health Services in Canada: Facts and Figures 2010*. 2010. Available at http://www.med.uottawa.ca/sim/data/Dental/Dental_Health_Services_in_Canada_June_2010.pdf. Accessed January 2014.

fruits and vegetables") is associated with a disability weight of 0.067 (95% CI of 0.045 to 0.095). [433]

- Other assumptions used in assessing the clinically preventable burden are detailed in the Reference Document.

Based on these assumptions, the CPB associated with preventing decayed, missing and filled teeth in children with permanent teeth is 157 (Table 1, row *m*). The CPB of 157 represents the gap between no coverage and improving coverage to 59%.

Table 1: CPB of Preventing Dental Caries in Children with Permanent Teeth in a Birth Cohort of 40,000 (B.C.)

Row Label	Variable	Base Case	Data Source
a	# of 6-year olds in a birth cohort of 40,000	39,829	√
b	Adherence with intervention	59%	√
c	Children 'accepting' intervention	23,499	=a*b
d	Estimated new caries between ages 6-20 per child - untreated	7.69	Calculated
e	Estimated new caries between ages 6-20 per child - treated	2.46	Calculated
f	Estimated new caries without intervention	180,668	=c*d
g	Estimated new caries with intervention	57,734	=c*e
h	New caries avoided with intervention	122,934	=f-g
i	Life-years lived without caries due to intervention	130,681	Calculated
j	Proportion of children living with caries with significant pain	12%	√
k	Life-years lived without caries or pain due to intervention	15,682	=i*j
l	Change in QoL associated with improved oral health	0.01	√
m	Potential QALYs gained, Intervention increasing from 0% to 59%	157	=k*l
n	Potential QALYs gained, Intervention increasing from 30% to 59%	90	=d18/7*4

√ = Estimates from the literature

We also modified a major assumption and recalculated the CPB as follows:

- Assume the change in QoL associated with improved oral health is reduced from 0.01 to 0.005 (Table 1, row m): CPB = 78
- Assume the change in QoL associated with improved oral health is increased from 0.01 to 0.019 (Table 4, row *m*): CPB = 298

Dental Sealants - Modelling Cost-Effectiveness

In this section, we model the CE associated with applying dental sealants for the prevention of dental caries in children and youth with permanent teeth.

In modelling CE, we made the following assumptions:

- The cost of applying sealants is estimated at $19.74 for the first tooth in a quadrant and $10.83 for each additional tooth in the quadrant (see Reference Document). The costs of applying dental sealants on the 1st molars at age six would therefore be $78.96, the 1st and 2nd bicuspids at age 10 would be $122.32 and the 2nd molars at age 12 would be $78.96 for a total cost of $280.24 (Table 2, row *d*).
- For patient time and travel costs, we estimated two hours of patient time per dental visit.

[433] Institute for Health Metrics and Evaluation. *GBD 2016 sequelae, health states, health state lay descriptions, and disability weights*. Available online at http://ghdx.healthdata.org/record/global-burden-disease-study-2016-gbd-2016-disability-weights. Accessed September 2023.

- An average of 1.84 fillings would be treated each time fillings are required (Table 2, row *l*).[434]
- An amalgam restoration costs between $83.10 and $102.40 depending on whether or not the restoration is bonded and to which teeth the restoration is applied.[435] We used the mid-point ($92.75, Table 2 row j) for the base case and the extremes in the sensitivity analysis.
- The cost per day surgery for dental cavities in BC is estimated at $1,782 which includes $1,515 for hospital and $267 for anaesthesia costs in 2011[436] or $2,108 in 2022 dollars.
- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the CE associated with preventing dental caries in children with permanent teeth by applying dental sealants is cost-saving (Table 2, row *v*).

Table 2: CE of Preventing Dental Caries in Children with Permanent Teeth in a Birth Cohort of 40,000 (B.C.)

Row Label	Variable	Base Case	Data Source
a	Children eligible for intervention	39,829	= Table 1 row a
b	Adherence with intervention	59%	= Table 1 row b
c	Children 'accepting' intervention	23,499	= Table 1 row c
	Costs of intervention		
d	Cost of dental sealant applications	$280.24	√
e	Value of patient time and travel for office visit	$74.32	√
f	# of sealant applications (at age 6, 10 and 12)	3	√
g	Estimated cost of intervention over lifetime of birth cohort	$8,713,514	Calculated
h	Estimated cost of patient time over lifetime of birth cohort	$5,239,388	Calculated
	Cost avoided		
i	Dental caries avoided with intervention	122,934	Calculated
j	Cost per filling	$92.75	√
k	Value of patient time and travel for office visit	$74.32	√
l	# of fillings per visit	1.84	√
m	# of dental visits avoided	66,812	=i/l
n	Filling costs avoided	-$11,402,091	=i*j
o	Patient costs avoided	-$4,965,448	=m*k
	CE calculation		
p	Cost of intervention over lifetime of birth cohort	$13,952,902	= g+h
q	Costs avoided	-$16,367,539	= n+o
r	QALYs saved	157	Table 1 row m
s	Cost of intervention over lifetime of birth cohort (1.5% discount	$13,276,048	Calculated
t	Costs avoided (1.5% discount)	-$14,593,381	Calculated
u	QALYs saved (1.5% discount)	140	Calculated
v	**CE ($/QALY saved)**	**-$9,413**	= (s-t) / u

√ = Estimates from the literature

[434] Dye B, Tan S, Smith V et al. Trends in oral health status: United States, 1988-1994 and 1999-2004. *National Center for Health Statistics*. 2007; 11(248): 1-104.
[435] Ibid.
[436] Canadian Institute for Health Information. *Treatment of Preventable Dental Cavities in Preschoolers: A Focus on Day Surgery Under General Anesthesia*. 2013. Available at https://secure.cihi.ca/free_products/Dental_Caries_Report_en_web.pdf. Accessed January 2018.

We also modified several major assumptions and recalculated the cost per QALY as follows:

- Assume the change in QoL associated with improved oral health is reduced from 0.01 to 0.005 (Table 1, row *l*): CE = Cost-saving
- Assume the change in QoL associated with improved oral health is increased from 0.01 to 0.019 (Table 1, row *l*): CE = Cost-saving
- Assume that the cost per filling is reduced from $92.75 to $83.10 (Table 2, row *j*): CE = Cost-saving
- Assume that the cost per filling is increased from $92.75 to $102.40 (Table 2, row *j*): CE = Cost-saving

Dental Sealants – Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with applying dental sealants for the prevention of dental caries in children and youth with permanent teeth is estimated to be 140 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be cost-saving (see Table 3).

Table 3: Dental Sealants for Children with Permanent Teeth in a Birth Cohort of 40,000

Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume No Current Service			
1.5% Discount Rate	**140**	70	266
3% Discount Rate	125	63	238
0% Discount Rate	157	78	298
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**Cost-saving**	Cost-saving	Cost-saving
3% Discount Rate	Cost-saving	Cost-saving	$4,475
0% Discount Rate	Cost-saving	Cost-saving	Cost-saving
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	Cost-saving	Cost-saving	Cost-saving
3% Discount Rate	Cost-saving	Cost-saving	Cost-saving
0% Discount Rate	Cost-saving	Cost-saving	Cost-saving

Screening for Asymptomatic Disease or Risk Factors

Screening for Breast Cancer

Canadian Task Force on Preventive Health Care Recommendations (2011)

For women aged 40–49 we recommend not routinely screening with mammography. (Weak recommendation; moderate quality evidence)

For women aged 50–69 years we recommend routinely screening with mammography every 2 to 3 years. (Weak recommendation; moderate quality evidence)

For women aged 70–74 we recommend routinely screening with mammography every 2 to 3 years. (Weak recommendation; low quality evidence) [437]

United States Preventive Services Task Force Recommendations (2016)

The USPSTF recommends biennial screening mammography for women aged 50 to 74 years. (B recommendation)[438]

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with screening women ages 50 to 74 years of age for breast cancer every 2 to 3 years.

In modelling CPB, we made the following assumptions:

- Based on BC life tables for 2018 to 2020, a total of 4,459 deaths would be expected in females between the ages of 50-79 in a BC birth cohort of 40,000 (see Table 1). While routine screening occurs to age 74, we have assumed the protective effect of that routine screening would continue to age 79.
- Based on BC vital statistics data, there were 2,049 deaths in females between the ages of 45 and 64 in BC in 2015, with 215 (10.49%) of these deaths due to breast cancer (ICD-10 codes C50). There were also 4,087 deaths between the ages of 65 and 79 that year, with 258 (6.31%) of these deaths due to breast cancer.[439] This suggests that 320 of the 4,459 (7.18%) of the female deaths in the BC birth cohort between the ages of 50 and 79 would be due to breast cancer (see Table 1).

[437] Canadian Task Force on Preventive Health Care. *Screening for Breast Cancer*. 2011. Available at http://canadiantaskforce.ca/guidelines/2011-breast-cancer/. Accessed October 2013.
[438] U.S. Preventive Services Task Force. Screening for breast cancer: U.S. Preventive Services Task Force recommendation statement. *Annals of Internal Medicine*. 2016; 164(4): 279-97.
[439] British Columbia Vital Statistics Agency. *Selected Vital Statistics and Health Status Indicators: One Hundred and Forty-Fourth Annual Report 2015*. Apendix 2. 2015. British Columbia Ministry of Health. Available at https://alpha.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2015/pdf/annual-report-2015.pdf. Accessed March 2023.

Table 1: Mortality Due to Breast Cancer Between the Ages of 50 and 79
in a British Columbia Birth Cohort of 40,000

Age Group	*Life Years Lived*	*Deaths in Birth Cohort*	*Deaths due to* Breast Cancer %	#	*Life Years Lost* Per Death	Total
50-54	96,645	198	10.49%	21	34.6	720
55-59	95,436	292	10.49%	31	30.0	920
60-64	93,628	443	10.49%	46	25.5	1,186
65-69	90,843	690	6.31%	44	21.2	923
70-74	86,461	1,095	6.31%	69	17.1	1,179
75-79	79,488	1,741	6.31%	110	13.3	1,456
		4,459	**7.18%**	**320**	**19.9**	**6,384**

- Screening mammography in women ages 50-74 leads to a reduction in breast cancer mortality of 21% (RR 0.79, 95% CI of 0.68 – 0.90). This is based on 10 trials in which the attendance rates at first screening were approximately 85%.[440]
- For every death avoided, 204 women will have false positive results.[441] We have assumed a one-time QALY loss of 0.013 (4.7 days) after a false-positive mammography result.[442]
- For every death avoided, 26 women will have an unnecessary biopsy.[443]
- For every death avoided, 3 women will have an unnecessary lumpectomy or mastectomy (with a 3:1 ratio for lumpectomy vs. mastectomy).[444]
- Other assumptions used in assessing the clinically preventable burden are detailed in the Reference Document.

Based on these assumptions, the CPB associated with screening women ages 50 to 74 years of age for breast cancer every 2 to 3 years is 1,380 QALYs saved (Table 2, row *o*). The CPB of 1,380 represents the gap between no coverage and the 'best in the world' coverage estimated at 88%. The CPB of 565 QALYs saved (see Table 2, row *p*) represents the gap between the current coverage of 52% and the 'best in the world' coverage estimated at 88%.

[440] Fitzpatrick-Lewis D, Hodgson N, Ciliska D et al. *Breast Cancer Screening*. 2011. Available at http://canadiantaskforce.ca/wp-content/uploads/2012/09/Systematic-review.pdf?0136ff. Accessed October 2013.
[441] Ibid.
[442] Schousboe JT, Kerlikowske K, Loh A et al. Personalizing mammography by breast density and other risk factors for breast cancer: analysis of health benefits and cost-effectiveness. *Annals of Internal Medicine*. 2011; 155(1): 10-20.
[443] Fitzpatrick-Lewis D, Hodgson N, Ciliska D et al. *Breast Cancer Screening*. 2011. Available at http://canadiantaskforce.ca/wp-content/uploads/2012/09/Systematic-review.pdf?0136ff. Accessed October 2013.
[444] Independent UK Panel on Breast Cancer Screening. The benefits and harms of breast cancer screening: an independent review. *The Lancet*. 2012; 380: 1778-86.

Table 2. Calculation of Clinically Preventable Burden of Breast Cancer Screening Being Offered to a Birth Cohort of 40,000 Between the Ages of 50 to 74			
Row	**Variable**	**Base Case**	**Data Source**
	Estimated Current Status		
a	Estimated deaths due to breast cancer in birth cohort between ages 50-79	320	Table 1
b	Effectiveness of mammography screening in preventing mortality (based on 85% adherence in clinical trials)	21.0%	√
c	Effectiveness of mammography screening in preventing mortality (assuming 100% adherence in clinical trials)	24.7%	=b*1.1764
d	Frequency of screening in last 30 months	52%	Ref Doc
e	Potential adherence	88%	Ref Doc
f	Predicted deaths in the absence of screening	368	= a / (1 - d * c)
	Benefits of Screening		
g	Deaths avoided - 100% adherence	91	= f * c
h	Deaths avoided - 88% adherence	80	= g * e
i	Deaths avoided - 52% adherence	47	= g * d
j	Life expectancy at average age of breast cancer death	19.9	Table 1
k	QALYs saved with 88% adherence to screening	1,592	= h * j
	Harms Associated with Screening		
l	False positive results per death avoided	204	√
m	Reduced QALYs per false positive	0.013	√
n	Reduced QALYs associated with false positives	-212	= h * l * m
	Summary of Benefits and Harms		
o	Potential QALYs saved - Utilization increasing from 0% to 88%	1,380	= k + n
p	Potential QALYs saved - Utilization increasing from 52% to 88%	565	= o * (e-d)/e

√ = Estimates from the literature

We modified the following major assumptions and recalculated the CPB as follows:

- Assume the effectiveness of screening mammography in reducing deaths from breast cancer is reduced from 21% to 10% (Table 2, row *b*): **CPB = 610**.
- Assume the effectiveness of screening mammography in reducing deaths from breast cancer is increased from 21% to 32% (Table 2, row *b*): **CPB = 2,280.**

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with screening women ages 50 to 74 years of age for breast cancer every 2 to 3 years.

In estimating the CE of screening mammography, we made the following assumptions:

- **Costs of screening** - Information from the BC Cancer Agency Screening Mammography Program indicates a cost of $79.35 per screen in 2015/16.[445] or $90.23 in 2022 CAD. There are a total of 463,013 life years lived in females ages 50-74 in a BC birth cohort of 40,000 (see Table 1). We assumed that, on average, women would participate in screening once every 30 months (i.e., every 2.5 years), resulting in 185,205 screens for the birth cohort assuming 100% adherence. At 88% adherence, the number of screens would be reduced to 162,981 (Table 3, row *a* & *b*).

[445] BC Cancer Agency. *Screening Mammography Program: 2016 Annual Report*. 2016. Available at http://www.bccancer.bc.ca/screening/Documents/SMP_Report-AnnualReport2016.pdf. Accessed August 2017.

- **Costs associated with overtreatment** – For every death avoided, 3 women will have an unnecessary lumpectomy or mastectomy (with a 75:25 ratio for lumpectomy vs. mastectomy) with a cost per lumpectomy of $5,770 and a mastectomy of $8,130 (see reference document) for a weighted cost of $6,360 (Table 2, row *k*).
- **Patient time and travel costs** - For patient time and travel costs, we assumed an estimated two hours of patient time required per screening visit of $74.32, 7.5 for a biopsy and 37.5 hours for a lumpectomy or mastectomy.
- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the CE associated with screening women ages 50 to 74 years of age for breast cancer every 2 to 3 years would be $20,211 / QALY (Table 3, row *u*).

Table 3. Summary of CE Estimate for Breast Cancer Screening B.C. Birth Cohort of 40,000

Row	Variable	Base Case	Data Source
a	Screening visits with 100% Adherence	185,205	√
b	Screening visits with 88% Adherence	162,981	= a * Table 2, row e
c	Cost per screen	$90.23	Ref Doc
d	Value of patient time (per hour)	$37.16	Ref Doc
e	Screening costs	$14,705,750	= b * c
f	Patient time costs	$12,112,727	= (b * d) * 2
g	Deaths avoided	80	Table 2, row h
h	Costs avoided per death prevented	-$52,821	Ref Doc
i	Costs avoided due to deaths prevented	-$4,220,980	= g * h
j	Unnecessary lumpectomies / mastectomies for every death avoided	3	√
k	Costs per lumpectomy / mastectomy	$6,360	Ref Doc
l	Costs associated with unnecessary lumpectomies / mastectomies	$1,524,702	= g * j * k
m	Unnecessary biopsies per death avoided	26	√
n	Cost per unnecessary biopsy	$430	Ref Doc
o	Costs for unnecessary biopsies	$893,405	= n * f * o
p	Patient time and travel costs associated with unnecessary procedures	$913,119	= ((g * j * 7.5)+(g * m * 37.5)) * d
q	Net costs undiscounted	$25,928,724	= e + f + i + l + o + p
r	CPB undiscounted	1,380	Table 2, row o
s	Net costs (1.5% discount)	$21,544,954	Calculated
t	CPB (1.5% discount)	1,066	Calculated
u	**CE ($/QALY saved)**	**$20,211**	= s / t

√ = Estimates from the literature

We also modified the major assumption and recalculated the cost per QALY as follows:

- Assume the effectiveness of screening mammography in reducing deaths from breast cancer is reduced from 21% to 10% (Table 2, row *b*): **CE = $46,596**.
- Assume the effectiveness of screening mammography in reducing deaths from breast cancer is increased from 21% to 32% (Table 2, row *b*): **CE = $11,966**.

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening women ages 50 to 74 years of age for breast cancer every 2 to 3 years is estimated to be 1,066 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $20,211 per QALY (see Table 4).

Table 4: Breast Cancer Screening Being Offered to a Birth Cohort of 40,000 Between the Ages of 50 to 74

Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume No Current Service			
1.5% Discount Rate	**1,066**	471	1,760
3% Discount Rate	837	370	1,382
0% Discount Rate	1,380	610	2,280
Gap between B.C. Current (52%) and 'Best in the World' (88%)			
1.5% Discount Rate	436	193	720
3% Discount Rate	342	151	565
0% Discount Rate	565	250	933
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$20,211**	$11,966	$46,596
3% Discount Rate	$21,573	$12,772	$49,735
0% Discount Rate	$18,783	$11,120	$43,303
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$10,058	$5,536	$24,526
3% Discount Rate	$10,735	$5,909	$26,178
0% Discount Rate	$9,347	$5,145	$22,793

Screening for Cervical Cancer

Background

Current Recommendations

Canadian Task Force on Preventive Health Care Recommendations (2013)

> *The following recommendations refer to cytologic screening, using either conventional or liquid-based methods, whether manual or computer-assisted.*
>
> *For women aged 20–24 years, we recommend not routinely screening for cervical cancer. (Weak recommendation; moderate-quality evidence)*
>
> *For women aged 25–29 years, we recommend routine screening for cervical cancer every 3 years. (Weak recommendation; moderate-quality evidence)*
>
> *For women aged 30–69 years, we recommend routine screening for cervical cancer every 3 years. (Strong recommendation; high-quality evidence)*
>
> *For women aged 70 years and older who have undergone adequate screening (i.e., 3 successive negative Pap test results in the previous 10 years), we recommend that routine screening may end. For women aged 70 years and older who have not undergone adequate screening, we recommend continued screening until 3 negative test results have been obtained. (Weak recommendation; low-quality evidence)*[446]

United States Preventive Services Task Force Recommendations (2018)

> *The USPSTF recommends screening for cervical cancer every 3 years with cervical cytology alone in women aged 21 to 29 years. (A recommendation)*
>
> *The USPSTF recommends screening every 3 years with cervical cytology alone, every 5 years with hrHPV testing alone, or every 5 years with hrHPV testing in combination with cytology (cotesting) in women aged 30 to 65 years. (A recommendation)*[447]

Both the CTFPHC and the USPSTF are in the process of updating their recommendations. The updated guideline by the CTFPHC is expected to be released in 2025.[448,449] The USPSTF is in the process of reviewing the available evidence and developing a draft recommendation. An expected date of completion is not provided.[450]

[446] Canadian Task Force on Preventive Health Care. Recommendations on screening for cervical cancer. *Canadian Medical Association Journal*. 2013; 185(1): 35-45.
[447] US Preventive Services Task Force. Screening for Cervical Cancer: US Preventive Services Task Force Recommendation Statement. *JAMA*. 2018; 320 (7): 674-86.
[448] Canadian Task Force on Preventive Health Care. *Cervical Cancer (Update)*. Available online at https://canadiantaskforce.ca/guidelines/upcoming-guidelines/cervical-cancer-update/. Accessed December 2023.
[449] Gates A, Pillay J, Reynolds D et al. Screening for the prevention and early detection of cervical cancer: Protocol for systematic reviews to inform Canadian recommendations. *Systematic Reviews*. 2021; 10(2)
[450] US Preventive Services Task Force. *Recommendations in Progress*. Available at https://www.uspreventiveservicestaskforce.org/uspstf/recommendation-topics/recommendations-in-progress. Accessed December 2023.

Purpose

In February of 2023, the British Columbia Ministry of Health (BC MoH) released a 10-year cancer action plan.[451] An important focus of this plan is to support the World Health Organization global call to action by moving towards the elimination of cervical cancer in the province. Key components of achieving this goal are enhanced HPV vaccination rates, moving to an HPV-based screening system and encouraging the self-collection of samples for cervical cancer screening.

At the time, BC Cancer and the Provincial Health Services Authority (PHSA) were in the process of developing a business case to support these goals by moving BC to a more high-performance screening test through HPV testing and to offer a lower barrier collection method in order to further improve cervix screening rates in the province.

During this process, the BC MoH asked H. Krueger & Associates Inc. for support to further understand and assess several components of the proposed shifts in cervical cancer screening in the province. The purpose of the analysis was to use the modelling approach developed for the Lifetime Prevention Schedule (LPS) to assess the clinically preventable burden (CPB) and cost-effectiveness (CE) associated with a number of potential cervical cancer screening approaches.

To do so, we accessed the latest high-quality research evidence on the effectiveness of HPV vaccination and HPV-based screening. When possible, we also utilized real-world results from jurisdictions with the earliest implementation of HPV vaccination and HPV-based screening. Furthermore, we included research data indicating a higher baseline risk of premature birth in a subsequent pregnancy associated with treatment for cervical intraepithelial neoplasia (CIN).

In light of this new evidence, the fact that the work completed for the BC MoH was closely aligned with the modelling for the LPS and that the updated recommendations from the USPSTF and CTFPHC are not expected for at least a year or two, the LPS Expert Committee authorized a full update of the cervical cancer screening modelling work included in the LPS. The LPS Expert Committee will review the updated task force recommendations as soon as they become available.

The Progression from HPV Infection to Invasive Cervical Cancer

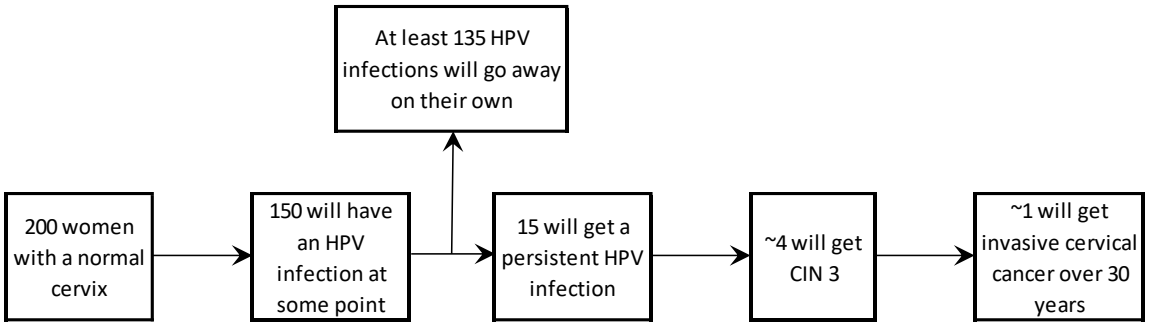
Persistent infection with the human papillomavirus (HPV) is necessary but not sufficient for the development of cervical cancer. Infection with high-risk HPV (hrHPV) is relatively common in sexually active individuals but approximately 90% of these infections will resolve on their own within two years. Regression of precancerous changes back to normal cervical cells is also fairly common. Nevertheless, some chronic HPV infections will result in severe pre-cancers and approximately 20-25% of these severe pre-cancers will become invasive cervical cancers (see Figure 1).[452] The progression from HPV infection, to persistent infection, to pre-cancerous cervical changes (cervical intraepithelial neoplasia or CIN), to invasive cervical cancer typically takes 10 – 15 years or more.[453]

[451] BC Ministry of Health. *Cancer Care You Can Count On: Multi-Year Policy Framework to Deliver Cancer Care in B.C.* February 2023. Available online at https://news.gov.bc.ca/files/CancerPlan2023.pdf. Accessed April 2023.

[452] Figure 1 is taken from Gates A, Pillay J, Reynolds D et al. Screening for the prevention and early detection of cervical cancer: Protocol for systematic reviews to inform Canadian recommendations. *Systematic Reviews*. 2021; 10(2)

[453] Gates A, Pillay J, Reynolds D et al. Screening for the prevention and early detection of cervical cancer: Protocol for systematic reviews to inform Canadian recommendations. *Systematic Reviews*. 2021; 10(2)

Figure 1: Progression from an HPV Infection to Invasive Cervical Cancer
Assuming No Treatment



The Point Prevalence of hrHPV Infection in BC

A number of BC-based studies have estimated the prevalence of HPV infection in BC females at a specific point in time. The study by Moore et al estimated the prevalence of any HPV infection in BC females ages 14 to 59 between March and July of 2004 (see Table 1).[454] The study by Ogilvie et al estimated the prevalence of any hrHPV infection in BC females ages 25-60+ between December of 2007 and December of 2009.[455] The second study by Ogilvie et al estimated the prevalence of any hrHPV infection in BC females ages 15 to 69 in June of 2010.[456] For context, we have also included a study from the US[457] and England[458] in Table 1.

Table 1: Point Prevalance of HPV in Females
Based on Cross-Sectional Studies

Jurisdiction	US	BC	England		BC	BC
Date	2003/04	2004	Oct 2007 to Jan 2009		Dec 2007 - Dec 2009	2010
Sample Size	1,921	4,980	4,719		6,150	4,330
Collection Type	Self-collected vaginal swab	Self-collected vaginal swab	Residual LBC samples		Office-based LBC collection for the FOCAL RCT	Routine office-based Pap screening
HPV Type	Any	Any	16, 18	Any HR type	Any HR type	Any HR type
Age Group						
14-19	24.5%	27.5%				25.7%
20-24	44.8%	24.2%				33.2%
25-29	27.4%	18.5%	9.2%	28.8%	24.0%	21.9%
30-39	27.5%	17.0%	6.2%	17.9%	11.1%	11.0%
40-49	25.2%	15.0%	2.8%	9.5%	5.4%	6.2%
50-59	19.6%	11.2%	2.7%	9.3%	4.9%	3.1%

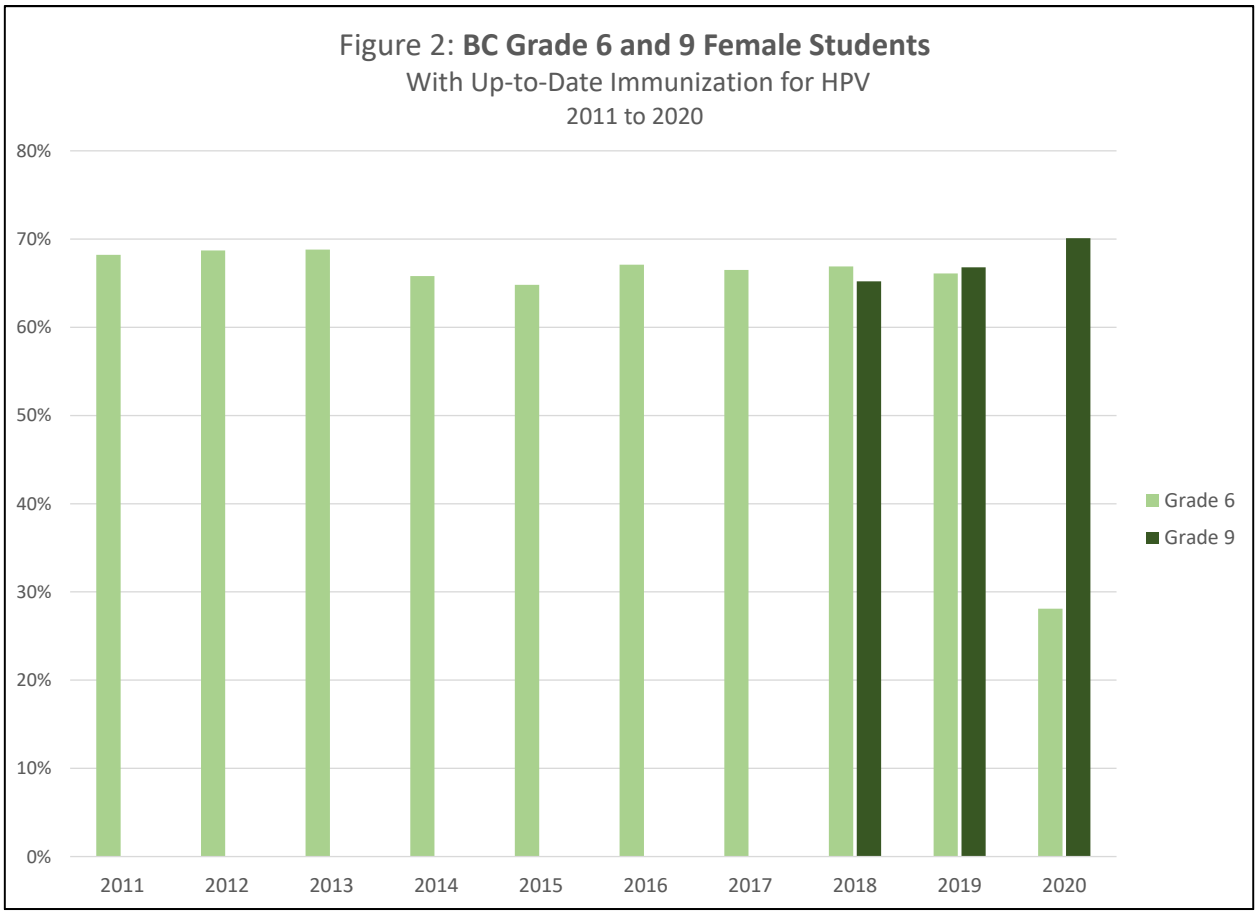
[454] Moore R, Ogilvie G, Fornika D et al. Prevalence and type distribution of human papillomavirus in 5,000 British Columbia women – implications for vaccination. *Cancer Causes & Control*. 2009; 20: 1387-96.
[455] Ogilvie G, van Niekerk D, Krajden M et al. A randomized controlled trial of human papillomavirus (HPV) testing for cervical cancer screening: Trial design and preliminary results (HPV FOCAL trial). *BMC Cancer*. 2010; 10: 111.
[456] Ogilvie G, Cook D, Taylor D et al. Population-based evaluation of type-specific HPV prevalence among women in British Columbia, Canada. *Vaccine*. 2013; 31: 1129-33.
[457] Dunne E, Unger E, Sternberg M et al. Prevalence of HPV infection among females in the United States. *JAMA*. 2007; 297(8): 813-19.
[458] Howell-Jones R, Bailey A, Beddows S et al. Multi-site study of HPV type-specific prevalence in women with cervical cancer, intraepithelial neoplasia and normal cytology, in England. *British Journal of Cancer*. 2010; 103: 209-16.

Note that Table 1 provides information on the **point prevalence** of HPV infection. Chesson and colleagues have estimated the **lifetime probability** of acquiring HPV among sexually active females to be 85%, with more than 80% of those infections acquired prior to the age of 45.[459] Markowitz et al have estimated that at least 42% of females in the US have been exposed to hrHPV types 6, 11, 16 & 18 by the age of 39. Their study detected antibodies to these hrHPV types but, because only an estimated 60% of exposed females develop antibodies, the actual proportion of females exposed to hrHPV types 6, 11, 16 & 18 by the age of 39 is likely closer to 70%.[460]

HPV Vaccination in BC

BC introduced its three dose[461] quadrivalent HPV vaccine program in September of 2008 for girls in grade 6 (11 years of age) and 9 (14 years of age) with an initial uptake rate of approximately 62%.[462] Between 2011 and 2020 vaccination rates have remained at between 65-70% with the notable exception of the rate in grade six girls in 2020 (see Figure 2). This decrease reflects the redirection of public health resources from routine immunization programs to the COVID-19 pandemic response in the latter part of the year.[463,464]

[459] Chesson H, Dunne E, Hariri S et al. The estimated lifetime probability of acquiring human papillomavirus in the United States. *Sexually Transmitted Diseases*. 2014; 41(11): 660-4.
[460] Markowitz L, Sternberg M, Dunne E et al. Seroprevalence of human papillomavirus types 6, 11, 16, and 18 in the United States: National Health and Nutrition Examination Survey 2003-2004. *The Journal of Infectious Diseases*. 2009; 200: 1059-67.
[461] Adjusted to a two dose regimen in October of 2014. See BC Centre for Disease Control. *Human Papillomavirus (HPV) Vaccine 2 Dose Schedule Q&A Document – October 2014*. Available online at http://www.bccdc.ca/resource-gallery/Documents/Guidelines%20and%20Forms/Guidelines%20and%20Manuals/Immunization/Vaccine%20Info/Archived_%202Dose_HPV_Program_QandA_Oct%202014.pdf. Accessed January 2023.
[462] Ogilvie G, Cook D, Taylor D et al. Population-based evaluation of type-specific HPV prevalence among women in British Columbia, Canada. *Vaccine*. 2013; 31: 1129-33.
[463] BC Centre for Disease Control. *Immunization Coverage in Grade 6 Students: 2011-2020*. February 25, 2022. Available online at http://www.bccdc.ca/resource-gallery/Documents/Statistics%20and%20Research/Statistics%20and%20Reports/Immunization/Coverage/Grade%206%20Coverage%20Results.pdf. Accessed January 2023.
[464] BC Centre for Disease Control. *Immunization Coverage in Grade 9 Students: 2011-2020*. May 13, 2021. Available online at http://www.bccdc.ca/resource-gallery/Documents/Statistics%20and%20Research/Statistics%20and%20Reports/Immunization/Coverage/Grade%209%20Coverage%20Results.pdf. Accessed January 2023.



The Effectiveness of HPV Vaccination

HPV vaccines have proven to be highly effective, particularly when vaccination takes place in early adolescence. All vaccine types target HPV 16 and HPV 18. The quadrivalent type also targets HPV 6 and HPV 11 while the nonavalent type also targets HPV 31, 33, 45, 52 and 58. The nonavalent vaccine targets the HPV types that cause approximately 90% of cervical cancers.

Evidence on the effectiveness of HPV vaccines in real-world settings summarized in a systematic review and meta-analysis by Drolet and co-authors[465] indicates that, after 5-8 years of vaccination, the prevalence of HPV 16 and 18 decreased by 83% in girls ages 13-19 and by 66% in females ages 20-24. After 5-9 years of vaccination, the prevalence of CIN2+ decreased by 51% among screened girls ages 15-19 and by 31% among females ages 20-24.

Evidence from BC indicates that females who received a complete series of vaccine on schedule between age 9 and 14 years had an adjusted RR of 0.42 (95% CI of 0.31 to 0.57) for CIN2+ over 7 years of follow-up compared to unvaccinated females.[466]

Evidence from Sweden and Denmark indicates a significant reduction in cervical cancers associated with vaccination. Sweden began its HPV vaccination program in 2007 and since has observed an 88% reduction in the incidence of cervical cancers in those vaccinated before

[465] Drolet M, Benard E, Perez N et al. Population-level impact and herd effects following the introduction of human papillomavirus vaccination programmes: Updated systematic review and meta-analysis. *Lancet*. 2019; 394(10197: 497-509.

[466] Racey C, Albert A, Donken R et al. Cervical intraepithelial neoplasia rates in British Columbia women: A population-level linkage evaluation of the school-based HPV immunization program. *The Journal of Infectious Diseases.* 2020; 221: 81-90.

the age of 17.[467] Denmark began its HPV vaccination program in 2008 and has since observed an 86% reduction in cervical cancers in those vaccinated before age 17 and a 68% reduction in those vaccinated between the ages of 17 and 19.[468]

Cervical Cancer Screening in BC

BC's cervical cancer screening program formally began in 1955 when all females over the age of 20 years were offered screening annually.[469] Initially, a relatively small proportion of the eligible population was screened but this increased to approximately 45% by 1970 (see Table 2). While annual screening was recommended at the time, the actual average interval for rescreening was once every two years.[470]

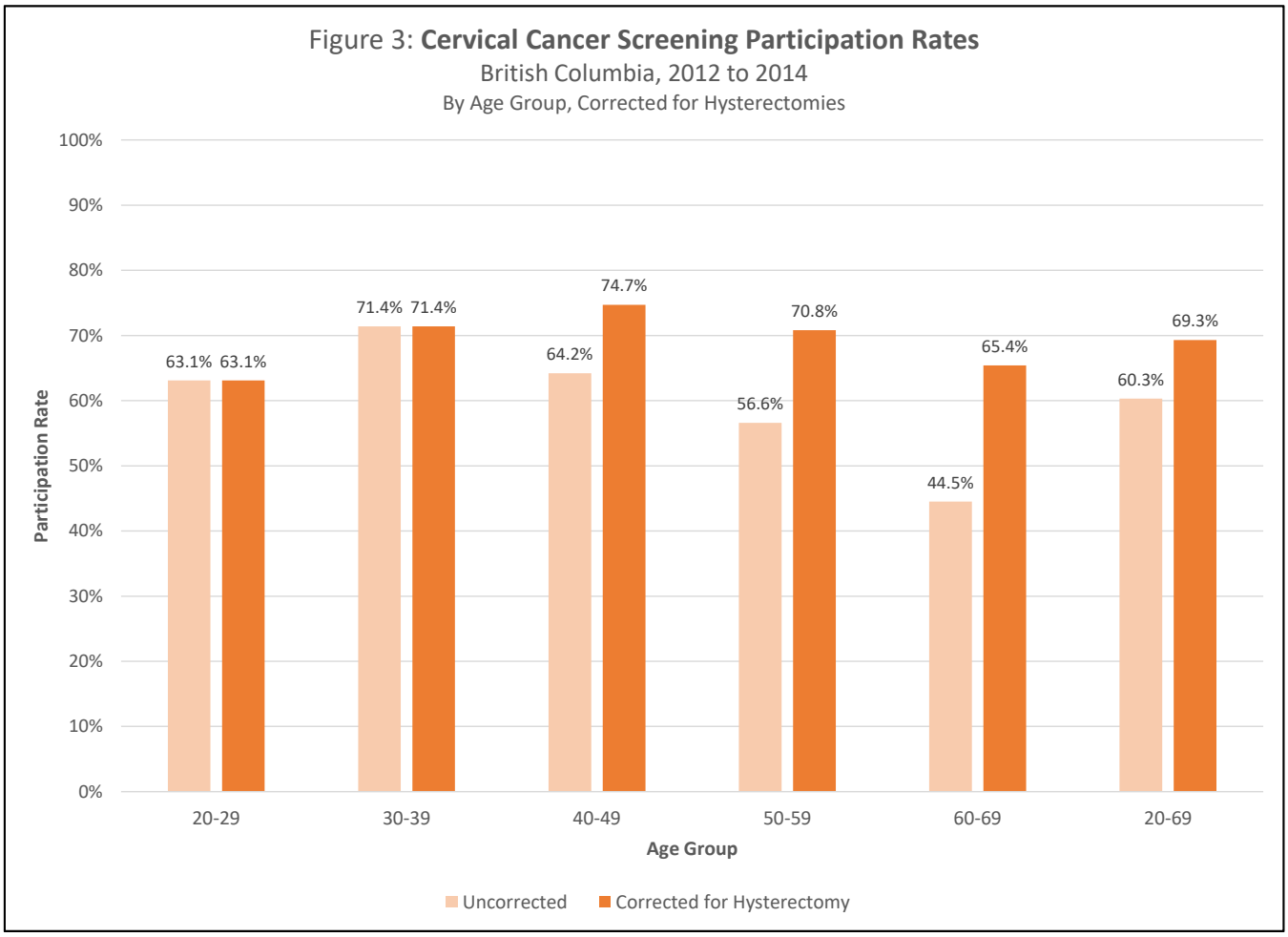
Table 2: Cervical Cancer Screening in BC
1955 to 1985

Year	BC Females Age 20+	Number of Screens	Percent Screened
1955	422,900	11,707	2.8%
1960	486,400	59,844	12.3%
1965	543,200	161,556	29.7%
1970	664,400	297,407	44.8%
1975	805,500	355,917	44.2%
1980	926,200	433,329	46.8%
1985	1,063,100	465,676	43.8%

In 1985, 24.8% of females ages 15-19 were screened. This increased to 59.1% for females ages 20-34 and 40.4% for females ages 35-59 before declining to 16.6% for females 60 year of age or older.[471]

[467] Lei J, Ploner A, Elfstrom K et al. HPV vaccination and the risk of invasive cervical cancer. *The New England Journal of Medicine*. 2020, 383(14): 1340-8.
[468] Kjar S, Dehlendorff C, Belmonte F et al. Real-world effectiveness of human papillomavirus vaccination against cervical cancer. *Journal of the National Cancer Institute*. 2021; 113(10): 1329-35.
[469] Anderson G, Boyes D, Benedict J et al. Organization and results of the cervical cytology screening programme in British Columbia, 1955-85. *British Medical Journal*. 1988; 296: 975-8.
[470] Ibid.
[471] Ibid.

By 2012-14 screening was recommended to begin at age 21 (or approximately 3 years after first sexual contact, whichever comes first). At the time, it was recommended that screening should take place once a year until there were three consecutive normal results. At this point, it was recommended that females should be screened every two years until age 69. At age 69, females could discontinue screening if no significant abnormality has been detected in their screening history.[472] In 2012-14, 69.3% of eligible BC females had at least one screen (over the 3-year time period) (see Figure 3).[473]

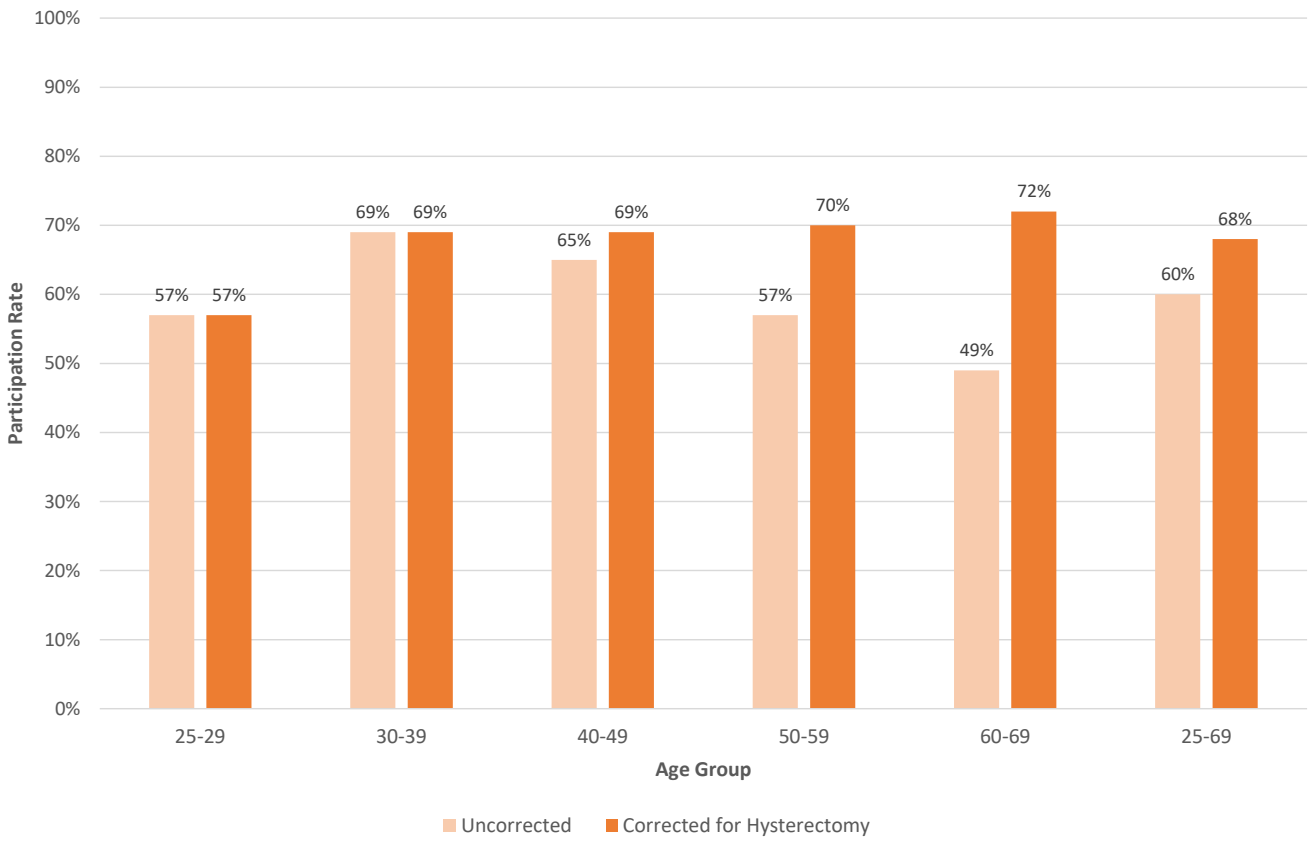


[472] BC Cancer Agency, Cervical Cancer Screening Program. *Cervical Cancer Screening Program 2015 Annual Report*. Available online at http://www.bccancer.bc.ca/screening/Documents/CCSP_Report-AnnualReport2015.pdf. Accessed January 2023.
[473] Ibid.

Screening in BC is currently recommended once every three years for females and individuals with a cervix, ages 25-69, who are or have been sexually active.[474,475] BC is also in the process of transitioning from conventional cytology collection methods to liquid based cytology (LBC).[476]

Screening participation rates for ages 25 – 69 in 2018 (the most recent year with publicly available data) are 68% (see Figure 4).[477]

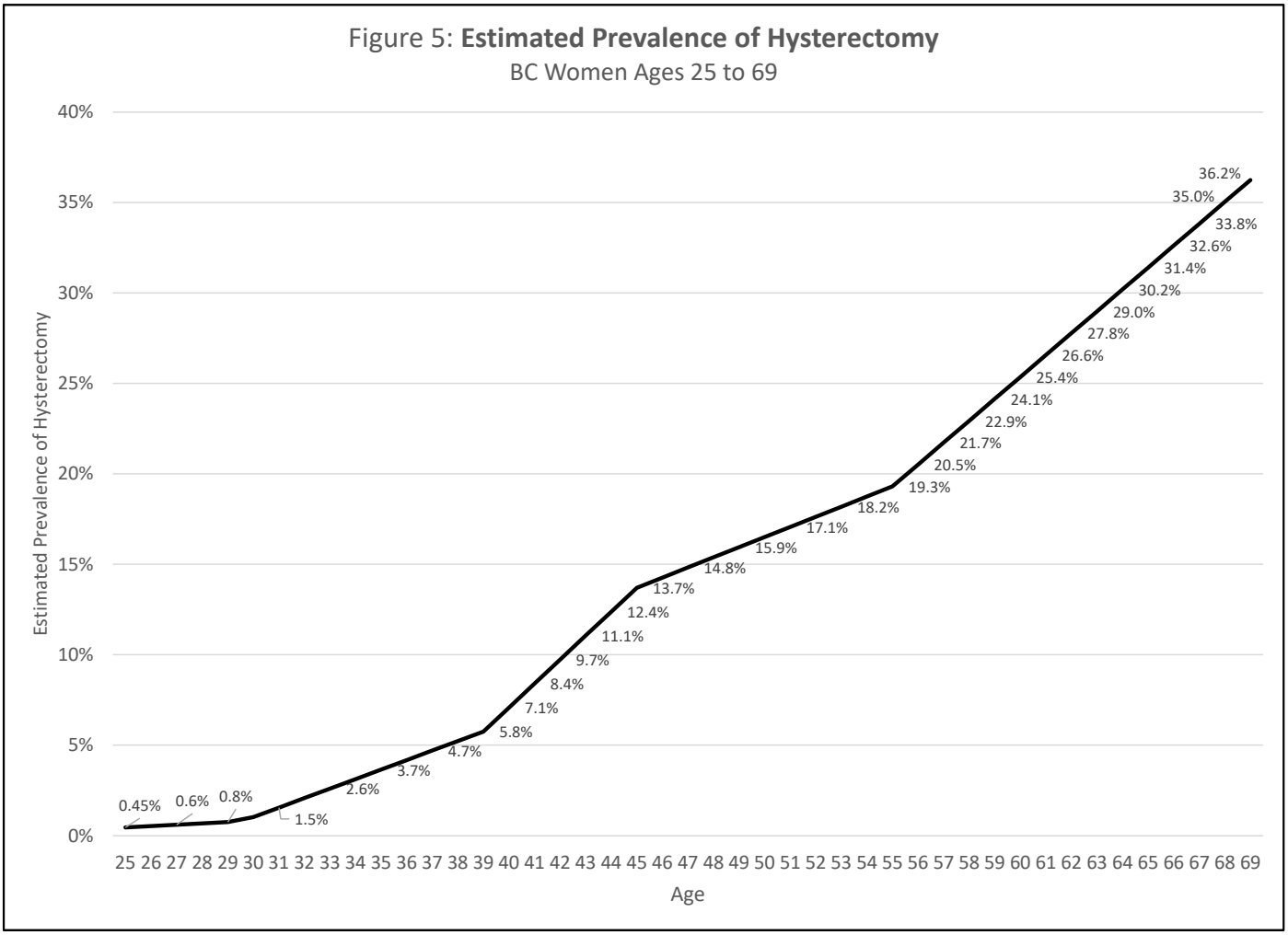
Figure 4: **Cervical Cancer Screening Participation Rates**
British Columbia, 2018
By Age Group, Corrected for Hysterectomies



[474] Krueger H, Kwon J, Sadownik L et al. What is the appropriate age to start screening women for cervical cancer? *BC Medical Journal*. 2013; 55(6): 282-6.
[475] BC Cancer Cervix Screening. *BC Cancer Cervix Screening Program Overview*. March 2022. Available online at http://www.bccancer.bc.ca/screening/Documents/Cervix-Program-Overview.pdf. Accessed January 2023.
[476] BC Cancer, Provincial Laboratory Medicine Services. *News Bulletin: A Rapid Transition to Liquid Based Cytology for Pap Tests is Underway*. October 2022. Available online at http://www.bccancer.bc.ca/lab-services-site/Documents/20221019%20LBC%20Transition%20info%20kit%20FINAL.docx.pdf. Accessed January 2023.
[477] BC Cancer Cervix Screening. *BC Cancer Cervix Screening 2018 Program Results*. March 2020. Available online at http://www.bccancer.bc.ca/screening/Documents/Cervix-Program-Results-2018.pdf. Accessed January 2023.

Prevalence of Hysterectomy in BC

Based on self-reported data for 2008, 13.7% of BC females ages 40-49 had a hysterectomy. This increased to 19.3% for ages 50-59 and 31.4% for ages 60-69.[478] In the US, hysterectomy rates in 2018 are 0.4 – 0.5% in females ages 20-29, 3.0 – 4.3% in females ages 30-39, 13.2 – 15.2% in females ages 40-49, 23.1 – 26.4% for females ages 50-59 and 28.9 – 34.3% in females ages 60-69.[479] Based on this data we have estimated the prevalence of hysterectomy in BC females between the ages of 25 and 69 (see Figure 5).



[478] Stankiewicz A, Pogany L, Popadiuk C. Prevalence of self-reported hysterectomy among Canadian women, 2000/01-2008. *Chronic Diseases and Injuries in Canada*. 2014; 34(1): 30-35.

[479] Adam E, White M, Saraiya M. US hysterectomy prevalence by age, race and ethnicity from BRFSS and NHIS: Implications for analysis of cervical and uterine cancer rates. *Cancer Causes & Control*. 2022; 33(1): 161-6.

Cervical Cancers in BC

Incidence – 1955 to 2017

BC Female Population – 1955 to 2017

To begin the process of estimating the annual number and rate of invasive cervical cancers in British Columbia between 1955 (the year screening started, see Table 2) and 2017 we first estimated the female population by age (from 20 to 79 and ≥80) for each year. Between 1986 and 2017 we used data from BC Stats.[480] Population estimates from this source were available for each individual age. Between 1971 and 1985 we used data from Statistics Canada.[481] This data was available by 5-year age groups. We assumed an equal distribution for each year in the 5-year age group. Between 1955 and 1970 we began with the population numbers in the research study by Anderson et al.[482] This source provided data on the total BC female population ages 20 and older for 1955, 1958, 1960, 1965 and 1970. We first assumed an equal annual growth in this total for years with missing data. We then distributed these totals by age based on the actual distribution for 1986 (the earliest year for which we have estimates by individual age from BC Stats).

Incidence of Invasive Cervical Cancers in BC – 1955 to 1985

Anderson et al. provide data on the number and incidence rate of invasive squamous carcinoma of the cervix in BC in 1955, 1958, 1960, 1965, 1970, 1975, 1980 and 1985.[483] We assumed a linear distribution in incidence rate for each of the years of missing data between two data points and then applied that rate to the annual population of females ages 20 and older to generate the estimated number of squamous cell carcinomas in a given year.

There are two main histological types of cervical cancers, squamous cell carcinoma (SCC) and adenocarcinoma (AC), with a number of other rare histological types. Conventional cytology screening has largely been effective at preventing SCC but not the other types of cervical cancers.[484,485,486] Indeed, research in Norway suggests that incidence of cervical cancers other than SCC fluctuated between 1.8 and 2.6 per 100,000 between 1956 and 2010. While the research in Norway observed a 74% reduction in the age-standardized incidence rate of SCC over that time period (associated with screening), the age-standardized incidence rate of AC **increased** by an average of 1.5% per year. Other rare cervical cancers decreased by an average of 0.9% per year.[487]

The study by Anderson et al only includes data on SCC.[488] To estimate the number of other cervical cancers for each year between 1955 and 1985 we used the rate per 100,000 of 3.01

[480] BC Stats. *Population Estimates & Projections for British Columbia.* Available online at https://bcstats.shinyapps.io/popApp/. Accessed January 2023.
[481] Statistics Canada. *Population Estimates on July 1st, by Age and Sex*. Table: 17-10-0005-01. Available online at https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710000501. Accessed January 2023.
[482] Anderson G, Boyes D, Benedict J et al. Organization and results of the cervical cytology screening programme in British Columbia, 1955-85. *British Medical Journal*. 1988; 296: 975-8.
[483] Ibid.
[484] Mitchell H, Medley G, Gordon I et al. Cervical cytology reported as negative and risk of adenocarcinoma of the cervix. No strong evidence of benefit. *British Journal of Cancer*. 1995; 71: 894-7.
[485] Zappa M, Visioli C, Ciatto S et al. Lower protection of cytological screening for adenocarcinomas and shorter protection for younger women: The results of a case-control study in Florence. *British Journal of Cancer*. 2004; 4(90): 1784-6.
[486] Lonnberg S, Hansen B, Haldorsen T et al. Cervical cancer prevented by screening: Long-term incidence trends by morphology in Norway. *International Journal of Cancer*. 2015; 137: 1758-64.
[487] Ibid.
[488] Anderson G, Boyes D, Benedict J et al. Organization and results of the cervical cytology screening programme in British Columbia, 1955-85. *British Medical Journal*. 1988; 296: 975-8.

for these other cancers based on the number and average rate per 100,000 of these other cancers between 2002 and 2017 (see following section).

Incidence of Invasive Cervical Cancers in BC – 2002 to 2017

Data on the number of cervical cancers between 2002 and 2008 were taken from the study by Coldman et al.[489] Based on that study, an estimated 68.4% of cervical cancers in BC each year were SCC.

Data on the annual number and rate per 100,000 of cervical cancers (by SCC and all other) between 2009 and 2013 were taken from the BC Cervical Cancer Screening Program 2015 Annual Report.[490]

Finally, data on the annual number and rate per 100,000 of cervical cancers (by SCC and all other) between 2014 and 2017 were taken from the BC Cancer Cervix Screening 2018 Program Results report.[491]

Between 2002 and 2017 there were an estimated 2,702 cervical cancers in BC, of which 855 (31.6%) were not SCC (see Table 3). The average rate for these other cervical cancers between 2002 and 2017 was 3.01 per 100,000, with no discernable trend or change in the rate over the 16-year period (see Figure 6). As noted above, this rate per 100,000 for other cervical cancers was used in the estimation for the years from 1955 to 1985.

[489] Coldman A, Niekerk D, Smith L et al. Cervical cancer incidence in British Columbia: Predicting effects of changes from Pap to human papillomavirus screening and changes in screening participation. *Journal of Medical Screening*. 2017; 24(4): 195-200.
[490] BC Cancer Agency, Cervical Cancer Screening Program. *Cervical Cancer Screening Program 2015 Annual Report*. Table 7. Available online at http://www.bccancer.bc.ca/screening/Documents/CCSP_Report-AnnualReport2015.pdf. Accessed January 2023.
[491] *BC Cancer Cervix Screening 2018 Program Results*. Table 7. Available online at http://www.bccancer.bc.ca/screening/Documents/Cervix-Program-Results-2018.pdf. Accessed January 2023.

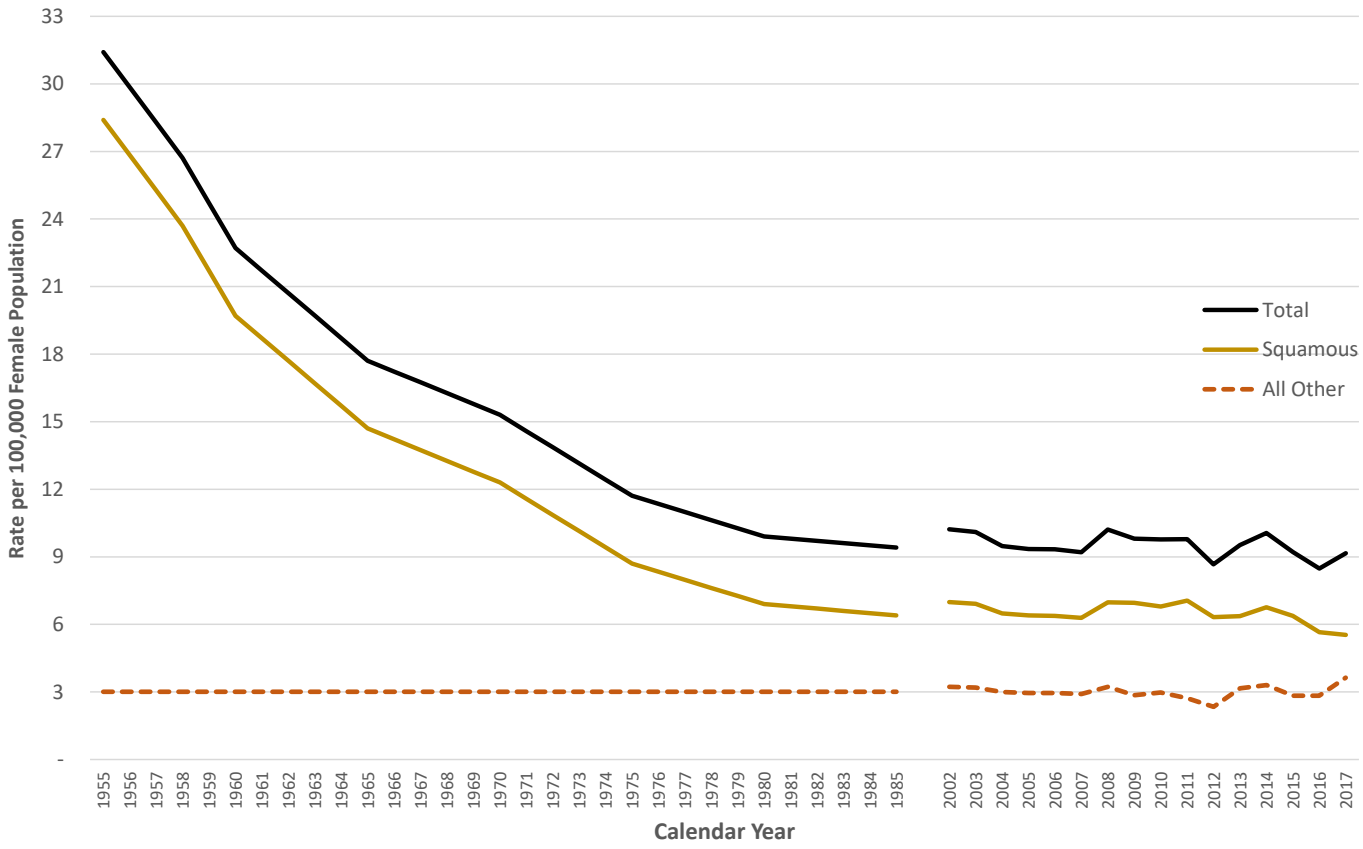
Table 3: Incidence of Invasive Carcinoma of the Cervix

In British Columbia, 1955 to 2017

Rate / 100,000 and Number of Cases

		Squamous Cell		*All Other*		*Total*	
Year	***Pop age ≥20***	Rate	N	Rate	N	Rate	N
1955	422,900	28.40	120	3.01	13	31.41	133
1956	439,600	26.83	118	3.01	13	29.84	131
1957	456,300	25.27	115	3.01	14	28.27	129
1958	473,000	23.70	112	3.01	14	26.71	126
1959	479,700	21.70	104	3.01	14	24.71	119
1960	486,400	19.70	96	3.01	15	22.71	110
1961	497,760	18.70	93	3.01	15	21.71	108
1962	509,120	17.70	90	3.01	15	20.71	105
1963	520,480	16.70	87	3.01	16	19.71	103
1964	531,840	15.70	83	3.01	16	18.71	99
1965	543,200	14.70	80	3.01	16	17.71	96
1966	567,440	14.22	81	3.01	17	17.23	98
1967	591,680	13.74	81	3.01	18	16.75	99
1968	615,920	13.26	82	3.01	19	16.27	100
1969	640,160	12.78	82	3.01	19	15.79	101
1970	664,400	12.30	82	3.01	20	15.31	102
1971	692,620	11.58	80	3.01	21	14.59	101
1972	720,840	10.86	78	3.01	22	13.87	100
1973	749,060	10.14	76	3.01	23	13.15	98
1974	777,280	9.42	73	3.01	23	12.43	97
1975	805,500	8.70	70	3.01	24	11.71	94
1976	826,980	8.34	69	3.01	25	11.35	94
1977	848,460	7.98	68	3.01	26	10.99	93
1978	869,940	7.62	66	3.01	26	10.63	92
1979	891,420	7.26	65	3.01	27	10.27	92
1980	912,900	6.90	63	3.01	27	9.91	90
1981	943,100	6.80	64	3.01	28	9.81	92
1982	973,300	6.70	65	3.01	29	9.71	94
1983	1,003,500	6.60	66	3.01	30	9.61	96
1984	1,033,700	6.50	67	3.01	31	9.51	98
1985	1,063,900	6.40	68	3.01	32	9.41	100
2002	1,584,502	6.99	111	3.23	51	10.22	162
2003	1,602,904	6.91	111	3.19	51	10.11	162
2004	1,624,216	6.49	105	3.00	49	9.48	154
2005	1,647,322	6.39	105	2.95	49	9.35	154
2006	1,672,182	6.38	107	2.95	49	9.33	156
2007	1,695,741	6.29	107	2.91	49	9.20	156
2008	1,723,573	6.98	120	3.23	56	10.21	176
2009	1,753,374	6.96	122	2.85	50	9.81	172
2010	1,781,051	6.79	121	2.98	53	9.77	174
2011	1,799,632	7.06	127	2.72	49	9.78	176
2012	1,834,487	6.32	116	2.34	43	8.67	159
2013	1,869,280	6.37	119	3.16	59	9.52	178
2014	1,908,657	6.76	129	3.30	63	10.06	192
2015	1,942,863	6.38	124	2.83	55	9.21	179
2016	1,980,652	5.65	112	2.83	56	8.48	168
2017	2,012,354	5.53	111	3.63	73	9.16	184

Figure 6: **Trend in Cervical Cancer Incidence in British Columbia**
1955 to 2017 by Morphology
Rate per 100,000 Female Population



Incidence by Age

1955, 1958 and 1960

To estimate a base historic incidence of cervical cancers in BC in the absence of screening we started with the total number of SCC in 1955, 1958, and 1960 as provided by Anderson et al. (see Table 3). This source, however, only provides the total number and rate of SCC for each year. As noted above, we also included other cervical cancers at a rate of 3.01 per 100,000 (see Table 3). To distribute the annual total number of cervical cancers by age we used Canadian age-specific incidence rates from 1972-76 as provided by Dickenson and colleagues.[492] Age-specific incidence rates from 1972-76 were the earliest we could find and likely reflect rates prior to the implementation of organized screening programs across Canada. While opportunistic screening was available during the 1970s, most provinces did not implement organized screening programs until the late 1980s.[493]

We then further distributed the estimated number of cervical cancers within the 20-29 year old age group into individual years based on research published by Krueger and colleagues (see Table 4).[494]

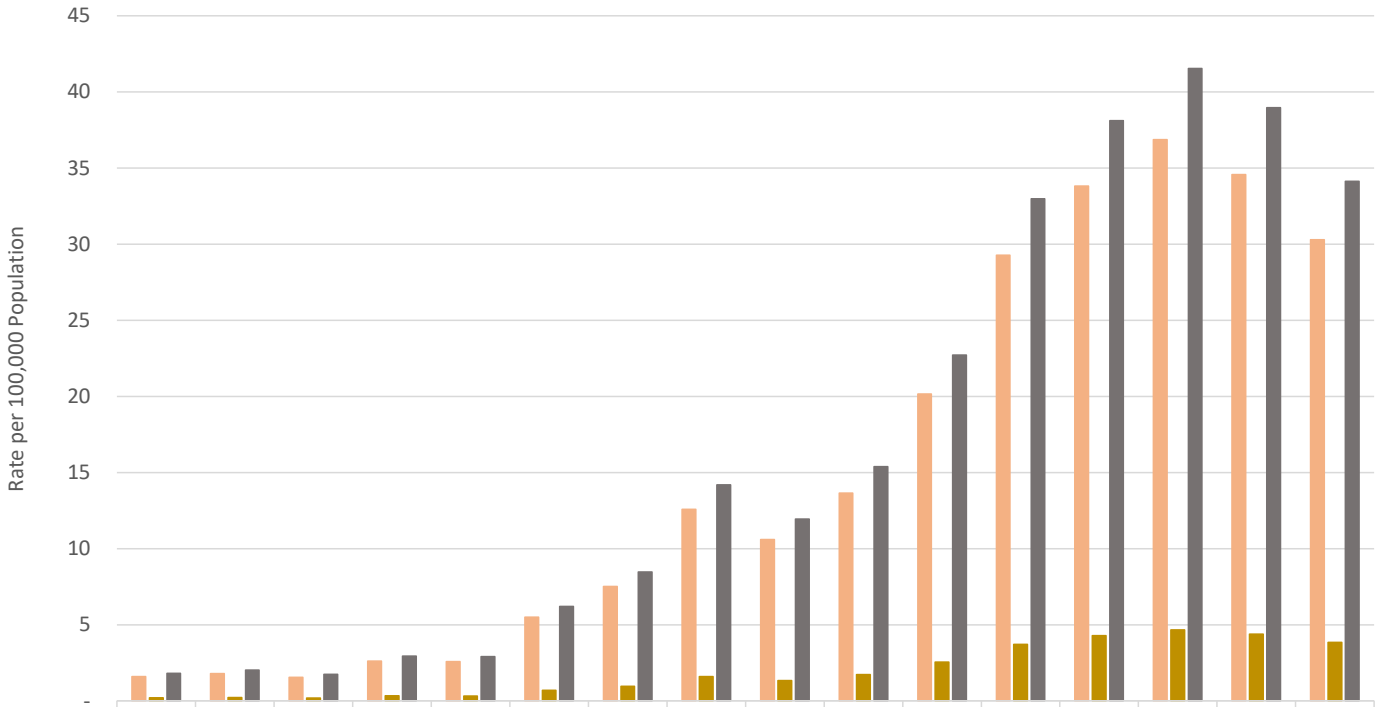
Table 4: Cervical Cancer in British Columbia
Females Aged 20-29, 1985-2009
Rate per 100,000 Population

Age	1985-89	1990-94	1995-99	2000-2004	2005-09	Total
20	0.90	1.74	1.62	0.73	0.70	1.11
21	0.86	1.69	2.41	0.73	0.69	1.25
22	-	2.48	1.58	1.48	-	1.08
23	2.35	0.81	3.87	1.51	0.68	1.82
24	2.26	1.60	2.25	1.52	1.36	1.79
25	2.94	5.45	2.90	5.36	2.71	3.82
26	4.37	3.75	6.35	6.13	5.47	5.22
27	7.24	14.31	4.17	9.85	8.32	8.74
28	6.47	10.95	9.60	5.24	4.23	7.36
29	5.00	7.95	12.92	15.13	6.40	9.48
Total	**3.38**	**5.38**	**4.95**	**4.78**	**3.04**	**4.28**

[492] Dickenson J, Stankiewicz A, Popadiuk C et al. Reduced cervical cancer incidence and mortality in Canada: National data from 1932 to 2006. *BMC Public Health*. 2012; 12: 992.
[493] Popadiuk C. Cervical cancer screening in Canada. *Journal of Obstetrics and Gynecology Canada*. 2019; 41(S2): S177-80.
[494] Krueger H, Kwon J, Sadownik L et al. What is the appropriate age to start screening women for cervical cancer? *BC Medical Journal*. 2013; 55(6): 282-6.

The results for SCC, all other cervical cancers and total cervical cancers by age are shown in Figure 7. The age and morphology specific incidence rates in Figure 7 are our best estimate of historic patterns prior to the implementation of cervical cancer screening programs in BC.

Figure 7: **Historic Invasive Cervical Cancer Rate in British Columbia**
By Age and Morphology
1955, 1958 and 1960



	20	21	22	23	24	25	26	27	28	29	30-39	40-49	50-59	60-69	70-79	≥80
Squamous	1.60	1.80	1.55	2.62	2.58	5.50	7.52	12.59	10.60	13.66	20.16	29.27	33.82	36.87	34.58	30.29
All Other	0.20	0.23	0.20	0.33	0.33	0.70	0.95	1.60	1.34	1.73	2.55	3.71	4.29	4.67	4.38	3.84
Total	1.80	2.03	1.75	2.95	2.91	6.20	8.47	14.19	11.94	15.39	22.71	32.98	38.11	41.54	38.96	34.12

Age

2002 to 2017

Data on the number of cervical cancers between 2002 and 2008 were taken from the study by Coldman et al.[495] This data source provides higher level data on the year of diagnosis, the age group at diagnosis and morphology (squamous and non-squamous).

Data on the annual number and rate per 100,000 of cervical cancers between 2009 and 2013 were taken from the BC Cervical Cancer Screening Program 2015 Annual Report.[496] This data source provides annual information on the number and rate of cervical cancers by age group and morphology (squamous and all other).

Finally, data on the annual number and rate per 100,000 of cervical cancers (by SCC and all other) between 2014 and 2017 were taken from the BC Cancer Cervix Screening 2018

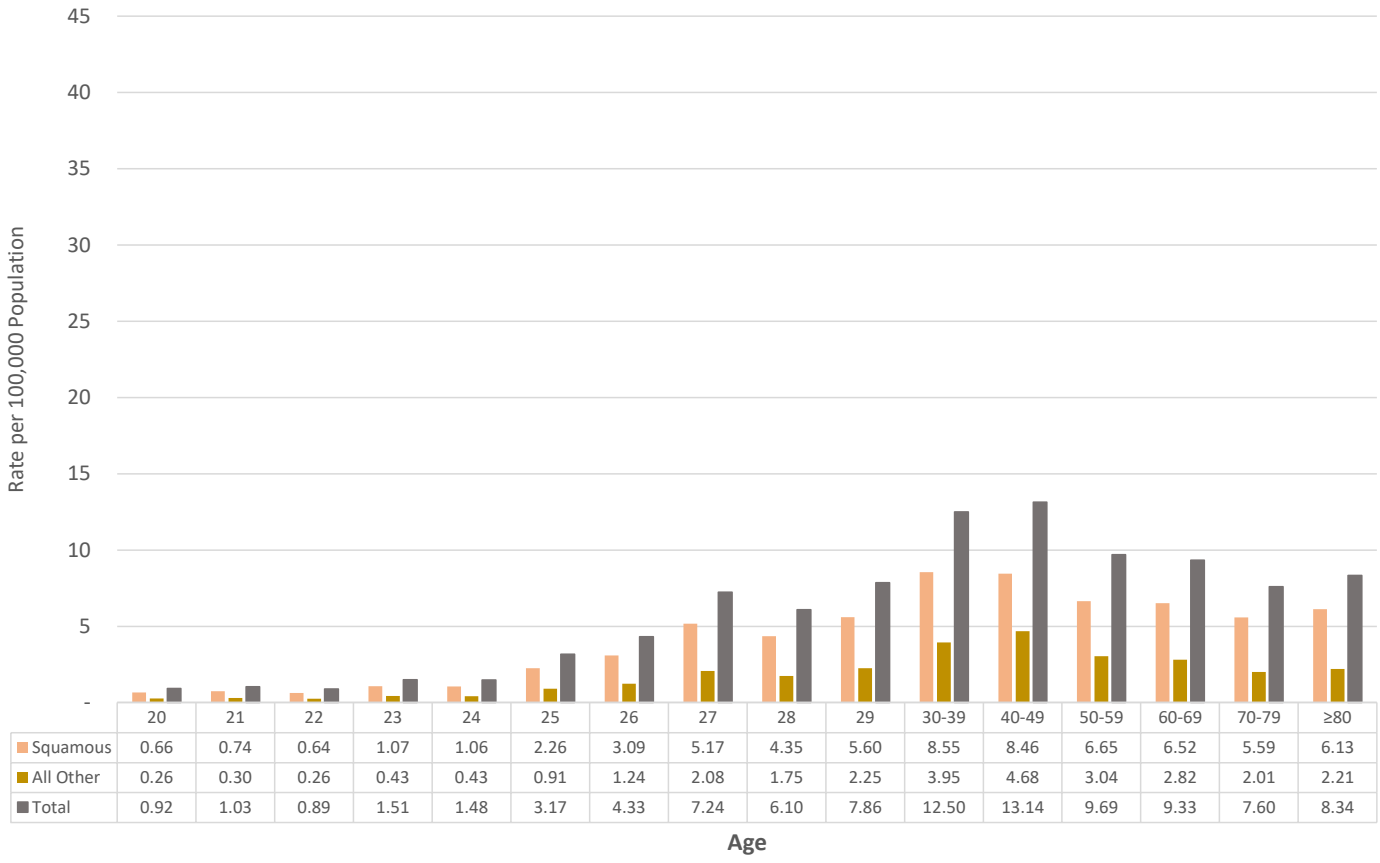
[495] Coldman A, Niekerk D, Smith L et al. Cervical cancer incidence in British Columbia: Predicting effects of changes from Pap to human papillomavirus screening and changes in screening participation. *Journal of Medical Screening*. 2017; 24(4): 195-200.
[496] BC Cancer Agency, Cervical Cancer Screening Program. *Cervical Cancer Screening Program 2015 Annual Report*. Table 7. Available online at http://www.bccancer.bc.ca/screening/Documents/CCSP_Report-AnnualReport2015.pdf. Accessed January 2023.

Program Results report.[497] This data source also provides annual information on the number and rate of cervical cancers by age group and morphology (squamous and all other).

We then further distributed the estimated number of cervical cancers within the 20-29 year old age group into individual years (see Table 4).[498]

The results for SCC, all other cervical cancers and total cervical cancers by age are shown in Figure 8. The age and morphology specific incidence rates in Figure 8 are our best estimate of current patterns based on current cervical cancer screening patterns in BC. *We have maintained the y-axis values from Figure 7 in Figure 8 to visually show the full impact of cervical cancer screening in BC.*

Figure 8: **Current Invasive Cervical Cancer Rate in British Columbia**
By Age and Morphology
2002 to 2017



	20	21	22	23	24	25	26	27	28	29	30-39	40-49	50-59	60-69	70-79	≥80
Squamous	0.66	0.74	0.64	1.07	1.06	2.26	3.09	5.17	4.35	5.60	8.55	8.46	6.65	6.52	5.59	6.13
All Other	0.26	0.30	0.26	0.43	0.43	0.91	1.24	2.08	1.75	2.25	3.95	4.68	3.04	2.82	2.01	2.21
Total	0.92	1.03	0.89	1.51	1.48	3.17	4.33	7.24	6.10	7.86	12.50	13.14	9.69	9.33	7.60	8.34

Age

[497] *BC Cancer Cervix Screening 2018 Program Results*. Table 7. Available online at http://www.bccancer.bc.ca/screening/Documents/Cervix-Program-Results-2018.pdf. Accessed January 2023.
[498] Krueger H, Kwon J, Sadownik L et al. What is the appropriate age to start screening women for cervical cancer? *BC Medical Journal*. 2013; 55(6): 282-6.

For modelling purposes the Lifetime Prevention Schedule analyses use a standard BC birth cohort of 40,000. Survival and life expectancy within the cohort by sex and age is based on BC life tables for 2018 to 2020.[499] We then applied age and morphology specific incidence rates from Figures 7 and 8 to the 20,000 females within this cohort (see Table 5). Applying historic rates to the cohort suggests that 305 invasive cervical cancers would be observed within the cohort between the ages of 25 (the start of screening) and 74 (5 years after the end of screening at age 69, we assumed a 5-year protective effect in our modelling). Based on current screening patterns, the estimated number of invasive cervical cancers is decreased to 99 (a 67.6% reduction). As expected, the change is most substantial for SCC (from 270 to 67, a 75.1% reduction). The reduction for all other cervical cancers is from 34 to 31, a reduction of 8.3% (see Table 5).

By way of validating the results observed in Table 5, Lonneberg and colleagues observed an overall reduction in the total cervical cancer burden in Norway between 1956 and 2010 of 68% and a 74% reduction in SCC.[500] These changes are virtually identical to those modelled in Table 5 based on BC data from 1955 to 2017 (67.6% and 75.1%, as noted above).

[499] Statistics Canada. Table 13-10-0114-01 Life expectancy and other elements of the complete life table, three-year estimates, Canada, all provinces except Prince Edward Island. Available online at http:https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=1310011401. Accessed January 2023.
[500] Lonnberg S, Hansen B, Haldorsen T et al. Cervical cancer prevented by screening: Long-term incidence trends by morphology in Norway. *International Journal of Cancer*. 2015; 137: 1758-64.

Table 5: Past and Current Incidence of Invasive Cervical Cancer
Between the Ages of 25 and 74
in a British Columbia Birth Cohort of 20,000 Females

		Historic Incidence of CC						***Current Incidence of CC***					
	Females in Birth	Squamous		All Other		Total		Squamous		All Other		Total	
Age	Cohort	Rate*	#	Rate	#	Rate	#	Rate	#	Rate	#	Rate	#
25	19,843	5.5	1.1	0.7	0.1	6.2	**1.2**	2.3	0.4	0.9	0.2	3.2	**0.6**
26	19,834	7.5	1.5	1.0	0.2	8.5	**1.7**	3.1	0.6	1.2	0.2	4.3	**0.9**
27	19,825	12.6	2.5	1.6	0.3	14.2	**2.8**	5.2	1.0	2.1	0.4	7.2	**1.4**
28	19,816	10.6	2.1	1.3	0.3	11.9	**2.4**	4.3	0.9	1.7	0.3	6.1	**1.2**
29	19,806	13.7	2.7	1.7	0.3	15.4	**3.0**	5.6	1.1	2.3	0.4	7.9	**1.6**
30	19,796	20.2	4.0	2.6	0.5	22.7	**4.5**	8.5	1.7	3.9	0.8	12.5	**2.5**
31	19,785	20.2	4.0	2.6	0.5	22.7	**4.5**	8.5	1.7	3.9	0.8	12.5	**2.5**
32	19,773	20.2	4.0	2.6	0.5	22.7	**4.5**	8.5	1.7	3.9	0.8	12.5	**2.5**
33	19,761	20.2	4.0	2.6	0.5	22.7	**4.5**	8.5	1.7	3.9	0.8	12.5	**2.5**
34	19,749	20.2	4.0	2.6	0.5	22.7	**4.5**	8.5	1.7	3.9	0.8	12.5	**2.5**
35	19,736	20.2	4.0	2.6	0.5	22.7	**4.5**	8.5	1.7	3.9	0.8	12.5	**2.5**
36	19,722	20.2	4.0	2.6	0.5	22.7	**4.5**	8.5	1.7	3.9	0.8	12.5	**2.5**
37	19,708	20.2	4.0	2.6	0.5	22.7	**4.5**	8.5	1.7	3.9	0.8	12.5	**2.5**
38	19,693	20.2	4.0	2.6	0.5	22.7	**4.5**	8.5	1.7	3.9	0.8	12.5	**2.5**
39	19,677	20.2	4.0	2.6	0.5	22.7	**4.5**	8.5	1.7	3.9	0.8	12.5	**2.5**
40	19,661	29.3	5.8	3.7	0.7	33.0	**6.5**	8.5	1.7	4.7	0.9	13.1	**2.6**
41	19,643	29.3	5.7	3.7	0.7	33.0	**6.5**	8.5	1.7	4.7	0.9	13.1	**2.6**
42	19,625	29.3	5.7	3.7	0.7	33.0	**6.5**	8.5	1.7	4.7	0.9	13.1	**2.6**
43	19,605	29.3	5.7	3.7	0.7	33.0	**6.5**	8.5	1.7	4.7	0.9	13.1	**2.6**
44	19,584	29.3	5.7	3.7	0.7	33.0	**6.5**	8.5	1.7	4.7	0.9	13.1	**2.6**
45	19,561	29.3	5.7	3.7	0.7	33.0	**6.5**	8.5	1.7	4.7	0.9	13.1	**2.6**
46	19,537	29.3	5.7	3.7	0.7	33.0	**6.4**	8.5	1.7	4.7	0.9	13.1	**2.6**
47	19,511	29.3	5.7	3.7	0.7	33.0	**6.4**	8.5	1.6	4.7	0.9	13.1	**2.6**
48	19,484	29.3	5.7	3.7	0.7	33.0	**6.4**	8.5	1.6	4.7	0.9	13.1	**2.6**
49	19,454	29.3	5.7	3.7	0.7	33.0	**6.4**	8.5	1.6	4.7	0.9	13.1	**2.6**
50	19,422	33.8	6.6	4.3	0.8	38.1	**7.4**	6.7	1.3	3.0	0.6	9.7	**1.9**
51	19,388	33.8	6.6	4.3	0.8	38.1	**7.4**	6.7	1.3	3.0	0.6	9.7	**1.9**
52	19,352	33.8	6.5	4.3	0.8	38.1	**7.4**	6.7	1.3	3.0	0.6	9.7	**1.9**
53	19,312	33.8	6.5	4.3	0.8	38.1	**7.4**	6.7	1.3	3.0	0.6	9.7	**1.9**
54	19,270	33.8	6.5	4.3	0.8	38.1	**7.3**	6.7	1.3	3.0	0.6	9.7	**1.9**
55	19,224	33.8	6.5	4.3	0.8	38.1	**7.3**	6.7	1.3	3.0	0.6	9.7	**1.9**
56	19,174	33.8	6.5	4.3	0.8	38.1	**7.3**	6.7	1.3	3.0	0.6	9.7	**1.9**
57	19,121	33.8	6.5	4.3	0.8	38.1	**7.3**	6.7	1.3	3.0	0.6	9.7	**1.9**
58	19,063	33.8	6.4	4.3	0.8	38.1	**7.3**	6.7	1.3	3.0	0.6	9.7	**1.8**
59	19,000	33.8	6.4	4.3	0.8	38.1	**7.2**	6.7	1.3	3.0	0.6	9.7	**1.8**
60	18,932	36.9	7.0	4.7	0.9	41.5	**7.9**	6.5	1.2	2.8	0.5	9.3	**1.8**
61	18,858	36.9	7.0	4.7	0.9	41.5	**7.8**	6.5	1.2	2.8	0.5	9.3	**1.8**
62	18,777	36.9	6.9	4.7	0.9	41.5	**7.8**	6.5	1.2	2.8	0.5	9.3	**1.8**
63	18,689	36.9	6.9	4.7	0.9	41.5	**7.8**	6.5	1.2	2.8	0.5	9.3	**1.7**
64	18,593	36.9	6.9	4.7	0.9	41.5	**7.7**	6.5	1.2	2.8	0.5	9.3	**1.7**
65	18,489	36.9	6.8	4.7	0.9	41.5	**7.7**	6.5	1.2	2.8	0.5	9.3	**1.7**
66	18,375	36.9	6.8	4.7	0.9	41.5	**7.6**	6.5	1.2	2.8	0.5	9.3	**1.7**
67	18,250	36.9	6.7	4.7	0.9	41.5	**7.6**	6.5	1.2	2.8	0.5	9.3	**1.7**
68	18,113	36.9	6.7	4.7	0.8	41.5	**7.5**	6.5	1.2	2.8	0.5	9.3	**1.7**
69	17,963	36.9	6.6	4.7	0.8	41.5	**7.5**	6.5	1.2	2.8	0.5	9.3	**1.7**
70	17,799	34.6	6.2	4.4	0.8	39.0	**6.9**	5.6	1.0	2.0	0.4	7.6	**1.4**
71	17,619	34.6	6.1	4.4	0.8	39.0	**6.9**	5.6	1.0	2.0	0.4	7.6	**1.3**
72	17,421	34.6	6.0	4.4	0.8	39.0	**6.8**	5.6	1.0	2.0	0.4	7.6	**1.3**
73	17,204	34.6	5.9	4.4	0.8	39.0	**6.7**	5.6	1.0	2.0	0.3	7.6	**1.3**
74	16,966	34.6	5.9	4.4	0.7	39.0	**6.6**	5.6	0.9	2.0	0.3	7.6	**1.3**
Total			**270**		**34.3**		**305**		**67**		**31.4**		**99**
** Rate is per 100,000 female population*						*Reduction from Historic to Current*		*75.1%*		*8.3%*		*67.6%*	

Trend in Mortality Rate – 1958 to 2020

Mortality Due to Cervical Cancers in BC - 1958 to 1985

Anderson et al. provide data on the number of deaths and mortality rate due to SCC in BC in 1958, 1960, 1965, 1970, 1975, 1980 and 1985.[501] We assumed a linear distribution in mortality rate for each of the years of missing data between two data points and then applied that rate to the annual population of females ages 20 and older to generate the estimated number of deaths in a given year.

The study by Anderson et al. only includes data on SCC.[502] To estimate the number of deaths due to other cervical cancers for each year between 1958 and 1985, we turned to data from Miller and coauthors on mortality rates due to cervical cancers in BC in 1951, 1961 and 1971.[503] This data source provides mortality rates for all cervical cancers but based on mortality only between the ages of 30-64.

To distribute the annual total number of deaths due to SCC from Andersen[504] by age we used Canadian age-specific mortality rates from 1952-56 and 1972-76 as provided by Dickenson and colleagues.[505] The age distribution from 1952-56 was used to distribute deaths due to SCC in 1958, 1960 and 1965 while the age distribution from 1972-76 was used to distribute deaths due to SCC in 1970, 1975, 1980 and 1985. We were then able to determine that deaths due to SCC contributed 76% of total cervical cancer deaths between the ages of 30-64. The deaths and mortality rate due to SCC in BC as noted by Anderson et al.[506] were thus increased by a factor of 1.3157. That is, the mortality rate per 100,000 females ages 20+ due to SCC in 1958 was 11.42. We increased this to 15.02 (11.42 * 1.3157) to take into account deaths due to cervical cancers other than SCC.

Mortality Due to Cervical Cancers in BC - 2000 to 2020

The annual number of deaths due to cervical cancer in BC between 2000 and 2020 were generated from Statistics Canada Table 13-10-0800-01.[507] We used this data to calculate a mortality rate per 100,000 females age ≥20 for each year between 2000 and 2020.

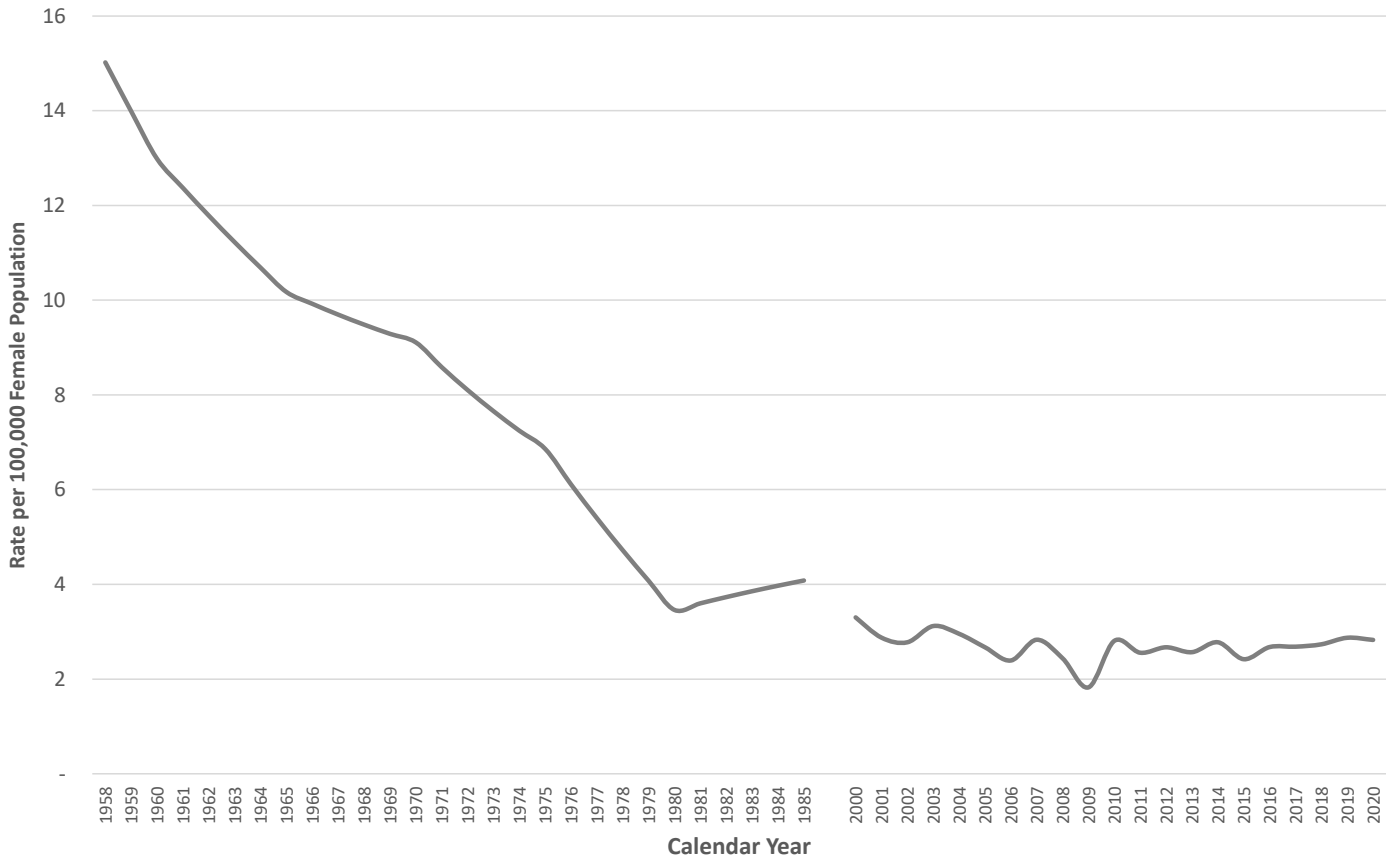
[501] Anderson G, Boyes D, Benedict J et al. Organization and results of the cervical cytology screening programme in British Columbia, 1955-85. *British Medical Journal*. 1988; 296: 975-8.
[502] Ibid.
[503] Miller A, Lindsay J, Hill G. Mortality from cancer of the uterus in Canada and its relationship to screening for cancer of the cervix. *International Journal of Cancer*. 1976; 17: 602-12.
[504] Anderson G, Boyes D, Benedict J et al. Organization and results of the cervical cytology screening programme in British Columbia, 1955-85. *British Medical Journal*. 1988; 296: 975-8.
[505] Dickenson J, Stankiewicz A, Popadiuk C et al. Reduced cervical cancer incidence and mortality in Canada: National data from 1932 to 2006. *BMC Public Health*. 2012; 12: 992.
[506] Anderson G, Boyes D, Benedict J et al. Organization and results of the cervical cytology screening programme in British Columbia, 1955-85. *British Medical Journal*. 1988; 296: 975-8.
[507] Statistics Canada. Table 13-10-0800-01. *Deaths and Mortality Rate, By Selected Grouped Causes*. Available online at https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=1310080001. Accessed January 2023.

Long-term Trends in Mortality

Between 1958 and 1985, the mortality rate due to cervical cancer per 100,000 females ages ≥20 declined from 15.0 to 4.1 (see Figure 9). While we included long-term incidence trends by morphology in Figure 6 due to the differential impact of screening by morphology, when adjusted for age and stage, morphology does not appear to affect cervical cancer survival[508] and is thus not differentiated in the long-term mortality trend (see Figure 9).

Between 2000 and 2020, the mortality rate due to cervical cancers essentially stabilized at an average rate of 2.70 / 100,000 (see Figure 9). Indeed, between 2000 and 2010 the average rate was 2.72 compared with 2.68 between 2011 and 2020.

Figure 9: **Trend in Mortality Rate in British Columbia**
Due to Cervical Cancer, 1958 to 2020
Rate per 100,000 Female Population



[508] Emmett M, Gildea C, NordinA et al. Cervical cancer – does the morphological subtype affect survival rates? *Journal of Obstetrics and Gynaecology*. 2018; 38(4): 548-55.

Mortality Rate by Age – Historic and Current

1958 & 1960

To estimate the mortality rate by age as screening was being implemented in BC, we began with the number of deaths due to SCC in 1958 and 1960 as provided by Anderson and colleagues[509] and adjusted this to include an estimate of deaths due to cervical cancers other than SCC (see earlier section on *Mortality Due to Cervical Cancers in BC - 1958 to 1985*). These total deaths due to cervical cancers were then distributed by age based on Canadian age-specific mortality rates from 1952-56 as provided by Dickenson and colleagues.[510]

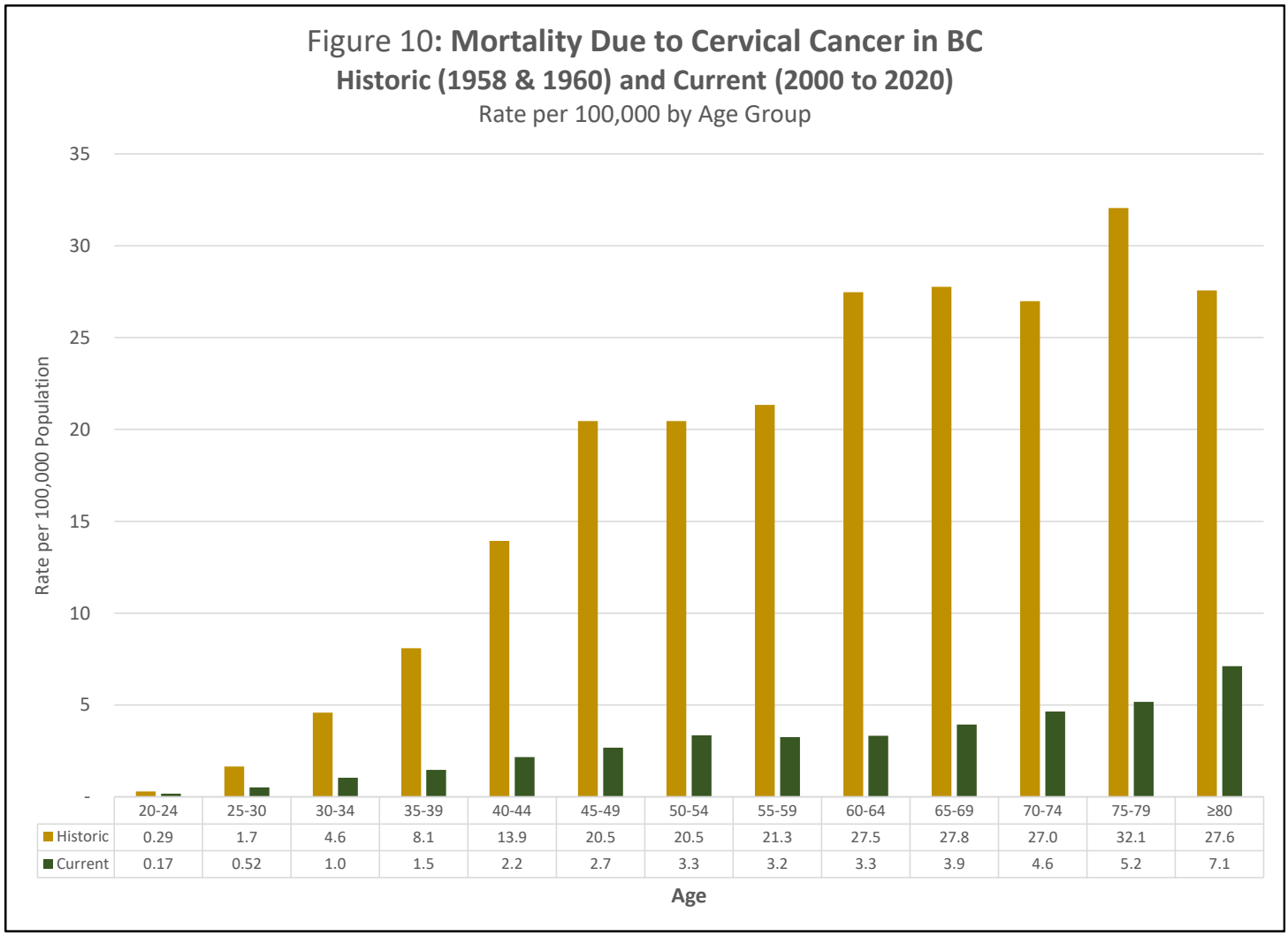
The results are summarized in Figure 10.

2000 to 2020

To estimate the current mortality rate by age we began with Statistics Canada data on the annual number of deaths due to cervical cancer in BC between 2000 and 2020.[511] These total deaths due to cervical cancers were then distributed by age based on Canadian age-specific mortality rates from 2002-06 as provided by Dickenson and colleagues.[512]

The results are summarized in Figure 10.

[509] Anderson G, Boyes D, Benedict J et al. Organization and results of the cervical cytology screening programme in British Columbia, 1955-85. *British Medical Journal*. 1988; 296: 975-8.
[510] Dickenson J, Stankiewicz A, Popadiuk C et al. Reduced cervical cancer incidence and mortality in Canada: National data from 1932 to 2006. *BMC Public Health*. 2012; 12: 992.
[511] Statistics Canada. Table 13-10-0800-01. *Deaths and Mortality Rate, By Selected Grouped Causes*. Available online at https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=1310080001. Accessed January 2023.
[512] Dickenson J, Stankiewicz A, Popadiuk C et al. Reduced cervical cancer incidence and mortality in Canada: National data from 1932 to 2006. *BMC Public Health*. 2012; 12: 992.



Mortality Due to Cervical Cancers in a BC Birth Cohort of 40,000 – Historic and Current

We then applied age specific mortality rates from Figure 10 to the 20,000 females within a BC birth cohort of 40,000 (see Table 6). Applying historic rates to the cohort suggests that 163 deaths (and 5,011 life years lost) due to cervical cancers would be observed within the cohort between the ages of 25 and 74. Based on current screening patterns, the estimated number of deaths and life years lost (LYL) would decrease to 25 and 783, a reduction of 85%.

Table 6: Past and Current Mortality Due to Invasive Cervical Cancer Between the Ages of 25 and 74

in a British Columbia Birth Cohort of 20,000 Females

	Females in Birth	*Historic*				*Current*			
Age	Cohort	Rate*	#	LE	LYL	Rate*	#	LE	LYL
25	19,843	1.7	0.3	60.5	20	0.5	0.1	60.5	6
26	19,834	1.7	0.3	59.6	20	0.5	0.1	59.6	6
27	19,825	1.7	0.3	58.6	19	0.5	0.1	58.6	6
28	19,816	1.7	0.3	57.6	19	0.5	0.1	57.6	6
29	19,806	1.7	0.3	56.6	19	0.5	0.1	56.6	6
30	19,796	4.6	0.9	55.7	50	1.0	0.2	55.7	11
31	19,785	4.6	0.9	54.7	50	1.0	0.2	54.7	11
32	19,773	4.6	0.9	53.7	49	1.0	0.2	53.7	11
33	19,761	4.6	0.9	52.8	48	1.0	0.2	52.8	11
34	19,749	4.6	0.9	51.8	47	1.0	0.2	51.8	11
35	19,736	8.1	1.6	50.8	81	1.5	0.3	50.8	15
36	19,722	8.1	1.6	49.9	80	1.5	0.3	49.9	14
37	19,708	8.1	1.6	48.9	78	1.5	0.3	48.9	14
38	19,693	8.1	1.6	47.9	76	1.5	0.3	47.9	14
39	19,677	8.1	1.6	47.0	75	1.5	0.3	47.0	14
40	19,661	13.9	2.7	46.0	126	2.2	0.4	46.0	20
41	19,643	13.9	2.7	45.1	123	2.2	0.4	45.1	19
42	19,625	13.9	2.7	44.1	121	2.2	0.4	44.1	19
43	19,605	13.9	2.7	43.1	118	2.2	0.4	43.1	18
44	19,584	13.9	2.7	42.2	115	2.2	0.4	42.2	18
45	19,561	20.5	4.0	41.2	165	2.7	0.5	41.2	22
46	19,537	20.5	4.0	40.3	161	2.7	0.5	40.3	21
47	19,511	20.5	4.0	39.3	157	2.7	0.5	39.3	21
48	19,484	20.5	4.0	38.4	153	2.7	0.5	38.4	20
49	19,454	20.5	4.0	37.4	149	2.7	0.5	37.4	19
50	19,422	20.5	4.0	36.5	145	3.3	0.7	36.5	24
51	19,388	20.5	4.0	35.6	141	3.3	0.6	35.6	23
52	19,352	20.5	4.0	34.6	137	3.3	0.6	34.6	22
53	19,312	20.5	4.0	33.7	133	3.3	0.6	33.7	22
54	19,270	20.5	3.9	32.8	129	3.3	0.6	32.8	21
55	19,224	21.3	4.1	31.9	131	3.2	0.6	31.9	20
56	19,174	21.3	4.1	30.9	127	3.2	0.6	30.9	19
57	19,121	21.3	4.1	30.0	122	3.2	0.6	30.0	19
58	19,063	21.3	4.1	29.1	118	3.2	0.6	29.1	18
59	19,000	21.3	4.1	28.2	114	3.2	0.6	28.2	17
60	18,932	27.5	5.2	27.3	142	3.3	0.6	27.3	17
61	18,858	27.5	5.2	26.4	137	3.3	0.6	26.4	17
62	18,777	27.5	5.2	25.5	132	3.3	0.6	25.5	16
63	18,689	27.5	5.1	24.6	127	3.3	0.6	24.6	15
64	18,593	27.5	5.1	23.8	121	3.3	0.6	23.8	15
65	18,489	27.8	5.1	22.9	118	3.9	0.7	22.9	17
66	18,375	27.8	5.1	22.0	112	3.9	0.7	22.0	16
67	18,250	27.8	5.1	21.2	107	3.9	0.7	21.2	15
68	18,113	27.8	5.0	20.3	102	3.9	0.7	20.3	14
69	17,963	27.8	5.0	19.5	97	3.9	0.7	19.5	14
70	17,799	27.0	4.8	18.7	90	4.6	0.8	18.7	15
71	17,619	27.0	4.8	17.9	85	4.6	0.8	17.9	15
72	17,421	27.0	4.7	17.1	80	4.6	0.8	17.1	14
73	17,204	27.0	4.6	16.3	76	4.6	0.8	16.3	13
74	16,966	27.0	4.6	15.5	71	4.6	0.8	15.5	12
Total			**163**	**30.8**	**5,011**		**25**	**31.5**	**783**

** Rate is per 100,000 female population*

LE = life expectancy; LYL = life years lost

Quality-Adjusted Life Years Lost – Historic and Current

- The diagnosis and treatment phase for cervical cancer lasts an average of 4.8 months[513] and is associated with a utility loss of 0.288 (95% CI of 0.193 to 0.399).[514]
- The ongoing, controlled phase (remission) for cervical cancer is associated with a utility loss of 0.049 (95% CI of 0.031 to 0.072).[515]
- The metastatic phase for cervical cancer lasts an average of 9.2 months[516] and is associated with a utility loss of 0.451 (95% CI of 0.307 to 0.600).[517]

Applying the above changes in quality of life (QoL) related with the various phases of cervical cancer treatment suggests that, in a BC birth cohort of 20,000 females, if historic rates (with no screening) of invasive cervical cancers and deaths due to cervical cancers were currently maintained, we would expect 305 incident invasive cervical cancers (see Table 5) and 163 deaths (see Table 6) between the ages of 25 and 74 in a BC birth cohort of 20,000 females. These cancers and deaths are associated with 5,386 QALYs lost (see Table 7).

Given current screening patterns, we would expect to see 99 incident invasive cervical cancers (see Table 5) and 25 deaths (see Table 6) between the ages of 25 and 74 in a BC birth cohort of 20,000 females. These cancers and deaths are associated with 978 QALYs lost (see Table 7).

That is, current screening is associated with 4,409 (5,386 – 978) QALYs gained in a BC birth cohort of 20,000 females.

[513] Fitzmaurice C, Allen C, Barber R et al. Global, regional, and national cancer incidence, mortality, years of life lost, years lived with disability, and disability-adjusted life-years for 32 cancer groups, 1990 to 2015: a systematic analysis for the global burden of disease study. *Journal of American Medical Association Oncology*. 2017; 3(4): 524-48.
[514] Institute for Health Metrics and Evaluation. *GBD 2016 sequelae, health states, health state lay descriptions, and disability weights*. Available online at http://ghdx.healthdata.org/record/global-burden-disease-study-2016-gbd-2016-disability-weights. Accessed October 2017.
[515] Fitzmaurice C, Allen C, Barber R et al. Global, regional, and national cancer incidence, mortality, years of life lost, years lived with disability, and disability-adjusted life-years for 32 cancer groups, 1990 to 2015: a systematic analysis for the global burden of disease study. *Journal of American Medical Association Oncology*. 2017; 3(4): 524-48.
[516] Ibid.
[517] Institute for Health Metrics and Evaluation. *GBD 2016 sequelae, health states, health state lay descriptions, and disability weights*. Available online at http://ghdx.healthdata.org/record/global-burden-disease-study-2016-gbd-2016-disability-weights. Accessed October 2017.

Table 7: Past and Current QALYs Lost Due to Invasive Cervical Cancer Between the Ages of 25 and 74

in a British Columbia Birth Cohort of 20,000 Females

		Historic								*Current*							
Age	Females in Birth Cohort	Incident Cervical Cancers	D&T QALYs Lost	RP QALYs Lost	MP QALYs Lost	Deaths	LE	LYL	***Total QALYs Lost***	Incident Cervical Cancers	D&T QALYs Lost	RP QALYs Lost	MP QALYs Lost	Deaths	LE	LYL	***Total QALYs Lost***
25	19,843	1.2	0.2	2.7	0.1	0.3	60.5	20	**23**	0.6	0.1	1.7	0.0	0.1	60.5	6	**8**
26	19,834	1.7	0.2	3.9	0.1	0.3	59.6	20	**24**	0.9	0.1	2.4	0.0	0.1	59.6	6	**9**
27	19,825	2.8	0.4	7.1	0.1	0.3	58.6	19	**27**	1.4	0.2	4.2	0.0	0.1	58.6	6	**10**
28	19,816	2.4	0.3	5.8	0.1	0.3	57.6	19	**25**	1.2	0.2	3.4	0.0	0.1	57.6	6	**9**
29	19,806	3.0	0.4	7.5	0.1	0.3	56.6	19	**27**	1.6	0.2	4.4	0.0	0.1	56.6	6	**10**
30	19,796	4.5	0.6	9.8	0.4	0.9	55.7	50	**61**	2.5	0.3	7.0	0.1	0.2	55.7	11	**19**
31	19,785	4.5	0.6	9.6	0.4	0.9	54.7	50	**60**	2.5	0.3	6.8	0.1	0.2	54.7	11	**18**
32	19,773	4.5	0.6	9.4	0.4	0.9	53.7	49	**59**	2.5	0.3	6.7	0.1	0.2	53.7	11	**18**
33	19,761	4.5	0.6	9.3	0.4	0.9	52.8	48	**58**	2.5	0.3	6.6	0.1	0.2	52.8	11	**18**
34	19,749	4.5	0.6	9.1	0.4	0.9	51.8	47	**57**	2.5	0.3	6.5	0.1	0.2	51.8	11	**17**
35	19,736	4.5	0.6	7.2	0.6	1.6	50.8	81	**89**	2.5	0.3	6.1	0.1	0.3	50.8	15	**21**
36	19,722	4.5	0.6	7.0	0.6	1.6	49.9	80	**88**	2.5	0.3	6.0	0.1	0.3	49.9	14	**21**
37	19,708	4.5	0.6	6.9	0.6	1.6	48.9	78	**86**	2.5	0.3	5.8	0.1	0.3	48.9	14	**20**
38	19,693	4.5	0.6	6.8	0.6	1.6	47.9	76	**84**	2.5	0.3	5.7	0.1	0.3	47.9	14	**20**
39	19,677	4.5	0.6	6.6	0.6	1.6	47.0	75	**83**	2.5	0.3	5.6	0.1	0.3	47.0	14	**20**
40	19,661	6.5	0.9	8.4	1.1	2.7	46.0	126	**136**	2.6	0.3	5.7	0.2	0.4	46.0	20	**26**
41	19,643	6.5	0.9	8.3	1.1	2.7	45.1	123	**134**	2.6	0.3	5.6	0.2	0.4	45.1	19	**25**
42	19,625	6.5	0.9	8.1	1.1	2.7	44.1	121	**131**	2.6	0.3	5.4	0.2	0.4	44.1	19	**25**
43	19,605	6.5	0.9	7.9	1.1	2.7	43.1	118	**128**	2.6	0.3	5.3	0.2	0.4	43.1	18	**24**
44	19,584	6.5	0.9	7.7	1.1	2.7	42.2	115	**125**	2.6	0.3	5.2	0.2	0.4	42.2	18	**24**
45	19,561	6.5	0.9	4.9	1.6	4.0	41.2	165	**172**	2.6	0.3	4.8	0.2	0.5	41.2	22	**27**
46	19,537	6.4	0.9	4.8	1.6	4.0	40.3	161	**168**	2.6	0.3	4.7	0.2	0.5	40.3	21	**26**
47	19,511	6.4	0.9	4.7	1.6	4.0	39.3	157	**164**	2.6	0.3	4.6	0.2	0.5	39.3	21	**26**
48	19,484	6.4	0.9	4.6	1.6	4.0	38.4	153	**160**	2.6	0.3	4.5	0.2	0.5	38.4	20	**25**
49	19,454	6.4	0.9	4.5	1.6	4.0	37.4	149	**156**	2.6	0.3	4.4	0.2	0.5	37.4	19	**24**
50	19,422	7.4	1.0	6.1	1.7	4.0	36.5	145	**154**	1.9	0.3	2.7	0.3	0.7	36.5	24	**27**
51	19,388	7.4	1.0	6.0	1.7	4.0	35.6	141	**150**	1.9	0.3	2.6	0.3	0.6	35.6	23	**26**
52	19,352	7.4	1.0	5.8	1.7	4.0	34.6	137	**146**	1.9	0.3	2.5	0.3	0.6	34.6	22	**26**
53	19,312	7.4	1.0	5.6	1.7	4.0	33.7	133	**141**	1.9	0.3	2.5	0.3	0.6	33.7	22	**25**
54	19,270	7.3	1.0	5.5	1.7	3.9	32.8	129	**137**	1.9	0.3	2.4	0.3	0.6	32.8	21	**24**
55	19,224	7.3	1.0	5.0	1.7	4.1	31.9	131	**138**	1.9	0.3	2.4	0.3	0.6	31.9	20	**23**
56	19,174	7.3	1.0	4.9	1.7	4.1	30.9	127	**134**	1.9	0.3	2.3	0.3	0.6	30.9	19	**22**
57	19,121	7.3	1.0	4.7	1.7	4.1	30.0	122	**130**	1.9	0.3	2.2	0.3	0.6	30.0	19	**21**
58	19,063	7.3	1.0	4.6	1.7	4.1	29.1	118	**126**	1.8	0.3	2.1	0.3	0.6	29.1	18	**21**
59	19,000	7.2	1.0	4.4	1.7	4.1	28.2	114	**121**	1.8	0.3	2.1	0.3	0.6	28.2	17	**20**
60	18,932	7.9	1.1	3.6	2.3	5.2	27.3	142	**149**	1.8	0.3	1.9	0.3	0.6	27.3	17	**20**
61	18,858	7.8	1.1	3.4	2.3	5.2	26.4	137	**144**	1.8	0.3	1.8	0.3	0.6	26.4	17	**19**
62	18,777	7.8	1.1	3.3	2.2	5.2	25.5	132	**138**	1.8	0.3	1.8	0.3	0.6	25.5	16	**18**
63	18,689	7.8	1.1	3.2	2.2	5.1	24.6	127	**133**	1.7	0.3	1.7	0.3	0.6	24.6	15	**18**
64	18,593	7.7	1.1	3.0	2.2	5.1	23.8	121	**128**	1.7	0.3	1.6	0.3	0.6	23.8	15	**17**
65	18,489	7.7	1.1	2.9	2.2	5.1	22.9	118	**124**	1.7	0.2	1.4	0.3	0.7	22.9	17	**19**
66	18,375	7.6	1.1	2.7	2.2	5.1	22.0	112	**118**	1.7	0.2	1.3	0.3	0.7	22.0	16	**18**
67	18,250	7.6	1.1	2.6	2.2	5.1	21.2	107	**113**	1.7	0.2	1.3	0.3	0.7	21.2	15	**17**
68	18,113	7.5	1.1	2.5	2.2	5.0	20.3	102	**108**	1.7	0.2	1.2	0.3	0.7	20.3	14	**16**
69	17,963	7.5	1.1	2.4	2.2	5.0	19.5	97	**103**	1.7	0.2	1.2	0.3	0.7	19.5	14	**15**
70	17,799	6.9	1.1	2.0	2.2	4.8	18.7	90	**95**	1.4	0.2	0.6	0.4	0.8	18.7	15	**17**
71	17,619	6.9	1.0	1.8	2.2	4.8	17.9	85	**90**	1.3	0.2	0.6	0.4	0.8	17.9	15	**16**
72	17,421	6.8	1.0	1.7	2.2	4.7	17.1	80	**85**	1.3	0.2	0.6	0.4	0.8	17.1	14	**15**
73	17,204	6.7	1.0	1.6	2.1	4.6	16.3	76	**80**	1.3	0.2	0.5	0.4	0.8	16.3	13	**14**
74	16,966	6.6	1.0	1.5	2.1	4.6	15.5	71	**76**	1.3	0.2	0.5	0.4	0.8	15.5	12	**13**
Total		**305**	**42**	**264**	**69**	**163**	**30.8**	**5,011**	**5,386**	**99**	**13**	**171**	**11**	**25**	**31.5**	**783**	**978**

Note: QALYs = Quality-adjusted life years; D&T = Diagnosis and treatment phase; RP = Remission phase; MP = Metastatic phase; LE = Life expectancy; LYL = Life years lost

Current Cytology-Based Screening for Cervical Cancers

Clinically Preventable Burden – Cytology-Based Screening

Current Screening Program Results

To inform our model assessing the clinically preventable burden (CPB) and cost-effectiveness (CE) of BC's current cytology-based cervical cancer screening program in a BC birth cohort of 20,000 females, we have generated the information in Table 8 based on actual results in 2018 in BC.[518]

The total BC female population ages 25-69 in 2018 is 1,559,008. Screening is up-to-date (have been screened at least once in the past 36 months) for 930,304 females, of whom 302,525 were screened in 2018.

A total of 3,910 (1.3%) screens had to be redone due to unsatisfactory quality.

A total of 9,210 (3.04%) females received a test result of atypical squamous cells of undetermined significance (ASCUS) or low-grade squamous intraepithelial lesion (LSIL). Of these females, 7,875 (86%) returned for a repeat screen in 6 months and 1,170 (12.7%) went on to receive a colposcopy.

A total of 3,935 (1.30%) females received a test result of atypical glandular cells (AGC), atypical squamous cells - cannot exclude high-grade squamous intraepithelial lesions (ASC-H) or high-grade squamous intraepithelial lesions / adenocarcinoma in situ /invasive carcinoma (HSIL+). Of these females, 3,510 (89.2%) went on to receive a colposcopy. In future sections of this report we have truncated the ACG/ASC-H/HSIL+ label to HSIL+.

Of the 4,680 females who received a colposcopy, 85% had a biopsy performed during the colposcopy.

Of the 4,680 females who received a colposcopy, 2,240 or 47.9% received a confirmed diagnosis of cervical intraepithelial neoplasia (CIN) 2 or 3 or adenocarcinoma in situ (AIS). By comparison, the study by Wentzensen et al. in Oklahoma, found that of patients who receive a colposcopy following a screening result of ASCUS+, 40.2% are histologically confirmed to have CIN2+.[519]

Patients with a diagnosis of CIN2+ are considered to have precancerous lesions and this diagnosis tends to be followed by treatment due to the higher risk of these lesions turning into cancer. Available treatments include cryotherapy, large loop excision of the transformation zone (LEEP/LLETZ), and cold knife conisation (CKC).

In BC, the standard treatment for CIN2+ is LEEP with the occasional use of laser conisation.[520] In 2021, for example, 98.9% of procedures were LEEP, with the remaining 1.1% being laser conisation.[521]

[518] BC Cancer Cervix Screening. *BC Cancer Cervix Screening 2018 Program Results*. March 2020. Available online at http://www.bccancer.bc.ca/screening/Documents/Cervix-Program-Results-2018.pdf. Accessed January 2023.

[519] Wentzensen N, Walker J, Gold M et al. Multiple biopsies and detection of cervical cancer precursors at colposcopy. *Journal of Clinical Oncology*. 2015; 33(1): 83-9.

[520]Ogilvie G, van Niekerk D, Krajden M et al. A randomized controlled trial of human papillomavirus (HPV) testing for cervical cancer screening: Trial design and preliminary results (HPV FOCAL trial). *BMC Cancer*. 2010; 10: 111.

[521] Dr. Lily Proctor, Medical Director, Cervix Screening Program, BC Cancer. Personal Communication. April 2023.

The 2017 meta-analysis by Arbyn et al found an overall recurrence rate of 6.6% (95% CI of 4.9% to 8.4%), 2.1% (95% CI of 0.4% to 4.9%) with laser conisation, 2.2% (95% CI of 1.8% to 2.6%) with cold-knife conisation and 6.7% (95% CI of 4.6% to 9.3%) with LEEP.[522]

Finally, a total of 168 females ages 25-69 were diagnosed with invasive cervical cancer.

Table 8: BC Cancer Cervix Screening

2018 Program Results by Age Group

	Age Group					
	25-29	30-39	40-49	50-59	60-69	**25-69**
Female Population	172,170	347,578	332,835	373,096	333,329	**1,559,008**
Screening Rate*	57%	69%	65%	57%	49%	**60%**
Total Screened Population	98,137	239,829	216,343	212,665	163,331	**930,304**
# of Patients Screened in 2018	34,465	77,775	70,290	69,115	50,880	**302,525**
% Screened	35%	32%	32%	32%	31%	**33%**
Unsatisfactory Screens						
#	551	1,244	914	691	509	**3,910**
%	1.6%	1.6%	1.3%	1.0%	1.0%	**1.3%**
Screen Results						
# ASCUS / LSIL	1,945	2,710	2,260	1,600	695	**9,210**
% ASCUS / LSIL	5.64%	3.48%	3.22%	2.31%	1.37%	**3.04%**
# AGC/ASC-H/HSIL+	790	1,300	845	675	325	**3,935**
% AGC/ASC-H/HSIL+	2.29%	1.67%	1.20%	0.98%	0.64%	**1.30%**
Repeat Screens for ASCUS/LSIL						
#	1,655	2,290	1,930	1,385	615	**7,875**
% of ACSUS / LSIL	85.1%	84.5%	85.4%	86.6%	88.5%	**85.5%**
% of Pts. Screened	4.8%	2.9%	2.7%	2.0%	1.2%	**2.6%**
Colposcopy						
# ASCUS / LSIL	265	385	275	185	60	**1,170**
% ASCUS / LSIL	13.6%	14.2%	12.2%	11.6%	8.6%	**12.7%**
# AGC/ASC-H/HSIL+	775	1,280	755	480	220	**3,510**
% AGC/ASC-H/HSIL+	98.1%	98.5%	89.3%	71.1%	67.7%	**89.2%**
Histologically Confirmed Pre-Cancerous Lesions						
Rate/1,000 Screened	18.1	12.0	6.0	2.3	2.0	**7.4**
# with CIN2+	624	933	422	159	102	**2,240**
% of all Colposcopies	60.0%	56.1%	40.9%	23.9%	36.3%	**47.9%**
Histologically Confirmed Invasive Cancers						
Rate/100,000 Females	5.81	12.37	12.32	9.11	12.00	**10.78**
# with Invasive Cancer	10	43	41	34	40	**168**

** Uncorrected for hysterectomy*

[522] Arbyn M, Redman C, Verdoodt F et al. Incomplete excision of cervical precancer as a predictor of treatment failure: A systematic review and meta-analysis. *Lancet Oncology*. 2017; 18: 1665-79.

BC Birth Cohort of 40,000

We then applied the results from Table 8 and the research evidence in the previous section to the 20,000 females in the BC birth cohort of 40,000 between the ages of 25 and 69 for screening (see Table 9). Within this cohort, we would expect 164,780 screens with an additional 2,138 repeat screens due to unsatisfactory samples and 4,312 repeat screens to follow-up patients with an original screening result of ASCUS / LSIL. Of the 5,044 patients with a screening result of ASCUS/LSIL, 641 (12.7%) would go on to receive a colposcopy. Of the 2,155 patients with a screening result of HSIL+, 1,928 (89.5%) would go on to receive a colposcopy.

Of those receiving a colposcopy, 1,238 (48.2%) would be histologically confirmed to have CIN2+, thus requiring treatment. Recurrent treatment within the next years is estimated at 6.7% or 83 of the 1,238.

Table 9: Screening for Cervical Cancer
Current Screening Model
in a British Columbia Birth Cohort of 20,000 Females

							Screening					***Screening Results***				***Colposcopies***						**Treatment**
	Females																					
	in Birth	***Hysterectomies***		Potential		# Up To	Annual	Unsatisfactory		Repeat		ASCUS / LSIL		HSIL+		ASCUS / LSIL		HSIL+		***CIN2+***		**Recurrence**
Age	Cohort	%	#	Cohort	Rate	Date	Screens	%	#	%	#	%	#	%	#	%	#	%	#	%	#	**6.7%**
25	19,843	0.5%	89	19,754	57%	11,260	3,954	1.6%	63	4.8%	190	5.6%	223	2.3%	91	13.6%	30	98.1%	89	60.0%	71.6	4.8
26	19,834	0.5%	104	19,730	57%	11,246	3,950	1.6%	63	4.8%	190	5.6%	223	2.3%	91	13.6%	30	98.1%	89	60.0%	71.5	4.8
27	19,825	0.6%	119	19,706	57%	11,233	3,945	1.6%	63	4.8%	189	5.6%	223	2.3%	90	13.6%	30	98.1%	89	60.0%	71.4	4.8
28	19,816	0.7%	134	19,682	57%	11,219	3,940	1.6%	63	4.8%	189	5.6%	222	2.3%	90	13.6%	30	98.1%	89	60.0%	71.3	4.8
29	19,806	0.8%	149	19,657	57%	11,205	3,935	1.6%	63	4.8%	189	5.6%	222	2.3%	90	13.6%	30	98.1%	88	60.0%	71.2	4.8
30	19,796	1.0%	202	19,594	69%	13,520	4,384	1.6%	70	2.9%	129	3.5%	153	1.7%	73	14.2%	22	98.5%	72	56.1%	52.6	3.5
31	19,785	1.5%	306	19,479	69%	13,440	4,359	1.6%	70	2.9%	128	3.5%	152	1.7%	73	14.2%	22	98.5%	72	56.1%	52.3	3.5
32	19,773	2.1%	410	19,364	69%	13,361	4,333	1.6%	69	2.9%	128	3.5%	151	1.7%	72	14.2%	21	98.5%	71	56.1%	52.0	3.5
33	19,761	2.6%	513	19,248	69%	13,281	4,307	1.6%	69	2.9%	127	3.5%	150	1.7%	72	14.2%	21	98.5%	71	56.1%	51.7	3.5
34	19,749	3.1%	617	19,132	69%	13,201	4,281	1.6%	68	2.9%	126	3.5%	149	1.7%	72	14.2%	21	98.5%	70	56.1%	51.4	3.4
35	19,736	3.7%	720	19,015	69%	13,121	4,255	1.6%	68	2.9%	125	3.5%	148	1.7%	71	14.2%	21	98.5%	70	56.1%	51.1	3.4
36	19,722	4.2%	824	18,899	69%	13,040	4,229	1.6%	68	2.9%	125	3.5%	147	1.7%	71	14.2%	21	98.5%	70	56.1%	50.7	3.4
37	19,708	4.7%	927	18,781	69%	12,959	4,203	1.6%	67	2.9%	124	3.5%	146	1.7%	70	14.2%	21	98.5%	69	56.1%	50.4	3.4
38	19,693	5.2%	1,030	18,663	69%	12,878	4,176	1.6%	67	2.9%	123	3.5%	146	1.7%	70	14.2%	21	98.5%	69	56.1%	50.1	3.4
39	19,677	5.8%	1,132	18,545	69%	12,796	4,150	1.6%	66	2.9%	122	3.5%	145	1.7%	69	14.2%	21	98.5%	68	56.1%	49.8	3.3
40	19,661	7.1%	1,392	18,269	69%	12,606	4,096	1.3%	53	2.7%	112	3.2%	132	1.2%	49	12.2%	16	89.3%	44	40.9%	24.6	1.6
41	19,643	8.4%	1,651	17,993	69%	12,415	4,034	1.3%	52	2.7%	111	3.2%	130	1.2%	48	12.2%	16	89.3%	43	40.9%	24.2	1.6
42	19,625	9.7%	1,909	17,716	69%	12,224	3,971	1.3%	52	2.7%	109	3.2%	128	1.2%	48	12.2%	16	89.3%	43	40.9%	23.8	1.6
43	19,605	11.1%	2,167	17,438	69%	12,032	3,909	1.3%	51	2.7%	107	3.2%	126	1.2%	47	12.2%	15	89.3%	42	40.9%	23.5	1.6
44	19,584	12.4%	2,424	17,160	69%	11,840	3,847	1.3%	50	2.7%	106	3.2%	124	1.2%	46	12.2%	15	89.3%	41	40.9%	23.1	1.5
45	19,561	13.7%	2,681	16,881	69%	11,648	3,784	1.3%	49	2.7%	104	3.2%	122	1.2%	45	12.2%	15	89.3%	41	40.9%	22.7	1.5
46	19,537	14.3%	2,787	16,750	69%	11,558	3,755	1.3%	49	2.7%	103	3.2%	121	1.2%	45	12.2%	15	89.3%	40	40.9%	22.5	1.5
47	19,511	14.8%	2,892	16,619	69%	11,467	3,726	1.3%	48	2.7%	102	3.2%	120	1.2%	45	12.2%	15	89.3%	40	40.9%	22.4	1.5
48	19,484	15.4%	2,997	16,486	69%	11,376	3,696	1.3%	48	2.7%	101	3.2%	119	1.2%	44	12.2%	14	89.3%	40	40.9%	22.2	1.5
49	19,454	15.9%	3,102	16,352	69%	11,283	3,666	1.3%	48	2.7%	101	3.2%	118	1.2%	44	12.2%	14	89.3%	39	40.9%	22.0	1.5
50	19,422	16.5%	3,205	16,217	70%	11,352	3,689	1.0%	37	2.0%	74	2.3%	85	1.0%	36	11.6%	10	71.1%	26	23.9%	8.5	0.6
51	19,388	17.1%	3,308	16,080	70%	11,256	3,658	1.0%	37	2.0%	73	2.3%	85	1.0%	36	11.6%	10	71.1%	25	23.9%	8.4	0.6
52	19,352	17.6%	3,411	15,941	70%	11,159	3,627	1.0%	36	2.0%	73	2.3%	84	1.0%	35	11.6%	10	71.1%	25	23.9%	8.3	0.6
53	19,312	18.2%	3,512	15,800	70%	11,060	3,595	1.0%	36	2.0%	72	2.3%	83	1.0%	35	11.6%	10	71.1%	25	23.9%	8.3	0.6
54	19,270	18.7%	3,612	15,658	70%	10,960	3,562	1.0%	36	2.0%	71	2.3%	82	1.0%	35	11.6%	10	71.1%	25	23.9%	8.2	0.5
55	19,224	19.3%	3,711	15,513	70%	10,859	3,529	1.0%	35	2.0%	71	2.3%	82	1.0%	34	11.6%	9	71.1%	25	23.9%	8.1	0.5
56	19,174	20.5%	3,933	15,241	70%	10,669	3,467	1.0%	35	2.0%	69	2.3%	80	1.0%	34	11.6%	9	71.1%	24	23.9%	8.0	0.5
57	19,121	21.7%	4,154	14,967	70%	10,477	3,405	1.0%	34	2.0%	68	2.3%	79	1.0%	33	11.6%	9	71.1%	24	23.9%	7.8	0.5
58	19,063	22.9%	4,372	14,691	70%	10,284	3,342	1.0%	33	2.0%	67	2.3%	77	1.0%	33	11.6%	9	71.1%	23	23.9%	7.7	0.5
59	19,000	24.1%	4,587	14,413	70%	10,089	3,279	1.0%	33	2.0%	66	2.3%	76	1.0%	32	11.6%	9	71.1%	23	23.9%	7.5	0.5
60	18,932	25.4%	4,800	14,132	72%	10,175	3,170	1.0%	32	1.2%	38	1.4%	43	0.6%	20	8.6%	4	67.7%	14	36.3%	6.3	0.4
61	18,858	26.6%	5,009	13,848	72%	9,971	3,106	1.0%	31	1.2%	38	1.4%	42	0.6%	20	8.6%	4	67.7%	13	36.3%	6.2	0.4
62	18,777	27.8%	5,215	13,562	72%	9,765	3,042	1.0%	30	1.2%	37	1.4%	42	0.6%	19	8.6%	4	67.7%	13	36.3%	6.1	0.4
63	18,689	29.0%	5,417	13,272	72%	9,556	2,977	1.0%	30	1.2%	36	1.4%	41	0.6%	19	8.6%	4	67.7%	13	36.3%	6.0	0.4
64	18,593	30.2%	5,614	12,979	72%	9,345	2,911	1.0%	29	1.2%	35	1.4%	40	0.6%	19	8.6%	3	67.7%	13	36.3%	5.8	0.4
65	18,489	31.4%	5,806	12,683	72%	9,131	2,845	1.0%	28	1.2%	34	1.4%	39	0.6%	18	8.6%	3	67.7%	12	36.3%	5.7	0.4
66	18,375	32.6%	5,993	12,382	72%	8,915	2,777	1.0%	28	1.2%	34	1.4%	38	0.6%	18	8.6%	3	67.7%	12	36.3%	5.6	0.4
67	18,250	33.8%	6,173	12,077	72%	8,695	2,709	1.0%	27	1.2%	33	1.4%	37	0.6%	17	8.6%	3	67.7%	12	36.3%	5.4	0.4
68	18,113	35.0%	6,346	11,767	72%	8,472	2,639	1.0%	26	1.2%	32	1.4%	36	0.6%	17	8.6%	3	67.7%	11	36.3%	5.3	0.4
69	17,963	36.2%	6,511	11,452	72%	8,246	2,569	1.0%	26	1.2%	31	1.4%	35	0.6%	16	8.6%	3	67.7%	11	36.3%	5.1	0.3
Total							**164,780**	**1.30%**	**2,138**	**2.62%**	**4,312**	**3.06%**	**5,044**	**1.31%**	**2,155**	**12.7%**	**641**	**89.5%**	**1,928**	**48.2%**	**1,238**	**83**

Potential Harms – Reduction in Quality of Life Associated with a Diagnosis

- Cytology screening with a low grade abnormality diagnosis is associated with a utility loss of 0.0231 for a period of 12 months.[523]
- Diagnosis and treatment for CIN2+ is associated with a utility loss of 0.066 for a period of 20 months.[524]

Table 10: Screening for Cervical Cancer
Current Screening Model - Harms
in a British Columbia Birth Cohort of 20,000 Females

Age	Females in Birth Cohort	# with Diagnosed ASCUS / LSIL	QALYs Lost	# with Diagnosed CIN2+	QALYs Lost	***Total QALYs Lost***
25	19,843	242	5.1	72	7.2	**12.3**
26	19,834	242	5.1	71	7.2	**12.3**
27	19,825	242	5.1	71	7.2	**12.3**
28	19,816	241	5.1	71	7.2	**12.3**
29	19,806	241	5.1	71	7.2	**12.3**
30	19,796	173	3.6	53	5.2	**8.7**
31	19,785	172	3.5	52	5.1	**8.7**
32	19,773	171	3.5	52	5.1	**8.6**
33	19,761	170	3.5	52	5.1	**8.6**
34	19,749	169	3.5	51	5.0	**8.5**
35	19,736	168	3.5	51	5.0	**8.5**
36	19,722	167	3.4	51	5.0	**8.4**
37	19,708	166	3.4	50	4.9	**8.4**
38	19,693	165	3.4	50	4.9	**8.3**
39	19,677	164	3.4	50	4.9	**8.3**
40	19,661	156	3.1	25	2.3	**5.4**
41	19,643	154	3.0	24	2.3	**5.3**
42	19,625	152	3.0	24	2.2	**5.2**
43	19,605	149	2.9	23	2.2	**5.2**
44	19,584	147	2.9	23	2.2	**5.1**
45	19,561	144	2.8	23	2.1	**5.0**
46	19,537	143	2.8	23	2.1	**4.9**
47	19,511	142	2.8	22	2.1	**4.9**
48	19,484	141	2.8	22	2.1	**4.9**
49	19,454	140	2.8	22	2.1	**4.8**
50	19,422	113	2.1	8	0.8	**2.9**
51	19,388	112	2.1	8	0.8	**2.9**
52	19,352	111	2.1	8	0.8	**2.9**
53	19,312	110	2.1	8	0.7	**2.8**
54	19,270	109	2.1	8	0.7	**2.8**
55	19,224	108	2.0	8	0.7	**2.8**
56	19,174	106	2.0	8	0.7	**2.7**
57	19,121	104	2.0	8	0.7	**2.7**
58	19,063	102	1.9	8	0.7	**2.6**
59	19,000	100	1.9	8	0.7	**2.6**
60	18,932	57	1.1	6	0.6	**1.6**
61	18,858	56	1.0	6	0.5	**1.6**
62	18,777	55	1.0	6	0.5	**1.5**
63	18,689	54	1.0	6	0.5	**1.5**
64	18,593	53	1.0	6	0.5	**1.5**
65	18,489	51	0.9	6	0.5	**1.4**
66	18,375	50	0.9	6	0.5	**1.4**
67	18,250	49	0.9	5	0.5	**1.4**
68	18,113	48	0.9	5	0.5	**1.3**
69	17,963	46	0.9	5	0.5	**1.3**
Total		**5,960**	**119**	**1,238**	**120**	**239**

[523] Simonella L, Howard K, Canfell K. A survey of population-based utility scores for cervical cancer prevention. *BMC Research Notes*. 2014; 7: 899

[524] Insinga R, Glass A, Myers E et al. Abnormal outcomes following cervical cancer screening: event duration and health utility loss. *Medical Decision Making*. 2007; 27(4): 414-22.

Potential Harms – Premature Births

Females with CIN have a higher baseline risk of a premature birth in a subsequent pregnancy. Excisional and ablative treatment for CIN further increases that risk. Research by Kyrgiou and colleagues is summarized in Table 11.[525,526] Treatment for CIN increases the risk of prematurity substantially, from 5.43% to 10.73%. The risk of prematurity increases with multiple treatments and cone depth and varies by the treatment modality (see Table 11).

Table 11 - Risk of Preterm Birth Associated with Treatment for CIN

	Untreated	Treated	RR (95% CI)
< 37 Weeks gestation	5.43%	10.73%	1.78 (1.60-1.98)
<32-34 Weeks gestation	1.43%	3.47%	2.40 (1.92-2.99)
<28-30 Weeks gestation	0.33%	1.03%	2.54 (1.77-3.63)
< 37 Weeks gestation by single vs. repeat teatment			
Single treatment	4.17%	7.48%	1.75 (1.49-2.06)
Repeat treatment	4.11%	13.25%	3.78 (2.65-5.39)
< 37 Weeks gestation by cone depth			
Cone depth ≤10-12mm	3.42%	7.14%	1.54 (1.09-2.18)
Cone depth ≥10-12mm	3.42%	9.77%	1.93 (1.62-2.31)
Cone depth ≥15-17mm	3.40%	10.05%	2.77 (1.95-3.93)
Cone depth ≥20mm	3.40%	10.22%	4.91 (2.06-11.68)
< 37 Weeks gestation by treatment modality			
Laser ablation	6.68%	7.25%	1.27 (0.67-2.40)
Loop electrosurgical excision procedure (LEEP)	4.66%	7.59%	1.69 (1.46-1.97)
Laser conisation	7.12%	14.17%	2.39 (1.24-4.61)
Cold knife conisation	6.12%	15.90%	3.28 (2.44-4.42)

[525] Kyrgiou M, Athanasiou A, Paraskevaidi M et al. Adverse obstetric outcomes after local treatment for cervical preinvasive and early invasive disease according to cone depth: Systematic review and meta-analysis. *BMJ*. 2016; 354: i3633.

[526] Kyrgiou M, Athanasiou A, Kalliala I et al. Obstetric outcomes after conservative treatment for cervical intraepithelial lesions and early invasive disease. *Cochrane Database of Systematic Reviews*. 2017.

More aggressive local CIN treatments are associated with a reduced risk of treatment failure but an increased risk of pre-term birth in subsequent pregnancies, as indicated in Table 12.[527]

Table 12 - Absolute Risks of CIN Treatment Failures and Preterm Birth

	Any Treatment Failure	High-Grade Treatment Failure	Preterm Birth
Cold coagulation	11.0%	4.8%	5.5%
Cryotherapy	17.3%	9.6%	8.0%
Laser ablation	16.2%	11.2%	8.3%
Loop electrosurgical excision procedure (LEEP)	10.2%	5.3%	10.5%
Laser conisation	6.3%	4.6%	13.2%
Radical diathermy	16.7%	11.2%	13.9%
Cold knife conisation	6.6%	3.5%	16.3%

As noted previously, standard treatment for CIN2+ in BC tends to be with LEEP.[528] The data specifically for LEEP (used in our modelling) is as follows: [529]

	Untreated	**Treated**	**RR (95% CI)**
< 37 Weeks gestation	4.68%	8.09%	1.56 (1.36 – 1.79)
<32-34 Weeks gestation	1.22%	2.05%	2.13 (1.66 – 2.75)
<28-30 Weeks gestation	0.25%	0.66%	2.57 (1.97 – 3.35)

[527] Athanasiou A, Veroniki A, Efthimiou O et al. Comparative effectiveness and risk of preterm birth of local treatments for cervical intraepithelial neoplasia and stage IA1 cervical cancer: A systematic review and network meta-analysis. *The Lancet*. 2022; 23: 1097-108.

[528] Ogilvie G, van Niekerk D, Krajden M et al. A randomized controlled trial of human papillomavirus (HPV) testing for cervical cancer screening: Trial design and preliminary results (HPV FOCAL trial). *BMC Cancer*. 2010; 10: 111.

[529] Kyrgiou M, Athanasiou A, Paraskevaidi M et al. Adverse obstetric outcomes after local treatment for cervical preinvasive and early invasive disease according to cone depth: Systematic review and meta-analysis. *BMJ*. 2016; 354: i3633.

To estimate the effect of local CIN2+ treatments on preterm births in a BC birth cohort of 40,000, we first calculated the fertility rate per 1,000 females based on data from BC Vital Statistics for the three years from 2013 to 2015 (see Table 13).[530]

Table 13: Number of Births and Fertility Rates of Women Aged 15-49
British Columbia, 2013 to 2015

Year	15-19	20-24	25-29	30-34	35-39	40-44	45-49	Total
				Number of Women*				
2013	131,378	152,798	159,870	158,541	150,258	165,004	173,233	1,091,082
2014	130,517	153,991	162,005	163,346	152,477	163,392	172,241	1,097,969
2015	130,179	152,108	163,734	166,612	155,270	161,338	173,302	1,102,543
Mean	**130,691**	**152,966**	**161,870**	**162,833**	**152,668**	**163,245**	**172,925**	**1,097,198**
				Fertility Rate per 1,000				
2013	7.6	30.8	73.5	98.6	56.7	11.9	0.8	10.3
2014	6.8	29.6	72.2	100.0	57.2	11.7	0.8	11.1
2015	6.2	28.8	69.3	100.0	57.3	12.3	0.8	10.9
Mean	**6.8**	**29.7**	**71.6**	**99.5**	**57.1**	**12.0**	**0.8**	**40.1**
				Annual # of Live Births				
2013**	993	4,711	11,747	15,628	8,515	1,966	130	43,690
2014***	889	4,553	11,702	16,336	8,725	1,915	141	44,261
2015****	802	4,385	11,339	16,654	8,894	1,984	137	44,195
Mean	**895**	**4,550**	**11,596**	**16,206**	**8,711**	**1,955**	**136**	**44,049**

*BC Stats. Population Estimates 2019. Available at https://bcstats.shinyapps.io/popApp/. Accessed February 2023.
** BC Vital Statistics Agency. *Annual Report 2013* - Table 3. Available online athttps://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2013/pdf/annual-report-2013.pdf. Accessed February 2023.
*** BC Vital Statistics Agency. *Annual Report 2014* - Table 3. Available online at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2014/pdf/annual-report-2014.pdf. Accessed February
**** BC Vital Statistics Agency. *Annual Report 2015* - Table 3. Available online at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2015/pdf/annual-report-2015.pdf. Accessed February

The age-specific fertility rate was then applied to the BC birth cohort, indicating that approximately 23,815 live births could be expected in the cohort between the ages of 25 and 49 (see Table 14). In the birth cohort, 1,100 females between the ages of 25 and 49 would receive treatment for CIN2+, as calculated in Table 9. Based on the differences in the rate of preterm births with or without LEEP treatment for CIN2+, we would expect an additional 37.5 babies to be preterm attributable to treatment (see Table 14). Of these 37.5 babies, 4.5 would be expected to be extremely preterm (gestational age < 28 completed weeks), 4.6 (9.1 – 4.5) would be expected to be very preterm (gestational age < 32 completed weeks) and 28.4 (37.5 – 4.6 – 4.5) would be expected to be late preterm (gestational age < 37 completed weeks) (see Table 14).

[530] BC Vital Statistics Annual Reports. Available online at https://www2.gov.bc.ca/gov/content/life-events/statistics-reports/vital-statistics-annual-reports. Accessed February 2023. These three years were chosen as the 2015 annual report is the most recent one available online.

Table 14: Treatment for CIN and the Risk of Preterm Birth

Age	Females in Birth Cohort	Fertility Rate per 1,000	# of Live Births	Tmt for CIN2+ (Table 9)	# of Preterm Births (PTB)								
					< 37 weeks			*<32-34 weeks*			*<28-30 weeks*		
					No Tmt	TMT	Due to Tmt	No Tmt	TMT	Due to Tmt	No Tmt	TMT	Due to Tmt
25	19,843	71.6	1,422	71.6	3.3	5.8	2.4	0.9	1.5	0.6	0.2	0.5	0.3
26	19,834	71.6	1,421	71.5	3.3	5.8	2.4	0.9	1.5	0.6	0.2	0.5	0.3
27	19,825	71.6	1,420	71.4	3.3	5.8	2.4	0.9	1.5	0.6	0.2	0.5	0.3
28	19,816	71.6	1,420	71.3	3.3	5.8	2.4	0.9	1.5	0.6	0.2	0.5	0.3
29	19,806	71.6	1,419	71.2	3.3	5.8	2.4	0.9	1.5	0.6	0.2	0.5	0.3
30	19,796	99.5	1,970	52.6	2.5	4.3	1.8	0.6	1.1	0.4	0.1	0.3	0.2
31	19,785	99.5	1,969	52.3	2.4	4.2	1.8	0.6	1.1	0.4	0.1	0.3	0.2
32	19,773	99.5	1,968	52.0	2.4	4.2	1.8	0.6	1.1	0.4	0.1	0.3	0.2
33	19,761	99.5	1,967	51.7	2.4	4.2	1.8	0.6	1.1	0.4	0.1	0.3	0.2
34	19,749	99.5	1,966	51.4	2.4	4.2	1.8	0.6	1.1	0.4	0.1	0.3	0.2
35	19,736	57.1	1,126	51.1	2.4	4.1	1.7	0.6	1.0	0.4	0.1	0.3	0.2
36	19,722	57.1	1,125	50.7	2.4	4.1	1.7	0.6	1.0	0.4	0.1	0.3	0.2
37	19,708	57.1	1,125	50.4	2.4	4.1	1.7	0.6	1.0	0.4	0.1	0.3	0.2
38	19,693	57.1	1,124	50.1	2.3	4.1	1.7	0.6	1.0	0.4	0.1	0.3	0.2
39	19,677	57.1	1,123	49.8	2.3	4.0	1.7	0.6	1.0	0.4	0.1	0.3	0.2
40	19,661	12.0	235	24.6	1.2	2.0	0.8	0.3	0.5	0.2	0.1	0.2	0.1
41	19,643	12.0	235	24.2	1.1	2.0	0.8	0.3	0.5	0.2	0.1	0.2	0.1
42	19,625	12.0	235	23.8	1.1	1.9	0.8	0.3	0.5	0.2	0.1	0.2	0.1
43	19,605	12.0	235	23.5	1.1	1.9	0.8	0.3	0.5	0.2	0.1	0.2	0.1
44	19,584	12.0	235	23.1	1.1	1.9	0.8	0.3	0.5	0.2	0.1	0.2	0.1
45	19,561	0.8	15	22.7	1.1	1.8	0.8	0.3	0.5	0.2	0.1	0.1	0.1
46	19,537	0.8	15	22.5	1.1	1.8	0.8	0.3	0.5	0.2	0.1	0.1	0.1
47	19,511	0.8	15	22.4	1.0	1.8	0.8	0.3	0.5	0.2	0.1	0.1	0.1
48	19,484	0.8	15	22.2	1.0	1.8	0.8	0.3	0.5	0.2	0.1	0.1	0.1
49	19,454	0.8	15	22.0	1.0	1.8	0.8	0.3	0.5	0.2	0.1	0.1	0.1
Total			**23,815**	**1,100**	**51.5**	**89.0**	**37.5**	**13.4**	**22.6**	**9.1**	**2.8**	**7.3**	**4.5**

Preterm birth is associated with substantial morbidity and mortality. In their review of the literature, Crump notes that "evidence has consistently shown that adult survivors of preterm birth have increased risks of chronic disorders involving various organ systems, including cardiovascular, endocrine/metabolic, respiratory, renal, neurodevelopmental, and psychiatric disorders, which either persist from childhood into adulthood or sometimes first manifest in adulthood."[531] Furthermore, these risks increase with increasing levels of prematurity.

Increase in Premature Mortality

Is a preterm birth associated with premature mortality? Crump notes that the disorders associated with preterm birth lead to "moderately (30% to 50%) increased mortality risks during early to mid-adulthood among persons born preterm compared with full-term, and even higher risks among those born at the earliest gestational ages."[532]

The 2021 systematic review by Crump found 8 studies that examined gestational age at birth in relation to mortality in adulthood.[533] The largest of these studies included 4,296,814

[531] Crump C. An overview of adult health outcomes after preterm birth. *Early Human Development*. 2020; 150: 105187.
[532] Ibid.
[533] Crump C. Preterm birth and mortality in adulthood: A systematic review. *Journal of Perinatology*. 2020; 40(6): 833-43.

singleton births in Sweden during 1973 to 2015, with a maximum age of 45 attained at December 31, 2017.[534] This large population-based Swedish study clearly indicated that the risk of premature all-cause mortality increases with increasing levels of prematurity (see Table 15).

Table 15: Adjusted Death Rate and Hazard Ratio
For All-Cause Mortality by Gestational Age
Sweden, 1973 - 2017

		Males		Females	
Atained Age	**Gestational Age at Birth**	Rate*	HR	Rate*	HR
0 <1 year					
	Full term	176	Ref	150	Ref
	Early term (37-38 weeks)	337	1.30	281	1.39
	Late preterm (34-36 weeks)	1,155	2.35	1,074	3.13
	Very preterm (28-33 weeks)	5,639	7.67	4,729	10.70
	Extremely preterm (Less than 28 weeks)	37,585	60.68	30,831	76.36
1-9 years					
	Full term	17	Ref	13	Ref
	Early term	19	1.14	16	1.27
	Late preterm	31	1.78	27	2.06
	Very preterm	51	2.99	48	3.67
	Extremely preterm	67	4.52	54	4.52
10-19 years					
	Full term	23	Ref	13	Ref
	Early term	26	1.12	16	1.27
	Late preterm	32	1.35	27	2.06
	Very preterm	41	1.74	48	3.67
	Extremely preterm	36	1.68	54	4.52
20-29 years					
	Full term	68	Ref	26	Ref
	Early term	79	1.15	30	1.16
	Late preterm	91	1.30	39	1.50
	Very preterm	99	1.40	39	1.50
	Extremely preterm	101	1.45	103	4.00
30-45 years					
	Full term	76	Ref	40	Ref
	Early term	90	1.15	47	1.18
	Late preterm	94	1.17	55	1.35
	Very preterm	95	1.15	94	2.31
	Extremely preterm	127	1.53	130	3.11

* Death rate / 100,000 person years. HR = hazard ratio

[534] Crump C, Sundquist J, Winkleby M et al. Gestational age at birth and mortality from infancy into mid-adulthood: A national cohort study. *Lancet Child and Adolescent Health*. 2019; 3(6): 408-17.

To estimate the effect of premature birth on mortality in the children born to a BC birth cohort of 20,000 females we first assumed that half of the 38 premature births would be male and half female. We then calculated the number of expected deaths by age if the births had been full term. The next step involved calculating the expected number of deaths by level of prematurity, sex and age based on the hazard ratios in Table 15. We assumed that the hazard ratio indicated for ages 30-45 years would remain constant through to age 85. Excess deaths due to prematurity were calculated by subtracting the number of expected deaths if full term from the number of expected of deaths if born premature. The life expectancy by sex and age was applied to these excess deaths to calculate life years lost.

The estimated excess deaths due to prematurity are associated with 111.7 life years lost, 41.8 in males (see Table 16) and 69.8 in females (see Table 17).

Table 16: Excess Preterm Births, Deaths and Life Years Lost in Males
Due to Local Treatment for CIN in Their Mothers

Age	Males in Birth Cohort	Deaths	% Dying	LE	Number Alive 35-37	32-34	<28-30	Expected # of Deaths if ***Full Term*** 35-37	32-34	<28-30	Expected # of Deaths if ***Premature*** 35-37	32-34	<28-30	Excess # of Deaths Due to ***Premature Birth*** 35-37	32-34	<28-30	Life Years Lost Due to ***Premature Birth*** 35-37	32-34	<28-30	Total
0	20,000			79.9	**14.19**	**2.31**	**2.26**													
1	19,921	79	0.39%	79.3	14.06	2.29	2.19	0.06	0.01	0.01	0.13	0.02	0.07	0.08	0.01	0.06	5.99	0.98	4.70	**11.67**
2	19,918	4	0.02%	78.3	14.05	2.29	2.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.03	0.06	**0.24**
3	19,915	3	0.01%	77.3	14.05	2.29	2.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.02	0.05	**0.19**
4	19,913	2	0.01%	76.3	14.05	2.29	2.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.02	0.04	**0.14**
5	19,911	2	0.01%	75.3	14.05	2.29	2.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.01	0.03	**0.13**
6	19,909	1	0.01%	74.3	14.04	2.29	2.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.01	0.02	**0.09**
7	19,908	1	0.01%	73.3	14.04	2.29	2.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.01	0.02	**0.09**
8	19,907	1	0.01%	72.3	14.04	2.29	2.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.01	0.02	**0.09**
9	19,906	1	0.01%	71.3	14.04	2.29	2.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.01	0.02	**0.06**
10	19,904	1	0.01%	70.3	14.04	2.29	2.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.01	**0.03**
11	19,903	1	0.01%	69.3	14.04	2.29	2.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.01	**0.03**
12	19,902	1	0.01%	68.3	14.04	2.28	2.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.01	**0.03**
13	19,900	2	0.01%	67.3	14.03	2.28	2.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.01	**0.04**
14	19,898	2	0.01%	66.3	14.03	2.28	2.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.01	**0.05**
15	19,896	3	0.01%	65.3	14.03	2.28	2.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.01	0.01	**0.07**
16	19,891	4	0.02%	64.4	14.03	2.28	2.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.01	0.02	**0.10**
17	19,885	6	0.03%	63.4	14.02	2.28	2.18	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.10	0.02	0.03	**0.15**
18	19,876	9	0.05%	62.4	14.01	2.28	2.18	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.14	0.02	0.05	**0.21**
19	19,864	11	0.06%	61.4	14.00	2.28	2.17	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.17	0.03	0.06	**0.26**
20	19,851	14	0.07%	60.5	13.99	2.28	2.17	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.17	0.03	0.04	**0.24**
21	19,835	16	0.08%	59.5	13.97	2.27	2.17	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.20	0.03	0.04	**0.28**
22	19,817	18	0.09%	58.6	13.96	2.27	2.17	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.22	0.04	0.05	**0.31**
23	19,796	20	0.10%	57.7	13.94	2.27	2.16	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.25	0.04	0.05	**0.34**
24	19,775	22	0.11%	56.7	13.92	2.27	2.16	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.26	0.04	0.05	**0.36**
25	19,751	23	0.12%	55.8	13.90	2.26	2.16	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.28	0.04	0.06	**0.38**
26	19,727	24	0.12%	54.8	13.87	2.26	2.15	0.02	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.28	0.05	0.06	**0.38**
27	19,702	25	0.13%	53.9	13.85	2.25	2.15	0.02	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.29	0.05	0.06	**0.39**
28	19,676	26	0.13%	53.0	13.83	2.25	2.14	0.02	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.29	0.05	0.06	**0.40**
29	19,649	27	0.14%	52.1	13.80	2.25	2.14	0.02	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.29	0.05	0.06	**0.40**
30	19,621	28	0.14%	51.1	13.78	2.24	2.14	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.17	0.03	0.02	**0.22**
31	19,593	28	0.14%	50.2	13.76	2.24	2.13	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.17	0.03	0.02	**0.22**
32	19,564	29	0.15%	49.3	13.73	2.24	2.13	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.17	0.03	0.02	**0.22**
33	19,535	29	0.15%	48.4	13.71	2.23	2.13	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.17	0.03	0.02	**0.22**
34	19,505	30	0.15%	47.4	13.68	2.23	2.12	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.17	0.03	0.02	**0.22**
35	19,474	31	0.16%	46.5	13.66	2.22	2.12	0.02	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.17	0.03	0.02	**0.23**
36	19,442	32	0.16%	45.6	13.63	2.22	2.11	0.02	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.17	0.03	0.02	**0.23**
37	19,409	33	0.17%	44.7	13.60	2.21	2.11	0.02	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.18	0.03	0.02	**0.23**
38	19,375	34	0.18%	43.7	13.58	2.21	2.11	0.02	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.18	0.03	0.02	**0.23**
39	19,339	35	0.18%	42.8	13.55	2.21	2.10	0.02	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.18	0.03	0.02	**0.24**
40	19,303	37	0.19%	41.9	13.52	2.20	2.10	0.03	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.18	0.03	0.03	**0.24**
41	19,264	38	0.20%	41.0	13.49	2.20	2.09	0.03	0.00	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.19	0.03	0.03	**0.24**
42	19,225	40	0.21%	40.1	13.45	2.19	2.09	0.03	0.00	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.19	0.03	0.03	**0.25**
43	19,183	41	0.22%	39.1	13.42	2.18	2.08	0.03	0.00	0.00	0.03	0.01	0.01	0.00	0.00	0.00	0.19	0.03	0.03	**0.25**
44	19,140	43	0.23%	38.2	13.38	2.18	2.08	0.03	0.00	0.00	0.04	0.01	0.01	0.01	0.00	0.00	0.20	0.03	0.03	**0.26**
45	19,094	46	0.24%	37.3	13.35	2.17	2.07	0.03	0.01	0.00	0.04	0.01	0.01	0.01	0.00	0.00	0.20	0.03	0.03	**0.26**
46	19,047	48	0.25%	36.4	13.31	2.17	2.07	0.03	0.01	0.01	0.04	0.01	0.01	0.01	0.00	0.00	0.21	0.03	0.03	**0.27**
47	18,996	50	0.26%	35.5	13.27	2.16	2.06	0.04	0.01	0.01	0.04	0.01	0.01	0.01	0.00	0.00	0.21	0.03	0.03	**0.28**
48	18,943	53	0.28%	34.6	13.22	2.15	2.05	0.04	0.01	0.01	0.04	0.01	0.01	0.01	0.00	0.00	0.22	0.04	0.03	**0.29**
49	18,887	56	0.30%	33.7	13.18	2.14	2.05	0.04	0.01	0.01	0.05	0.01	0.01	0.01	0.00	0.00	0.23	0.04	0.03	**0.29**
50	18,827	60	0.32%	32.8	13.13	2.14	2.04	0.04	0.01	0.01	0.05	0.01	0.01	0.01	0.00	0.00	0.23	0.04	0.03	**0.30**
51	18,763	64	0.34%	31.9	13.08	2.13	2.03	0.04	0.01	0.01	0.05	0.01	0.01	0.01	0.00	0.00	0.24	0.04	0.03	**0.31**
52	18,695	68	0.36%	31.0	13.02	2.12	2.02	0.05	0.01	0.01	0.06	0.01	0.01	0.01	0.00	0.00	0.25	0.04	0.03	**0.33**
53	18,622	73	0.39%	30.2	12.96	2.11	2.01	0.05	0.01	0.01	0.06	0.01	0.01	0.01	0.00	0.00	0.26	0.04	0.04	**0.34**
54	18,545	78	0.42%	29.3	12.90	2.10	2.00	0.05	0.01	0.01	0.06	0.01	0.01	0.01	0.00	0.00	0.27	0.04	0.04	**0.35**
55	18,461	83	0.45%	28.4	12.83	2.09	1.99	0.06	0.01	0.01	0.07	0.01	0.01	0.01	0.00	0.00	0.28	0.05	0.04	**0.36**
56	18,372	89	0.48%	27.5	12.76	2.08	1.98	0.06	0.01	0.01	0.07	0.01	0.01	0.01	0.00	0.00	0.29	0.05	0.04	**0.38**
57	18,277	95	0.52%	26.7	12.68	2.06	1.97	0.07	0.01	0.01	0.08	0.01	0.01	0.01	0.00	0.00	0.30	0.05	0.04	**0.39**
58	18,175	102	0.56%	25.8	12.59	2.05	1.96	0.07	0.01	0.01	0.08	0.01	0.01	0.01	0.00	0.00	0.31	0.05	0.04	**0.41**
59	18,065	110	0.61%	25.0	12.50	2.04	1.94	0.08	0.01	0.01	0.09	0.01	0.01	0.01	0.00	0.00	0.33	0.05	0.04	**0.42**
60	17,947	118	0.66%	24.1	12.41	2.02	1.93	0.08	0.01	0.01	0.10	0.02	0.01	0.01	0.00	0.00	0.34	0.05	0.05	**0.44**
61	17,820	127	0.71%	23.3	12.31	2.00	1.91	0.09	0.01	0.01	0.10	0.02	0.02	0.02	0.00	0.00	0.35	0.06	0.05	**0.45**
62	17,684	136	0.77%	22.5	12.19	1.99	1.90	0.09	0.02	0.01	0.11	0.02	0.02	0.02	0.00	0.00	0.36	0.06	0.05	**0.47**
63	17,537	147	0.84%	21.7	12.07	1.97	1.88	0.10	0.02	0.02	0.12	0.02	0.02	0.02	0.00	0.00	0.38	0.06	0.05	**0.49**
64	17,379	158	0.91%	20.9	11.95	1.94	1.86	0.11	0.02	0.02	0.13	0.02	0.02	0.02	0.00	0.00	0.39	0.06	0.05	**0.51**
65	17,208	171	0.99%	20.1	11.81	1.92	1.84	0.12	0.02	0.02	0.14	0.02	0.02	0.02	0.00	0.00	0.40	0.07	0.06	**0.53**
66	17,024	184	1.08%	19.3	11.66	1.90	1.81	0.13	0.02	0.02	0.15	0.02	0.02	0.02	0.00	0.00	0.42	0.07	0.06	**0.54**
67	16,826	198	1.18%	18.5	11.50	1.87	1.79	0.14	0.02	0.02	0.16	0.03	0.02	0.02	0.00	0.00	0.43	0.07	0.06	**0.56**
68	16,612	214	1.29%	17.7	11.32	1.84	1.76	0.15	0.02	0.02	0.17	0.03	0.03	0.03	0.00	0.00	0.45	0.07	0.06	**0.58**
69	16,381	231	1.41%	17.0	11.14	1.81	1.73	0.16	0.03	0.02	0.19	0.03	0.03	0.03	0.00	0.00	0.46	0.07	0.06	**0.60**
70	16,132	249	1.54%	16.2	10.94	1.78	1.70	0.17	0.03	0.03	0.20	0.03	0.03	0.03	0.00	0.00	0.47	0.08	0.07	**0.62**
71	15,863	269	1.69%	15.5	10.72	1.75	1.67	0.19	0.03	0.03	0.22	0.04	0.03	0.03	0.01	0.00	0.49	0.08	0.07	**0.63**
72	15,573	290	1.86%	14.8	10.49	1.71	1.63	0.20	0.03	0.03	0.23	0.04	0.04	0.03	0.01	0.00	0.50	0.08	0.07	**0.65**
73	15,260	313	2.05%	14.1	10.23	1.67	1.60	0.21	0.03	0.03	0.25	0.04	0.04	0.04	0.01	0.01	0.51	0.08	0.07	**0.67**
74	14,923	337	2.26%	13.4	9.96	1.62	1.55	0.23	0.04	0.04	0.27	0.04	0.04	0.04	0.01	0.01	0.53	0.09	0.07	**0.68**
75	14,560	363	2.49%	12.7	9.67	1.57	1.51	0.25	0.04	0.04	0.29	0.05	0.04	0.04	0.01	0.01	0.54	0.09	0.07	**0.70**
76	14,170	390	2.75%	12.0	9.36	1.52	1.46	0.27	0.04	0.04	0.31	0.05	0.05	0.05	0.01	0.01	0.54	0.09	0.08	**0.71**
77	13,751	419	3.05%	11.4	9.03	1.47	1.41	0.29	0.05	0.04	0.33	0.05	0.05	0.05	0.01	0.01	0.55	0.09	0.08	**0.72**
78	13,301	450	3.38%	10.8	8.67	1.41	1.36	0.31	0.05	0.05	0.36	0.06	0.05	0.05	0.01	0.01	0.56	0.09	0.08	**0.73**
79	12,820	481	3.75%	10.1	8.29	1.35	1.30	0.33	0.05	0.05	0.38	0.06	0.06	0.06	0.01	0.01	0.56	0.09	0.08	**0.73**
80	12,306	514	4.18%	9.5	7.89	1.28	1.23	0.35	0.06	0.05	0.40	0.07	0.06	0.06	0.01	0.01	0.56	0.09	0.08	**0.73**
81	11,759	547	4.65%	9.0	7.46	1.21	1.17	0.37	0.06	0.06	0.43	0.07	0.07	0.06	0.01	0.01	0.56	0.09	0.08	**0.73**
82	11,179	580	5.19%	8.4	7.00	1.14	1.10	0.39	0.06	0.06	0.45	0.07	0.07	0.07	0.01	0.01	0.55	0.09	0.08	**0.72**
83	10,565	614	5.81%	7.9	6.53	1.06	1.03	0.41	0.07	0.06	0.48	0.08	0.07	0.07	0.01	0.01	0.54	0.09	0.08	**0.71**
84	9,919	646	6.51%	7.3	6.03	0.98	0.95	0.42	0.07	0.07	0.50	0.08	0.08	0.07	0.01	0.01	0.53	0.09	0.07	**0.69**
85	9,244	676	7.31%	6.8	5.51	0.90	0.87	0.44	0.07	0.07	0.52	0.08	0.08	0.07	0.01	0.01	0.51	0.08	0.07	**0.67**
Total								**7.33**	**1.19**	**1.14**	**8.68**	**1.41**	**1.39**	**1.34**	**0.22**	**0.24**	**28.8**	**4.7**	**8.3**	**41.8**

Table 17: Excess Preterm Births, Deaths and Life Years Lost in Females
Due to Local Treatment for CIN in Their Mothers

Age	Females in Birth Cohort	Deaths	% Dying	LE	Number Alive 35-37	32-34	<28-30	Expected # of Deaths if ***Full Term*** 35-37	32-34	<28-30	Expected # of Deaths if ***Premature*** 35-37	32-34	<28-30	Excess # of Deaths Due to ***Premature Birth*** 35-37	32-34	<28-30	Life Years Lost Due to ***Premature Birth*** 35-37	32-34	<28-30	Total
0	20,000			84.9	**14.19**	**2.31**	**2.26**													
1	19,933	67	0.34%	84.2	14.04	2.29	2.17	0.05	0.01	0.01	0.15	0.02	0.08	0.10	0.02	0.07	8.58	1.40	6.21	**16.19**
2	19,929	4	0.02%	83.2	14.03	2.28	2.17	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.24	0.04	0.09	**0.37**
3	19,926	3	0.01%	82.2	14.03	2.28	2.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.03	0.07	**0.27**
4	19,924	2	0.01%	81.3	14.03	2.28	2.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.02	0.06	**0.23**
5	19,922	2	0.01%	80.3	14.02	2.28	2.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.02	0.04	**0.17**
6	19,920	2	0.01%	79.3	14.02	2.28	2.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.02	0.04	**0.15**
7	19,919	1	0.01%	78.3	14.02	2.28	2.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.01	0.03	**0.13**
8	19,918	1	0.01%	77.3	14.02	2.28	2.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.01	0.03	**0.11**
9	19,917	1	0.01%	76.3	14.02	2.28	2.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.01	0.03	**0.11**
10	19,915	1	0.01%	75.3	14.02	2.28	2.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.01	0.03	**0.10**
11	19,914	1	0.01%	74.3	14.01	2.28	2.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.01	0.03	**0.10**
12	19,913	1	0.01%	73.3	14.01	2.28	2.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.01	0.03	**0.10**
13	19,911	2	0.01%	72.3	14.01	2.28	2.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.01	0.03	**0.13**
14	19,910	2	0.01%	71.3	14.01	2.28	2.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.02	0.04	**0.15**
15	19,907	2	0.01%	70.3	14.00	2.28	2.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.02	0.04	**0.18**
16	19,904	3	0.02%	69.3	14.00	2.28	2.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.03	0.07	**0.27**
17	19,900	4	0.02%	68.3	13.99	2.28	2.16	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.22	0.04	0.09	**0.35**
18	19,894	6	0.03%	67.4	13.98	2.28	2.16	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.28	0.05	0.11	**0.44**
19	19,888	6	0.03%	66.4	13.98	2.28	2.16	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.31	0.05	0.12	**0.48**
20	19,881	7	0.03%	65.4	13.97	2.27	2.15	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.15	0.02	0.02	**0.20**
21	19,874	7	0.03%	64.4	13.96	2.27	2.15	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.15	0.03	0.02	**0.20**
22	19,867	7	0.04%	63.5	13.95	2.27	2.15	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.16	0.03	0.03	**0.22**
23	19,859	8	0.04%	62.5	13.95	2.27	2.15	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.17	0.03	0.03	**0.23**
24	19,851	8	0.04%	61.5	13.94	2.27	2.15	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.17	0.03	0.03	**0.23**
25	19,843	8	0.04%	60.5	13.93	2.27	2.15	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.17	0.03	0.03	**0.23**
26	19,834	9	0.04%	59.6	13.92	2.27	2.15	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.18	0.03	0.03	**0.24**
27	19,825	9	0.05%	58.6	13.91	2.26	2.15	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.19	0.03	0.03	**0.24**
28	19,816	9	0.05%	57.6	13.90	2.26	2.14	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.19	0.03	0.03	**0.25**
29	19,806	10	0.05%	56.6	13.89	2.26	2.14	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.19	0.03	0.03	**0.26**
30	19,796	10	0.05%	55.7	13.88	2.26	2.14	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.14	0.02	0.08	**0.24**
31	19,785	11	0.06%	54.7	13.87	2.26	2.14	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.15	0.02	0.09	**0.26**
32	19,773	11	0.06%	53.7	13.86	2.26	2.13	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.15	0.02	0.09	**0.26**
33	19,761	12	0.06%	52.8	13.85	2.25	2.13	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.16	0.03	0.09	**0.27**
34	19,749	13	0.06%	51.8	13.83	2.25	2.13	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.16	0.03	0.09	**0.28**
35	19,736	13	0.07%	50.8	13.82	2.25	2.12	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.16	0.03	0.09	**0.28**
36	19,722	14	0.07%	49.9	13.81	2.25	2.12	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.17	0.03	0.10	**0.29**
37	19,708	14	0.07%	48.9	13.80	2.25	2.12	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.17	0.03	0.10	**0.30**
38	19,693	15	0.08%	47.9	13.78	2.24	2.11	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.18	0.03	0.10	**0.31**
39	19,677	16	0.08%	47.0	13.77	2.24	2.11	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.18	0.03	0.10	**0.31**
40	19,661	16	0.08%	46.0	13.75	2.24	2.11	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.18	0.03	0.11	**0.32**
41	19,643	18	0.09%	45.1	13.74	2.24	2.10	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.19	0.03	0.11	**0.34**
42	19,625	19	0.09%	44.1	13.72	2.23	2.10	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.20	0.03	0.12	**0.35**
43	19,605	20	0.10%	43.1	13.70	2.23	2.09	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.21	0.03	0.12	**0.36**
44	19,584	21	0.11%	42.2	13.68	2.23	2.09	0.01	0.00	0.00	0.02	0.00	0.01	0.01	0.00	0.00	0.22	0.04	0.13	**0.38**
45	19,561	23	0.12%	41.2	13.66	2.22	2.08	0.02	0.00	0.00	0.02	0.00	0.01	0.01	0.00	0.00	0.23	0.04	0.13	**0.40**
46	19,537	24	0.12%	40.3	13.63	2.22	2.08	0.02	0.00	0.00	0.02	0.00	0.01	0.01	0.00	0.00	0.24	0.04	0.14	**0.41**
47	19,511	26	0.13%	39.3	13.61	2.22	2.07	0.02	0.00	0.00	0.02	0.00	0.01	0.01	0.00	0.00	0.25	0.04	0.14	**0.43**
48	19,484	28	0.14%	38.4	13.58	2.21	2.06	0.02	0.00	0.00	0.03	0.00	0.01	0.01	0.00	0.00	0.26	0.04	0.15	**0.45**
49	19,454	30	0.15%	37.4	13.56	2.21	2.06	0.02	0.00	0.00	0.03	0.00	0.01	0.01	0.00	0.00	0.27	0.04	0.15	**0.47**
50	19,422	32	0.16%	36.5	13.53	2.20	2.05	0.02	0.00	0.00	0.03	0.00	0.01	0.01	0.00	0.00	0.28	0.05	0.16	**0.49**
51	19,388	34	0.18%	35.6	13.49	2.20	2.04	0.02	0.00	0.00	0.03	0.01	0.01	0.01	0.00	0.00	0.30	0.05	0.17	**0.51**
52	19,352	37	0.19%	34.6	13.46	2.19	2.03	0.03	0.00	0.00	0.03	0.01	0.01	0.01	0.00	0.01	0.31	0.05	0.17	**0.53**
53	19,312	39	0.20%	33.7	13.42	2.19	2.02	0.03	0.00	0.00	0.04	0.01	0.01	0.01	0.00	0.01	0.32	0.05	0.18	**0.56**
54	19,270	43	0.22%	32.8	13.38	2.18	2.01	0.03	0.00	0.00	0.04	0.01	0.01	0.01	0.00	0.01	0.34	0.06	0.19	**0.59**
55	19,224	46	0.24%	31.9	13.34	2.17	2.00	0.03	0.01	0.00	0.04	0.01	0.01	0.01	0.00	0.01	0.36	0.06	0.20	**0.61**
56	19,174	49	0.26%	30.9	13.29	2.16	1.99	0.03	0.01	0.01	0.05	0.01	0.01	0.01	0.00	0.01	0.37	0.06	0.21	**0.64**
57	19,121	53	0.28%	30.0	13.24	2.16	1.97	0.04	0.01	0.01	0.05	0.01	0.01	0.01	0.00	0.01	0.39	0.06	0.22	**0.67**
58	19,063	58	0.30%	29.1	13.19	2.15	1.96	0.04	0.01	0.01	0.05	0.01	0.01	0.01	0.00	0.01	0.41	0.07	0.23	**0.71**
59	19,000	63	0.33%	28.2	13.13	2.14	1.95	0.04	0.01	0.01	0.06	0.01	0.01	0.02	0.00	0.01	0.43	0.07	0.24	**0.74**
60	18,932	68	0.36%	27.3	13.07	2.13	1.93	0.05	0.01	0.01	0.06	0.01	0.02	0.02	0.00	0.01	0.45	0.07	0.25	**0.78**
61	18,858	74	0.39%	26.4	13.00	2.12	1.91	0.05	0.01	0.01	0.07	0.01	0.02	0.02	0.00	0.01	0.48	0.08	0.26	**0.82**
62	18,777	81	0.43%	25.5	12.92	2.10	1.89	0.06	0.01	0.01	0.08	0.01	0.02	0.02	0.00	0.01	0.50	0.08	0.27	**0.85**
63	18,689	88	0.47%	24.6	12.84	2.09	1.87	0.06	0.01	0.01	0.08	0.01	0.02	0.02	0.00	0.01	0.52	0.09	0.29	**0.90**
64	18,593	96	0.52%	23.8	12.75	2.08	1.85	0.07	0.01	0.01	0.09	0.01	0.02	0.02	0.00	0.01	0.55	0.09	0.30	**0.94**
65	18,489	105	0.57%	22.9	12.65	2.06	1.83	0.07	0.01	0.01	0.10	0.02	0.02	0.03	0.00	0.01	0.58	0.09	0.31	**0.99**
66	18,375	114	0.62%	22.0	12.55	2.04	1.80	0.08	0.01	0.01	0.11	0.02	0.03	0.03	0.00	0.01	0.61	0.10	0.33	**1.03**
67	18,250	125	0.68%	21.2	12.43	2.02	1.77	0.09	0.01	0.01	0.12	0.02	0.03	0.03	0.00	0.02	0.64	0.10	0.34	**1.08**
68	18,113	137	0.76%	20.3	12.30	2.00	1.74	0.09	0.02	0.01	0.13	0.02	0.03	0.03	0.01	0.02	0.67	0.11	0.36	**1.13**
69	17,963	150	0.83%	19.5	12.17	1.98	1.71	0.10	0.02	0.01	0.14	0.02	0.03	0.04	0.01	0.02	0.70	0.11	0.37	**1.19**
70	17,799	164	0.92%	18.7	12.01	1.96	1.67	0.11	0.02	0.02	0.15	0.02	0.04	0.04	0.01	0.02	0.73	0.12	0.39	**1.24**
71	17,619	180	1.02%	17.9	11.85	1.93	1.63	0.12	0.02	0.02	0.17	0.03	0.04	0.04	0.01	0.02	0.77	0.13	0.40	**1.29**
72	17,421	198	1.13%	17.1	11.67	1.90	1.59	0.13	0.02	0.02	0.18	0.03	0.04	0.05	0.01	0.02	0.80	0.13	0.41	**1.35**
73	17,204	217	1.26%	16.3	11.47	1.87	1.54	0.15	0.02	0.02	0.20	0.03	0.05	0.05	0.01	0.03	0.84	0.14	0.43	**1.40**
74	16,966	238	1.40%	15.5	11.25	1.83	1.49	0.16	0.03	0.02	0.22	0.04	0.05	0.06	0.01	0.03	0.87	0.14	0.44	**1.45**
75	16,704	261	1.56%	14.7	11.01	1.79	1.44	0.18	0.03	0.02	0.24	0.04	0.05	0.06	0.01	0.03	0.91	0.15	0.45	**1.51**
76	16,417	287	1.75%	14.0	10.75	1.75	1.38	0.19	0.03	0.03	0.26	0.04	0.06	0.07	0.01	0.03	0.94	0.15	0.46	**1.56**
77	16,102	315	1.96%	13.2	10.47	1.70	1.32	0.21	0.03	0.03	0.28	0.05	0.06	0.07	0.01	0.04	0.97	0.16	0.47	**1.60**
78	15,757	346	2.19%	12.5	10.16	1.65	1.25	0.23	0.04	0.03	0.31	0.05	0.07	0.08	0.01	0.04	1.01	0.16	0.47	**1.64**
79	15,378	379	2.46%	11.8	9.82	1.60	1.18	0.25	0.04	0.03	0.34	0.05	0.07	0.09	0.01	0.04	1.03	0.17	0.48	**1.68**
80	14,963	415	2.77%	11.1	9.45	1.54	1.10	0.27	0.04	0.03	0.37	0.06	0.08	0.10	0.02	0.04	1.06	0.17	0.48	**1.71**
81	14,510	453	3.12%	10.5	9.06	1.47	1.02	0.30	0.05	0.03	0.40	0.06	0.08	0.10	0.02	0.05	1.08	0.18	0.47	**1.73**
82	14,016	494	3.53%	9.8	8.62	1.40	0.94	0.32	0.05	0.04	0.43	0.07	0.08	0.11	0.02	0.05	1.10	0.18	0.46	**1.74**
83	13,478	538	3.99%	9.2	8.16	1.33	0.85	0.34	0.06	0.04	0.46	0.08	0.09	0.12	0.02	0.05	1.11	0.18	0.45	**1.74**
84	12,895	583	4.52%	8.6	7.66	1.25	0.77	0.37	0.06	0.04	0.50	0.08	0.09	0.13	0.02	0.05	1.11	0.18	0.43	**1.72**
85	12,264	631	5.14%	8.0	7.13	1.16	0.67	0.39	0.06	0.04	0.53	0.09	0.09	0.14	0.02	0.05	1.10	0.18	0.41	**1.69**
Total								**5.14**	**0.84**	**0.66**	**7.06**	**1.15**	**1.58**	**1.92**	**0.31**	**0.92**	**41.3**	**6.7**	**21.8**	**69.8**

Is a preterm birth associated with a reduced QoL in adulthood? The research in this area has tended to focus on individuals born very preterm (gestational age < 32 completed weeks) or with very low birth weight (VLBW <1,500 grams[535]).

A systematic review in 2008 assessed the available literature on differences in QoL of formerly VLBW infants from preschool age to adulthood. QoL tended to be lower for these children than normal birth weight peers but this difference tended to decrease with increasing age. The authors note that this decrease in the gap with age may reflect adaptation of individuals over time. In addition, the QoL gap was greater if input came from the parents rather than the individuals.[536]

The 2020 systematic review by van der Pal and colleagues found "no conclusive evidence" that differences in QoL persisted into early adulthood.[537] They did note, however, that a number of longitudinal studies have found ongoing differences in QoL, including a Canadian study. The Canadian study has followed and assessed QoL in 153 extremely low birth weight (ELBW <1,000 grams[538]) individuals born between 1977 and 1982 (who were between 29-36 years of age at the time of the latest publication).[539] They have found a consistently lower QoL in the ELBW group when compared with normal birth weight peers, especially if the ELBW survivors also had neurosensory impairments.

More recently, the meta-analysis by Bolbocean et al., which included over 2,100 adult VLBW survivors ages 18-29 found a significantly lower QoL (a decrement of 0.06 with a 95% CI of 0.04 to 0.08) in this group when compared with normal birth weight peers.[540]

In calculating the effect of premature birth on QoL in a BC birth cohort of 40,000, we assumed an annual decrement of 0.06 but only in the cohort of babies born <28-30 weeks premature (VLBW). Based on this assumption, we would expect 23.4 QALYs lost associated with babies born VLBW, 11.8 QALYs lost in males and 11.6 QALYs lost in females (see Table 18).

[535] Or 3.3 pounds.
[536] Zwicker J, Harris S. Quality of life of formerly preterm and very low birth weight infants from preschool age to adulthood: A systematic review. *Pediatrics*. 2008; 121(2): e366-76.
[537] van der Pal S, Steinhof M, Grevinga M et al. Quality of life of adults born very preterm or very low birth weight: A systematic review. *Acta Paediatrica*. 2020; 109: 1974-88.
[538] Or 2.2 pounds.
[539] Saigal S, Ferro M, van Lieshout R et al. Health-related quality of life trajectories of extremely low birth weight survivors into adulthood. *The Journal of Pediatrics*. 2016; 179: 68-73.
[540] Bolbocean C, van der Pal S, van Buuren S et al. Health-related quality-of-life outcomes of very preterm or very low birth weight adults: Evidence from an individual participant meta-analysis. *Pharmacoeconomics*. 2023; 41: 93-105.

Table 18: Quality-adjusted Life Years Lost Due to VLBW
Due to Local Treatment for CIN in Their Mothers

	Males			*Females*			
		Very Low Birth Weight			*Very Low Birth Weight*		**Total**
Age	LE	# Alive	QALYs Lost	LE	# Alive	QALYs Lost	**QALYs Lost**
0	79.9	2.26	0.15	84.9	2.26	0.15	0.30
1	79.3	2.19	0.14	84.2	2.17	0.14	0.29
2	78.3	2.19	0.14	83.2	2.17	0.14	0.29
3	77.3	2.18	0.14	82.2	2.17	0.14	0.29
4	76.3	2.18	0.14	81.3	2.17	0.14	0.29
5	75.3	2.18	0.14	80.3	2.17	0.14	0.29
6	74.3	2.18	0.14	79.3	2.17	0.14	0.29
7	73.3	2.18	0.14	78.3	2.17	0.14	0.29
8	72.3	2.18	0.14	77.3	2.17	0.14	0.29
9	71.3	2.18	0.14	76.3	2.17	0.14	0.29
10	70.3	2.18	0.14	75.3	2.17	0.14	0.29
11	69.3	2.18	0.14	74.3	2.17	0.14	0.29
12	68.3	2.18	0.14	73.3	2.17	0.14	0.29
13	67.3	2.18	0.14	72.3	2.17	0.14	0.29
14	66.3	2.18	0.14	71.3	2.16	0.14	0.29
15	65.3	2.18	0.14	70.3	2.16	0.14	0.29
16	64.4	2.18	0.14	69.3	2.16	0.14	0.28
17	63.4	2.18	0.14	68.3	2.16	0.14	0.28
18	62.4	2.18	0.14	67.4	2.16	0.14	0.28
19	61.4	2.17	0.14	66.4	2.16	0.14	0.28
20	60.5	2.17	0.14	65.4	2.15	0.14	0.28
21	59.5	2.17	0.14	64.4	2.15	0.14	0.28
22	58.6	2.17	0.14	63.5	2.15	0.14	0.28
23	57.7	2.16	0.14	62.5	2.15	0.14	0.28
24	56.7	2.16	0.14	61.5	2.15	0.14	0.28
25	55.8	2.16	0.14	60.5	2.15	0.14	0.28
26	54.8	2.15	0.14	59.6	2.15	0.14	0.28
27	53.9	2.15	0.14	58.6	2.15	0.14	0.28
28	53.0	2.14	0.14	57.6	2.14	0.14	0.28
29	52.1	2.14	0.14	56.6	2.14	0.14	0.28
30	51.1	2.14	0.14	55.7	2.14	0.14	0.29
31	50.2	2.13	0.14	54.7	2.14	0.14	0.29
32	49.3	2.13	0.14	53.7	2.13	0.14	0.29
33	48.4	2.13	0.14	52.8	2.13	0.14	0.29
34	47.4	2.12	0.14	51.8	2.13	0.14	0.29
35	46.5	2.12	0.14	50.8	2.12	0.14	0.29
36	45.6	2.11	0.14	49.9	2.12	0.14	0.29
37	44.7	2.11	0.14	48.9	2.12	0.14	0.29
38	43.7	2.11	0.14	47.9	2.11	0.14	0.28
39	42.8	2.10	0.14	47.0	2.11	0.14	0.28
40	41.9	2.10	0.15	46.0	2.11	0.15	0.30
41	41.0	2.09	0.15	45.1	2.10	0.15	0.29
42	40.1	2.09	0.15	44.1	2.10	0.15	0.29
43	39.1	2.08	0.15	43.1	2.09	0.15	0.29
44	38.2	2.08	0.15	42.2	2.09	0.15	0.29
45	37.3	2.07	0.15	41.2	2.08	0.15	0.29
46	36.4	2.07	0.15	40.3	2.08	0.15	0.29
47	35.5	2.06	0.14	39.3	2.07	0.15	0.29
48	34.6	2.05	0.14	38.4	2.06	0.14	0.29
49	33.7	2.05	0.14	37.4	2.06	0.14	0.29
50	32.8	2.04	0.15	36.5	2.05	0.15	0.30
51	31.9	2.03	0.15	35.6	2.04	0.15	0.30
52	31.0	2.02	0.15	34.6	2.03	0.15	0.30
53	30.2	2.01	0.15	33.7	2.02	0.15	0.30
54	29.3	2.00	0.15	32.8	2.01	0.15	0.29
55	28.4	1.99	0.15	31.9	2.00	0.15	0.29
56	27.5	1.98	0.14	30.9	1.99	0.15	0.29
57	26.7	1.97	0.14	30.0	1.97	0.14	0.29
58	25.8	1.96	0.14	29.1	1.96	0.14	0.29
59	25.0	1.94	0.14	28.2	1.95	0.14	0.28
60	24.1	1.93	0.14	27.3	1.93	0.14	0.29
61	23.3	1.91	0.14	26.4	1.91	0.14	0.29
62	22.5	1.90	0.14	25.5	1.89	0.14	0.28
63	21.7	1.88	0.14	24.6	1.87	0.14	0.28
64	20.9	1.86	0.14	23.8	1.85	0.14	0.28
65	20.1	1.84	0.14	22.9	1.83	0.14	0.28
66	19.3	1.81	0.14	22.0	1.80	0.14	0.27
67	18.5	1.79	0.13	21.2	1.77	0.13	0.27
68	17.7	1.76	0.13	20.3	1.74	0.13	0.26
69	17.0	1.73	0.13	19.5	1.71	0.13	0.26
70	16.2	1.70	0.13	18.7	1.67	0.13	0.27
71	15.5	1.67	0.13	17.9	1.63	0.13	0.26
72	14.8	1.63	0.13	17.1	1.59	0.13	0.26
73	14.1	1.60	0.13	16.3	1.54	0.12	0.25
74	13.4	1.55	0.12	15.5	1.49	0.12	0.24
75	12.7	1.51	0.12	14.7	1.44	0.11	0.23
76	12.0	1.46	0.12	14.0	1.38	0.11	0.23
77	11.4	1.41	0.11	13.2	1.32	0.10	0.22
78	10.8	1.36	0.11	12.5	1.25	0.10	0.21
79	10.1	1.30	0.10	11.8	1.18	0.09	0.20
80	9.5	1.23	0.11	11.1	1.10	0.10	0.20
81	9.0	1.17	0.10	10.5	1.02	0.09	0.19
82	8.4	1.10	0.09	9.8	0.94	0.08	0.18
83	7.9	1.03	0.09	9.2	0.85	0.07	0.16
84	7.3	0.95	0.08	8.6	0.77	0.07	0.15
85	6.8	0.87	0.07	8.0	0.67	0.06	0.13
Total			**11.8**			**11.6**	**23.4**

There is also a substantial **economic burden attributable to prematurity**, which will be discussed in more detail when we consider costs and potential costs avoided in calculating cost-effectiveness.[541]

Summary of CPB

Based on the assumptions above, the CPB associated with BC's current cytology-based cervical cancer screening program in a BC birth cohort of 20,000 females is 4,034 (see Table 19).

Table 19: Calculation of Clinically Preventable Burden for Cervical Cancer Without and With Cytology-Based Screening

In a BC Birth Cohort of 40,000

Row	Variable	Base Case	Data Source
	Without Cytology-Based Screening		
a	Estimated number of cervical cancers	305	Table 5
b	QALYs lost due to cervical cancers	375	Table 7
c	Estimated number of deaths due to cervical cancers	163	Table 6
d	Life-years lost per death from cervical cancers	30.8	= e / c
e	Total life-years lost due to deaths from cervical cancers	5,011	Table 7
f	**Total QALYs Lost**	**5,386**	= b + e
	With Cytology-Based Screening		
g	Estimated number of cervical cancers	99	Table 5
h	QALYs lost due to cervical cancers	195	Table 7
i	Estimated number of deaths due to cervical cancers	25	Table 6
j	Life-years lost per death from cervical cancers	31.5	= k / i
k	Total life-years lost due to deaths from cervical cancers	783	Table 7
l	**Total QALYs Lost**	**978**	= h + k
	Harms Associated with Screening & Treatment		
m	Reduction in quality of life associated with a CIN diagnosis	239	Table 10
n	Premature births associated with treatment	38	Table 14
o	Reduction in life years lived due to premature birth	112	Tables 16 & 17
p	Reduction in QALYs due to premature birth	23	Table 18
q	**Total QALYs lost due to harms**	**374**	= m + o + p
	Clinically Preventable Burden		
r	CPB associated with cytology-based screening	**4,034**	= f - l - q

v = Estimates from the literature

We also modified a key assumption and recalculated the CPB as follows:

- Assume the disutility associated with the diagnosis and treatment phase for cervical cancer of 0.288 is reduced to 0.193, the disutility associated with the ongoing, controlled phase (remission) for cervical cancer is reduced from 0.049 to 0.031 and the disutility associated with the metastatic phase for cervical cancer is reduced from 0.451 to 0.307: **CPB = 3,972**.
- Assume the disutility associated with the diagnosis and treatment phase for cervical cancer of 0.288 is increased to 0.399, the disutility associated with the ongoing, controlled phase (remission) for cervical cancer is increased from 0.049 to 0.072 and

[541] Johnston K, Gooch K, Korol E et al. The economic burden of prematurity in Canada. *BMC Paediatrics*. 2014; 14(93).

the disutility associated with the metastatic phase for cervical cancer is increased from 0.451 to 0.600: **CPB = 4,108**.

Cost-Effectiveness – Cytology-Based Screening

Unit Costs

- Three Canadian studies estimated the *cost of a conventional cytology screen* to be $28[542], $57[543] and $92[544] in 2005 or 2006 CAD. We updated these estimates to 2022 CAD and then used the average for the base case estimate and the extremes in the sensitivity analysis ($79 with a range from $37 to $124, in 2022 CAD). [545,546]
- Three Canadian studies estimated the *cost of a colposcopy with biopsy* to be $148[547], $151[548] and $337[549] in 2005 or 2006 CAD. We updated these estimates to 2022 CAD and then used the average for the base case estimate and the extremes in the sensitivity analysis ($283 with a range from $200 to $444, in 2022 CAD).
- Three Canadian studies estimated the *cost per treatment for a precancerous lesion* to be $965[550], $1,032[551] and $1,071[552] in 2005 or 2006 CAD. We updated these estimates to 2022 CAD and then used the average for the base case estimate and the extremes in the sensitivity analysis ($1,371 with a range from $1,271 to $1,447, in 2022 CAD).
- Based on data from Ontario, the cost estimates for the *acute phase* of a fatal cervical cancer are $41,536 (95% CI of $38,642 to $44,429) in 2009 CAD.[553] We converted this to $50,961 (95% CI of $47,410 to $54,510) in 2022 CAD.

[542] Kulasingam S, Rajan R, St Pierre Y et al. Human papillomavirus testing with Pap triage for cervical cancer prevention in Canada: a cost-effectiveness analysis. *BioMed Central Medicine*. 2009; 7(1): 69.
[543] Brisson M, Van de Velde N, De Wals P et al. The potential cost-effectiveness of prophylactic human papillomavirus vaccines in Canada. *Vaccine*. 2007; 25(29): 5399-408.
[544] Krahn M, McLauchlin M, Pham B et al. *Liquid-Based Techniques for Cervical Cancer Screening: Systematic Review and Cost-Effectiveness Analysis*. 2008. Available at https://www.cadth.ca/sites/default/files/pdf/333_LBC-Cervical-Cancer-Screenin_tr_e.pdf. Accessed August 2017.
[545] Shemilt I, Thomas J and Morciano M. A web-based tool for adjusting costs to a specific target currency and price year. *Evidence & Policy: A Journal of Research, Debate and Practice*. 2010; 6(1): 51-9.
[546] The Campbell and Cochrane Economics Methods Group and Evidence for Policy and Practice Information and Coordinating Centre. *CCEMG - EPPI-Centre Cost Converter*. 2019. Available at https://eppi.ioe.ac.uk/costconversion/ https://eppi.ioe.ac.uk/costconversion/. Accessed May 2023.
[547] Brisson M, Van de Velde N, De Wals P et al. The potential cost-effectiveness of prophylactic human papillomavirus vaccines in Canada. *Vaccine*. 2007; 25(29): 5399-408.
[548] Krahn M, McLauchlin M, Pham B et al. *Liquid-Based Techniques for Cervical Cancer Screening: Systematic Review and Cost-Effectiveness Analysis*. 2008. Available at https://www.cadth.ca/sites/default/files/pdf/333_LBC-Cervical-Cancer-Screenin_tr_e.pdf. Accessed August 2017.
[549] Kulasingam S, Rajan R, St Pierre Y et al. Human papillomavirus testing with Pap triage for cervical cancer prevention in Canada: a cost-effectiveness analysis. *BioMed Central Medicine*. 2009; 7(1): 69.
[550] Ibid.
[551] Krahn M, McLauchlin M, Pham B et al. *Liquid-Based Techniques for Cervical Cancer Screening: Systematic Review and Cost-Effectiveness Analysis*. 2008. Available at https://www.cadth.ca/sites/default/files/pdf/333_LBC-Cervical-Cancer-Screenin_tr_e.pdf. Accessed August 2017.
[552] Brisson M, Van de Velde N, De Wals P et al. The potential cost-effectiveness of prophylactic human papillomavirus vaccines in Canada. *Vaccine*. 2007; 25(29): 5399-408.
[553] de Oliveira C, Bremner K, Pataky R et al. Understanding the costs of cancer care before and after diagnosis for the 21 most common cancers in Ontario: a population-based descriptive study. *Canadian Medical Association Journal Open*. 2013; 1(1): E1-E8.

- Based on data from Ontario, the estimated *first year costs* associated with a cervical cancer survivor are $18,055 (95% CI of $17,305 to $18,804) in 2009 CAD.[554] We converted this to $22,676 (95% CI of $21,734 to $23,617) in 2022 CAD.
- Based on data from Ontario, the *ongoing annual costs* associated with a cervical cancer survivor after the first year are estimated at between $633 and $1,174 in 2022 CAD.[555] We used the midpoint of this range ($904) in our base case estimate and the extremes in the sensitivity analysis.
- Cervical cancers in BC occur at the mean age of 49.1 years.[556] A BC female 49.1 years of age has a life expectancy of 37.4 years. [557] Cervical cancer is associated with approximately 17 years of life lost.[558,559,560] Therefore, we estimated that the average female in BC with cervical cancer would survive for 20.4 years (37.4 – 17).
- We assumed that the costs avoided per cervical cancer avoided would be $41,118 ($22,676 + $904 * 20.4).
- Patient time costs resulting from receiving, as well as travelling to and from, a service are valued based on the average hourly wage rate in BC in 2022 ($31.49[561]) plus 18% benefits for an average cost per hour of $37.16. Patient time costs are truncated at $278.70 per day (7.5 hours times $37.16). If, for example, we are valuing a patient's time costs while in hospital, each day would be assessed a value of $278.70 (rather than 24 hours times $37.16 or $891.84).
- For patient time and travel costs, we estimated two hours of patient time would be required per screening visit and 7.5 hours per colposcopy or treatment for a precancerous lesion.
- Johnston and colleagues estimated the economic burden attributable to prematurity during the first 10 years of life to be $67,467 for early preterm infants (<28 weeks gestational age), $52,796 for moderate preterm infants (28-32 weeks) and $10,010 for late preterm infants (33-36 weeks), in 2012 CAD.[562] In our modelling we have assumed a distribution of 12.0% early, 12.3% moderate and 75.7% late preterm births. The weighted cost per pre-term birth would thus be $22,188 in 2012 CAD

[554] de Oliveira C, Bremner K, Pataky R et al. Understanding the costs of cancer care before and after diagnosis for the 21 most common cancers in Ontario: a population-based descriptive study. *Canadian Medical Association Journal Open*. 2013; 1(1): E1-E8.
[555] Sander B, Wong W, Yeung M et al. The cost-utility of integrated cervical cancer prevention strategies in the Ontario setting–Can we do better? *Vaccine*. 2016; 34(16): 1936-44.
[556] Dickinson J, Stankiewicz A, Popadiuk C et al. Reduced cervical cancer incidence and mortality in Canada: national data from 1932 to 2006. *BioMed Central Public Health*. 2012; 12(1): 992.
[557] Statistics Canada. Table 13-10-0114-01 Life expectancy and other elements of the complete life table, three-year estimates, Canada, all provinces except Prince Edward Island. Available online at http:https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=1310011401. Accessed September 2022.
[558] Liu P, Wang J and Keating N. Expected years of life lost for six potentially preventable cancers in the United States. *Preventive Medicine*. 2013; 56(5): 309-13.
[559] Burnet N, Jefferies S, Benson R et al. Years of life lost (YLL) from cancer is an important measure of population burden–and should be considered when allocating research funds. *British Journal of Cancer*. 2005; 92(2): 241-5.
[560] Brustugun O, Møller B and Helland Å. Years of life lost as a measure of cancer burden on a national level. *British Journal of Cancer*. 2014; 111(5): 1014-20.
[561] BC Stats. *Earning & Employment Trends – August 2022*. Available at https://www2.gov.bc.ca/assets/gov/data/statistics/people-population-community/income/earnings_and_employment_trends_data_tables.pdf. Accessed September 2022.
[562] Johnston K, Gooch K, Korol E et al. The economic burden of prematurity in Canada. *BMC Pediatrics*. 2014; 14(93):

(12.0% * $67,467 + 12.3% * $52,796 + 75.7% * $10,010), adjusted to $25,931 in 2022 CAD.

- Other costs and assumptions used in in assessing cost-effectiveness are detailed in the Reference Document.
- Discount Rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Costs Associated with Cytology-Based Screening for Cervical Cancer

Cytology-based screening between the ages of 25 and 69 in a BC birth cohort of 20,000 females would be associated with 171,230 screens. These screens would be associated with $13.5 million in healthcare costs and $12.7 million in patient time costs (see Table 20). The estimated 2,569 colposcopies would be associated with $0.7 million in healthcare costs and $0.7 million in patient time costs. The estimated 1,321 treatments for CIN 2+ would be associated with $1.8 million in healthcare costs and $0.4 million in patient time costs. Finally, the estimated 38 premature births attributable to treatment for CIN2+ would be associated $1.0 million in healthcare costs (see Table 20).

Table 20: Costs Associated with Screening for Cervical Cancer

Current Screening Model

in a British Columbia Birth Cohort of 20,000 Females

Age	Females in Birth Cohort	# of Screens	Cost of Screening		Colposcopies			Treatment for CIN2+			Pre-term Births	
			HC System	Patient	#	HC System $	Patient $	#	HC System $	Patient $	#	HC System $
25	19,843	4,207	$332,389	$312,698	119	$33,768	$33,255	76	$104,701	$21,284	2.4	$63,288
26	19,834	4,202	$331,991	$312,324	119	$33,728	$33,216	76	$104,575	$21,258	2.4	$63,212
27	19,825	4,197	$331,590	$311,947	119	$33,687	$33,175	76	$104,449	$21,233	2.4	$63,136
28	19,816	4,192	$331,183	$311,563	119	$33,646	$33,135	76	$104,321	$21,207	2.4	$63,058
29	19,806	4,187	$330,769	$311,174	119	$33,604	$33,093	76	$104,191	$21,180	2.4	$62,980
30	19,796	4,584	$362,106	$340,655	94	$26,562	$26,159	56	$76,965	$15,646	1.8	$46,523
31	19,785	4,557	$359,982	$338,656	93	$26,407	$26,005	56	$76,513	$15,554	1.8	$46,250
32	19,773	4,530	$357,852	$336,653	93	$26,250	$25,852	55	$76,060	$15,462	1.8	$45,976
33	19,761	4,503	$355,714	$334,641	92	$26,094	$25,697	55	$75,606	$15,369	1.8	$45,701
34	19,749	4,476	$353,568	$332,622	92	$25,936	$25,542	55	$75,150	$15,277	1.8	$45,425
35	19,736	4,448	$351,416	$330,598	91	$25,778	$25,387	54	$74,693	$15,184	1.7	$45,149
36	19,722	4,421	$349,257	$328,567	91	$25,620	$25,231	54	$74,234	$15,090	1.7	$44,872
37	19,708	4,394	$347,090	$326,528	90	$25,461	$25,074	54	$73,773	$14,997	1.7	$44,593
38	19,693	4,366	$344,911	$324,479	89	$25,301	$24,917	53	$73,310	$14,903	1.7	$44,313
39	19,677	4,338	$342,725	$322,422	89	$25,141	$24,759	53	$72,845	$14,808	1.7	$44,032
40	19,661	4,261	$336,644	$316,701	60	$16,984	$16,726	26	$35,948	$7,308	0.8	$21,729
41	19,643	4,197	$331,547	$311,906	59	$16,727	$16,473	26	$35,404	$7,197	0.8	$21,400
42	19,625	4,132	$326,441	$307,103	58	$16,470	$16,219	25	$34,858	$7,086	0.8	$21,071
43	19,605	4,067	$321,325	$302,290	57	$16,212	$15,965	25	$34,312	$6,975	0.8	$20,740
44	19,584	4,002	$316,196	$297,465	56	$15,953	$15,710	25	$33,764	$6,864	0.8	$20,409
45	19,561	3,937	$311,056	$292,628	55	$15,693	$15,455	24	$33,215	$6,752	0.8	$20,078
46	19,537	3,907	$308,655	$290,370	55	$15,572	$15,336	24	$32,959	$6,700	0.8	$19,923
47	19,511	3,876	$306,234	$288,092	55	$15,450	$15,215	24	$32,701	$6,647	0.8	$19,766
48	19,484	3,845	$303,790	$285,793	54	$15,327	$15,094	24	$32,440	$6,594	0.8	$19,609
49	19,454	3,814	$301,321	$283,471	54	$15,202	$14,971	23	$32,176	$6,541	0.8	$19,449
50	19,422	3,800	$300,206	$282,422	35	$10,046	$9,893	9	$12,413	$2,523		
51	19,388	3,768	$297,671	$280,037	35	$9,961	$9,809	9	$12,308	$2,502		
52	19,352	3,735	$295,103	$277,621	35	$9,875	$9,725	9	$12,202	$2,480		
53	19,312	3,703	$292,500	$275,172	35	$9,788	$9,639	9	$12,094	$2,459		
54	19,270	3,669	$289,857	$272,686	34	$9,699	$9,552	9	$11,985	$2,436		
55	19,224	3,635	$287,175	$270,163	34	$9,610	$9,464	9	$11,874	$2,414		
56	19,174	3,571	$282,142	$265,428	33	$9,441	$9,298	9	$11,666	$2,371		
57	19,121	3,507	$277,073	$260,659	33	$9,271	$9,131	8	$11,456	$2,329		
58	19,063	3,443	$271,963	$255,852	32	$9,100	$8,962	8	$11,245	$2,286		
59	19,000	3,377	$266,811	$251,005	32	$8,928	$8,792	8	$11,032	$2,243		
60	18,932	3,240	$255,934	$240,773	17	$4,936	$4,861	7	$9,274	$1,885		
61	18,858	3,175	$250,799	$235,941	17	$4,837	$4,764	7	$9,087	$1,847		
62	18,777	3,109	$245,612	$231,062	17	$4,737	$4,665	6	$8,900	$1,809		
63	18,689	3,043	$240,366	$226,126	16	$4,636	$4,566	6	$8,709	$1,770		
64	18,593	2,975	$235,059	$221,134	16	$4,534	$4,465	6	$8,517	$1,731		
65	18,489	2,907	$229,685	$216,079	16	$4,430	$4,363	6	$8,322	$1,692		
66	18,375	2,838	$224,240	$210,956	15	$4,325	$4,259	6	$8,125	$1,652		
67	18,250	2,769	$218,715	$205,759	15	$4,219	$4,154	6	$7,925	$1,611		
68	18,113	2,698	$213,107	$200,482	15	$4,110	$4,048	6	$7,722	$1,570		
69	17,963	2,625	$207,408	$195,121	14	$4,000	$3,940	5	$7,515	$1,528		
Total		**171,230**	**$13,527,180**	**$12,725,823**	**2,569**	**$727,059**	**$716,012**	**1,321**	**$1,811,533**	**$368,253**	**38**	**$972,683**

Costs Avoided with Cytology-Based Screening for Cervical Cancer

Cytology-based screening between the ages of 25 and 69 in a BC birth cohort of 20,000 females is associated with an estimated reduction of 206 incident cervical cancers (see Table 5) and 138 deaths attributable to cervical cancers (see Table 6). Each incident cervical cancer is associated with $41,118 in healthcare costs while each death attributable to cervical cancer is associated with $50,961 in health care costs. The avoidance of the incident cancers is associated with $8.5 million in healthcare costs avoided while the avoidance of the deaths due to cervical cancer is associated with $7.0 million in healthcare costs avoided (see Table 21).

Table 21: Costs Avoided with Screening for Cervical Cancer

Current Screening Model

in a British Columbia Birth Cohort of 20,000 Females

Age	Females in Birth Cohort	*Incident Cervical Cancers*				*Deaths Due to Cervical Cancer*			
		No Screening	Screening	Avoided	HC System $	No Screening	Screening	Avoided	HC System $
25	19,843	1.2	0.6	0.6	$24,760	0.3	0.1	0.2	$11,529
26	19,834	1.7	0.9	0.8	$33,823	0.3	0.1	0.2	$11,524
27	19,825	2.8	1.4	1.4	$56,597	0.3	0.1	0.2	$11,519
28	19,816	2.4	1.2	1.2	$47,618	0.3	0.1	0.2	$11,514
29	19,806	3.0	1.6	1.5	$61,327	0.3	0.1	0.2	$11,508
30	19,796	4.5	2.5	2.0	$83,147	0.9	0.2	0.7	$35,730
31	19,785	4.5	2.5	2.0	$83,101	0.9	0.2	0.7	$35,710
32	19,773	4.5	2.5	2.0	$83,053	0.9	0.2	0.7	$35,690
33	19,761	4.5	2.5	2.0	$83,003	0.9	0.2	0.7	$35,668
34	19,749	4.5	2.5	2.0	$82,950	0.9	0.2	0.7	$35,645
35	19,736	4.5	2.5	2.0	$82,895	1.6	0.3	1.3	$66,497
36	19,722	4.5	2.5	2.0	$82,838	1.6	0.3	1.3	$66,451
37	19,708	4.5	2.5	2.0	$82,778	1.6	0.3	1.3	$66,403
38	19,693	4.5	2.5	2.0	$82,715	1.6	0.3	1.3	$66,353
39	19,677	4.5	2.5	2.0	$82,650	1.6	0.3	1.3	$66,300
40	19,661	6.5	2.6	3.9	$160,367	2.7	0.4	2.3	$117,869
41	19,643	6.5	2.6	3.9	$160,223	2.7	0.4	2.3	$117,764
42	19,625	6.5	2.6	3.9	$160,071	2.7	0.4	2.3	$117,652
43	19,605	6.5	2.6	3.9	$159,910	2.7	0.4	2.3	$117,533
44	19,584	6.5	2.6	3.9	$159,737	2.7	0.4	2.3	$117,406
45	19,561	6.5	2.6	3.9	$159,553	4.0	0.5	3.5	$177,305
46	19,537	6.4	2.6	3.9	$159,355	4.0	0.5	3.5	$177,086
47	19,511	6.4	2.6	3.9	$159,145	4.0	0.5	3.5	$176,852
48	19,484	6.4	2.6	3.9	$158,920	4.0	0.5	3.5	$176,602
49	19,454	6.4	2.6	3.9	$158,678	4.0	0.5	3.5	$176,333
50	19,422	7.4	1.9	5.5	$226,921	4.0	0.7	3.3	$169,354
51	19,388	7.4	1.9	5.5	$226,524	4.0	0.6	3.3	$169,057
52	19,352	7.4	1.9	5.5	$226,096	4.0	0.6	3.3	$168,738
53	19,312	7.4	1.9	5.5	$225,636	4.0	0.6	3.3	$168,395
54	19,270	7.3	1.9	5.5	$225,138	3.9	0.6	3.3	$168,023
55	19,224	7.3	1.9	5.5	$224,603	4.1	0.6	3.5	$177,193
56	19,174	7.3	1.9	5.4	$224,026	4.1	0.6	3.5	$176,737
57	19,121	7.3	1.9	5.4	$223,402	4.1	0.6	3.5	$176,245
58	19,063	7.3	1.8	5.4	$222,724	4.1	0.6	3.4	$175,711
59	19,000	7.2	1.8	5.4	$221,990	4.1	0.6	3.4	$175,132
60	18,932	7.9	1.8	6.1	$250,716	5.2	0.6	4.6	$232,972
61	18,858	7.8	1.8	6.1	$249,734	5.2	0.6	4.6	$232,059
62	18,777	7.8	1.8	6.0	$248,666	5.2	0.6	4.5	$231,067
63	18,689	7.8	1.7	6.0	$247,501	5.1	0.6	4.5	$229,984
64	18,593	7.7	1.7	6.0	$246,232	5.1	0.6	4.5	$228,805
65	18,489	7.7	1.7	6.0	$244,847	5.1	0.7	4.4	$224,554
66	18,375	7.6	1.7	5.9	$243,335	5.1	0.7	4.4	$223,167
67	18,250	7.6	1.7	5.9	$241,679	5.1	0.7	4.3	$221,649
68	18,113	7.5	1.7	5.8	$239,868	5.0	0.7	4.3	$219,987
69	17,963	7.5	1.7	5.8	$237,884	5.0	0.7	4.3	$218,168
70	17,799	6.9	1.4	5.6	$229,470	4.8	0.8	4.0	$202,648
71	17,619	6.9	1.3	5.5	$227,147	4.8	0.8	3.9	$200,597
72	17,421	6.8	1.3	5.5	$224,599	4.7	0.8	3.9	$198,347
73	17,204	6.7	1.3	5.4	$221,802	4.6	0.8	3.8	$195,876
74	16,966	6.6	1.3	5.3	$218,731	4.6	0.8	3.8	$193,164
Total		**305**	**99**	**206**	**$8,468,487**	**163**	**25**	**138**	**$7,018,072**

Summary of CE

Based on these assumptions, the CE associated with cytology-based screening of females ages 25 to 69 years of age for cervical cancer as currently performed in BC would be $5,077 / QALY (Table 22, row w).

Table 22: Summary of CE Estimate for Cervical Cancer Screening With Cytology-Based Screening

In a BC Birth Cohort of 40,000

Row	Variable	Base Case	Data Source
	Cost of Screening and Treatment		
a	Estimated number of screens	171,230	Table 20
b	Cost of Screening - Healthcare	$13,527,180	Table 20
c	Cost of Screening - Patient time	$12,725,823	Table 20
d	Estimated number of colposcopies	2,569	Table 20
e	Cost of colposcopies - Healthcare	$727,059	Table 20
f	Cost of colposcopies - Patient time	$716,012	Table 20
g	Estimated number of treatments for CIN2+	1,321	Table 20
h	Cost of treatments for CIN2+ - Healthcare	$1,811,533	Table 20
i	Cost of treatments for CIN2+ - Patient time	$368,253	Table 20
j	Estimated number of premature births attributable to treatment for CIN2+	38	Table 20
k	Costs attributable to preterm births	$972,683	Table 20
l	**Total cost of screening and treatment**	**$30,848,543**	= b + c + e + f + h + i + k
	Costs Avoided		
m	Deaths prevented	138	Table 21
n	Costs avoided due to deaths prevented	-$7,018,072	Table 21
o	# of cervical cancers avoided	206	Table 21
p	Costs avoided due to cervical cancers prevented	-$8,468,487	Table 21
q	**Total costs avoided**	**-$15,486,558**	= n + p
	Calculating CE		
r	Net costs	$15,361,984	= l + q
s	CPB undiscounted	4,034	Table 19
t	CE undiscounted	$3,808	= r / s
u	**Net Costs (1.5% discount)**	**$13,706,925**	Calculated
v	**CPB (1.5% discount)**	**2,700**	Calculated
w	**CE ($/QALY Saved)**	**$5,077**	= u / v

√ = Estimates from the literature

We also modified a number of key assumptions and recalculated the CE as follows:

- Assume the disutility associated with the diagnosis and treatment phase for cervical cancer of 0.288 is reduced to 0.193, the disutility associated with the ongoing, controlled phase (remission) for cervical cancer is reduced from 0.049 to 0.031 and the disutility associated with the metastatic phase for cervical cancer is reduced from 0.451 to 0.307: CE = $5,160.
- Assume the disutility associated with the diagnosis and treatment phase for cervical cancer of 0.288 is increased to 0.399, the disutility associated with the ongoing, controlled phase (remission) for cervical cancer is increased from 0.049 to 0.072 and the disutility associated with the metastatic phase for cervical cancer is increased from 0.451 to 0.600: CE = $4,982.

- Assume that unit costs are at the lower end of the 95% CI. The cost per conventional cytology screen is reduced from $79 to $37, the cost per colposcopy is reduced from $283 to $200, the cost per treatment for CIN2+ is reduced from $1,371 to $1,271, the cost per cervical cancer avoided is reduced from $41,118 to $39,410 and the cost per death due to cervical cancer avoided is reduced from $50,961 to $47,410: **CE = $3,154**.
- Assume that unit costs are at the higher end of the 95% CI. The cost per conventional cytology screen is increased from $79 to $124 the cost per colposcopy is increased from $283 to $444, the cost per treatment for CIN2+ is increased from $1,371 to $1,447, the cost per cervical cancer avoided is increased from $41,118 to $42,824 and the cost per death due to cervical cancer avoided is increased from $50,961 to $54,510: **CE = $7,196**.

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with cytology-based cervical cancer screening is estimated to be 2,700 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $5,077 per QALY (see Table 23).

Table 23: Cytology-Based Screening for Cervical Cancer in a Birth Cohort of 40,000

Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Gap between 0% and Current BC Screening Rate (69%)			
1.5% Discount Rate	**2,700**	2,656	2,751
3% Discount Rate	1,827	1,796	1,864
0% Discount Rate	4,034	3,972	4,108
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$5,077**	$3,154	$7,196
3% Discount Rate	$6,648	$4,394	$9,131
0% Discount Rate	$3,808	$2,148	$5,637
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$1,172	Cost-saving	$3,290
3% Discount Rate	$2,130	Cost-saving	$4,613
0% Discount Rate	$385	Cost-saving	$2,214

Moving from Conventional to Liquid-Based Cytology Collection

Despite the significant effect on cervical cancer incidence and mortality associated with systematic screening using conventional cytology, some challenges remain. These include the limited accuracy of the test resulting in a high level of false-negative and false-positive results and limitations in sampling and slide preparation which can result in a high proportion of unsatisfactory samples. In an attempt to address some of these challenges associated with conventional cytology collection, manufacturers developed liquid-based cytology (LBC) collection.

The ThinPrep® Pap test (Hologic, Inc.) was the first LBC to be approved by the US Food and Drug Administration (FDA) in 1996.[563] Based on early research evidence, the US Food and Drug Administration allowed the makers of the LBC ThinPrep® 2000 System to claim that their system "is significantly more effective than the conventional Pap smear for the detection of Low Grade Squamous Intraepithelial (LSIL) and more severe lesions in a variety of patient populations. Specimen quality with the ThinPrep® 2000 System is significantly improved over that of conventional Pap smear preparation in a variety of patient populations."[564]

Despite the initial excitement about the effectiveness of LBC, significant controversy remained. In 2006, Davey and colleagues published a systematic review in which they combined the available literature to determine whether the use of LBC (compared with conventional cytology) increases test sensitivity and reduces the proportion of slides that are satisfactory for assessment.[565] While they included 56 primary studies, only 5 were considered to be of high quality. Results varied significantly based on the quality of the study. They conclude; "we saw no evidence that liquid-based cytology reduced the proportion of unsatisfactory slides, or detected more high-grade lesions in high-quality studies, than conventional cytology."

In 2008, Arbyn and co-authors found 8 studies in which all subjects "were submitted to gold standard verification, based on colposcopy and histology of colposcopy-targeted biopsies."[566] Based on a meta-analysis of these high quality study results, they found that LBC is "neither more sensitive nor more specific for detection of high-grade cervical intraepithelial neoplasia compared with the conventional Pap test."

The 2011 systematic review for the USPSTF included just two fair quality observational studies[567,568] and two RCT studies, one fair (NTCC)[569] and one good quality

[563] Gibb R, Martens M. The impact of liquid-based cytology in decreasing the incidence of cervical cancer. *Reviews in Obstetrics & Gynecology*. 2011; 4(1): S2-11.
[564] Gutman S. Labeling liquid-based systems: FDA clarification. *Acta Cytologica*. 2000; 44(6): 1120.
[565] Davey E, Barratt A, Irwig L et al. Effect of study design and quality on unsatisfactory rates, cytology classifications, and accuracy in liquid-based versus conventional cervical cytology: A systematic review. *The Lancet*. 2006; 367: 122-32.
[566] Arbyn M, Bergeron C. Klinkhamer P et al. Liquid compared with conventional cervical cytology: A systematic review and meta-analysis. *Obstetrics & Gynecology*. 2008; 111(1): 167-77.
[567] Coste J, Cochand-Priollet B, de Cremoux P et al. Cross sectional study of conventional cervical smear, monolayer cytology, and human papillomavirus DNA testing for cervical cancer screening. *British Medical Journal*. 2003; 326: 733.
[568] Taylor S, Kuhn L, Dupree W et al. Direct comparison of liquid-based and conventional cytology in a South African screening trial. *International Journal of Cancer*. 2006; 118: 957-62.
[569] Ronco G, Cuzick J, Pierottti P et al. Accuracy of liquid based versus conventional cytology: Overall results of new technologies for cervical cancer screening randomised controlled trial. *British Medical Journal*. 2007; 335: 28.

(NETHCON).[570,571] The two RCTs were completed and published in response to the call from Davey et al in 2006 for additional high quality studies, in particular large RCTs.[572] The NTCC included 45,174 females while the NETHCON included 89,784 females. Based on these four studies, the reviewers for the USPSTF concluded that "LBC and conventional cytology did not differ substantially in relative detection or absolute sensitivity or specificity for detection of CIN2+ / CIN3+ at any cytologic threshold."[573] However, "most of the evidence indicated a lower proportion of unsatisfactory slides for LBC than conventional cytology (0.33% vs. 1.11% in NETHCON; 2.6% vs. 4.1% in NTCC)."[574]

The benefits of LBC in reducing the proportion of unsatisfactory slides may be of particular importance in jurisdictions such as England and Scotland where the proportion of unsatisfactory slides using conventional cytology was approximately 7.5%.[575,576] As noted earlier, the proportion of unsatisfactory samples in BC in 2018 using conventional cytology collection was 1.3%.[577]

Besides the potential benefits in reducing the proportion of unsatisfactory slides, other benefits associated with LBC might include greater reproducibility, ***the capacity for HPV DNA testing*** and improved productivity.[578] To enable a shift to HPV-based screening, BC began the process of transitioning from conventional cytology collection methods to LBC in 2022.[579]

Moving from Liquid-Based Cytology to HPV-Based Screening

False-Positive and False-Negative Results

We noted in the previous section that conventional and liquid-based cytology are essentially equivalent tests in terms of sensitivity and specificity.[580] How might the transition to HPV-based testing change the ratio of true / false positive results (sensitivity) and true / false negative results (specificity)?

To illustrate this we generated a sensitivity of 0.561 and a specificity of 0.968 for conventional / liquid based cytology for the detection of CIN2+ based on data from Arbyn et

[570] Siebers A, Klinkhamer P, Arbyn M et al. Cytologic detection of cervical abnormalities using liquid-based compared with conventional cytology: A randomized controlled trial. *Obstetrics & Gynaecology*. 2008; 112(6): 1327-34.
[571] Siebers A, Klinkhamer P, Grefte J et al. Comparison of liquid-based cytology with conventional cytology for detection of cervical cancer precursors: A randomized controlled trial. *JAMA*. 2009; 302(16): 1757-64.
[572] Davey E, Barratt A, Irwig L et al. Effect of study design and quality on unsatisfactory rates, cytology classifications, and accuracy in liquid-based versus conventional cervical cytology: A systematic review. *Lancet*. 2006; 367: 122-32.
[573] Whitlock E, Vesco K, Eder M et al. Liquid-based cytology and human papillomavirus testing to screen for cervical cancer: A systematic review for the U.S. Preventive Services Task Force. *Annals of Internal Medicine*. 2011; 155(10): 687-98.
[574] Ibid.
[575] Sasieni P, Fielder H, Rose B. Liquid-based versus conventional cervical cytology. *The Lancet*. 2006; 367: 1481.
[576] Imrie J, Colquhoun C. Liquid-based versus conventional cervical cytology. *The Lancet*. 2006; 367: 1481.
[577] BC Cancer Cervix Screening. *BC Cancer Cervix Screening 2018 Program Results*. March 2020. Available online at http://www.bccancer.bc.ca/screening/Documents/Cervix-Program-Results-2018.pdf. Accessed January 2023.
[578] Sass M. Use of a liquid-based, thin-layer Pap test in a community hospital: Impact on cytology performance and productivity. *Acta Cytologica*. 2004; 48(1): 17-22.
[579] BC Cancer, Provincial Laboratory Medicine Services. *News Bulletin: A Rapid Transition to Liquid Based Cytology for Pap Tests is Underway*. October 2022. Available online at http://www.bccancer.bc.ca/lab-services-site/Documents/20221019%20LBC%20Transition%20info%20kit%20FINAL.docx.pdf. Accessed January 2023.
[580] Arbyn M, Bergeron C. Klinkhamer P et al. Liquid compared with conventional cervical cytology: A systematic review and meta-analysis. *Obstetrics & Gynecology*. 2008; 111(1): 167-77.

al.[581] We then generated a sensitivity of 0.899 and a specificity of 0.899 for hrHPV-based testing for the detection of CIN2+ using data from Koliopoulos et al.[582] These results were applied in an environment in which 0.62% (or 62 out of 10,000) females would be diagnosed with CIN2+.[583]

In this example, 27 of the 62 females with CIN2+ would receive a negative result (a false negative) with cytology-based or LBC screening while just 6 would receive a false negative result with HPV-based screening (see Table 24). On the other hand, 313 of the females who did not have CIN2+ would receive a positive result (a false positive) with cytology-based / LBC screening but this would increase to 1,006 females with HPV-based screening. The ability of HPV-based testing to reduce the false-negative rate (from 27 to 6 in our example) is clearly a benefit. The higher false-positive rate (1,006 with HPV vs 313 with conventional / LBC screening), however, is a challenge as these false-positive results will likely lead to unnecessary follow-up testing and treatment.

Table 24: Comparison of Screening Tests in Detecting CIN2+

Conventional / Liquid-Based Cytology

Test Result	Disease Present	Disease NOT Present	Total	Sensitivity =	0.561
Positive	35	313	348	Specificity =	0.968
Negative	27	9,625	9,652		
Total	***62***	***9,938***	10,000		

HPV-Based Screening

Test Result	Disease Present	Disease NOT Present	Total	Sensitivity =	0.899
Positive	56	1,006	1,062	Specificity =	0.899
Negative	6	8,932	8,938		
Total	***62***	***9,938***	10,000		

Effectiveness of HPV-Based Screening

The HPV FOCAL RCT in BC assessed the relative effectiveness of primary HPV testing versus LBC. A total of 19,009 females were randomized to either the intervention group (primary HPV testing, N=9,552) or the control group (LBC, N=9,457). At 48 months follow-up, the incidence rate of CIN3+ was 2.3 / 1,000 in the intervention group versus 5.5 / 1,000 in the control group. That is, the use of primary HPV testing compared with LBC resulted in a significantly lower likelihood of CIN3+ at 48 months.[584]

The benefits of HPV-based screening are also clearly indicated in the study by Ronco and colleagues.[585] Based on a median follow-up of 6.5 years of four European randomised controlled trials comparing cytology-based with HPV-based screening for cervical cancers,

[581] Arbyn M, Bergeron C. Klinkhamer P et al. Liquid compared with conventional cervical cytology: A systematic review and meta-analysis. *Obstetrics & Gynecology*. 2008; 111(1): 167-77.
[582] Koliopoulos G, Nyaga V, Santesso N et al. Cytology versus HPV testing for cervical cancer screening in the general population. *Cochrane Database of Systematic Reviews*. 2017; Issue 8(8): CD008587.
[583] Siebers A, Klinkhamer P, Grefte J et al. Comparison of liquid-based cytology with conventional cytology for detection of cervical cancer precursors: A randomized controlled trial. *JAMA*. 2009; 302(16): 1757-64.
[584] Ogilvie G, van Niekerk D, Krajden M et al. Effect of screening with primary cervical HPV testing vs cytology on high-grade cervical intraepithelial neoplasia at 48 months: The HPV FOCAL randomized clinical trial. *JAMA*. 2018; 320(1): 43-52.
[585] Ronco G, Dillner J, Elfstrom K et al. Efficacy of HPV-based screening for prevention of invasive cervical cancer: Follow-up of four European randomised controlled trials. *The Lancet*. 2014; 383: 524-32.

they found that HPV-based screening provides significantly greater protection against invasive cervical cancers compared with cytology-based screening. At 6.5 years follow-up, 44 invasive cervical cancers were identified in the group receiving HPV-based screening and 63 in the cytology-based screening, a comparative rate of 6.7 and 11.2 per 100,000 person-years (see Table 25). That is, more precursors were identified and treated in the HPV-based screening group leading to fewer invasive cancers. This is particularly noticeable for adenocarcinomas (AC), with a comparative rate of 1.4 and 4.5 per 100,000 person-years, indicating that HPV-based screening does identify the precursors for AC much more often than cytology-based screening. The benefits of HPV-based screening occur at all ages but are most pronounced between 30-34 years of age, with a comparative rate of 4.3 and 14.6 per 100,000 person-years (see Table 25).

Table 25: Cases of Invasive Cervical Cancers by Screening Methodology

6.5 Years of Follow-up

Screening	*Cancer Morphology*			*Time from Enrollment*			*Age at Enrollment (Years)*				
Methodology	SCC	AC	Total	≤2.5 Yrs	≥2.5 Yrs	Total	<30	30-34	35-49	≥50	Total
HPV-Based	35	9	44	25	19	44	3	5	25	11	44
Cytology-Based	38	25	63	27	36	63	2	15	32	14	63
Total	73	34	107	52	55	107	5	20	57	25	107
	per 100,000 person-years										
	SCC	AC	**Total**	≤2.5 Yrs	≥2.5 Yrs	**Total**	<30	30-34	35-49	≥50	Total
HPV-Based	5.4	1.4	6.7	10.7	4.5	6.7	5.5	4.3	7.8	6.8	6.7
Cytology-Based	6.8	4.5	11.2	13.3	10.0	11.2	5.7	14.6	11.4	9.9	11.2
Total	6.0	2.8	8.8	11.9	7.1	8.8	5.6	9.1	9.5	8.2	8.8

Does HPV-Based Screening Increase the Rate of Colposcopies?

Early results from Australia suggest that the colposcopy rate increased from 0.8% with cytology-based screening to 2.55% with HPV-based screening.[586] In the Netherlands the rate increased from 0.9% with cytology-based screening to 2.9% with HPV-based screening[587] and 2.1% to 6.6% in a region of Southern Denmark.[588]

These results suggest that the initial round of HPV-based screening increases the colposcopy referral rate by a factor of 2-3, likely due to the increased ability (sensitivity) of HPV-based screening to detect both incident and prevalent CIN2+ when compared to cytology-based screening. A key question is whether these higher colposcopy rates would continue in future rounds of HPV-based screening. Because of the 5-year period between screening intervals, few jurisdictions have real-world experience with colposcopy referral rates during a second or subsequent round of HPV-based screening. Australia, for example, adopted HPV-based screening in December of 2017 so they would now be in their sixth year post implementation (see following section).

An additional complexity in addressing this question is the role of vaccination. In jurisdictions with early adoption of vaccination, such as BC and Australia, females who have been vaccinated are now entering the 25-29 year old screening cohort. Vaccination has led to

[586] Machalek D, Garland S, Brotherton J et al. Very low prevalence of vaccine human papillomavirus types among 18- to 35-year old Australian women 9 years following implementation of vaccination. *Journal of Infectious Diseases*. 2018; 217: 1590-1600.

[587] Mayer P, Poljak M. Primary HPV-based cervical cancer screening in Europe: Implementation status, challenges, and future plans. *Clinical Microbiology and Infection*. 2020; 26: 579-83.

[588] Thomsen L, Kjar S, Munk C et al. Benefits and potential harms of human papillomavirus (HPV)-based cervical cancer screening: A real-world comparison of HPV testing versus cytology. *Acta Obstetricia et Gynecologica Scandinavica*. 2021; 100: 394-402.

a dramatic decrease in the incidence of infection with HPV 16 & 18. When HPV 16 and/or 18 are detected in an HPV-based screening program, the females are generally referred directly to colposcopy. Lower rates of HPV 16 & 18 infection lead to a lower number of referrals to colposcopy in the vaccinated cohort.

A number of modelling studies have attempted to determine whether HPV-based screening would increase the rate of colposcopies over the longer term. Work in BC, using early FOCAL study data, suggested that when compared with LBC, HPV-based screening would only increase long-term colposcopy rates in the 25-29 year old cohort. This early modelling study did not incorporate the effect of vaccination.[589]

In Australia, modellers have suggested that colposcopy volumes will increase by 46% by the 3rd round of HPV-screening when vaccination is ***not*** taken into account. When including vaccination in their model, they anticipated an initial increase of 23% during the 1st round but a steady state by the 3rd round.[590]

Modellers in Wales have assessed the longer-term demand for colposcopy after the introduction of HPV-based screening in the context of HPV vaccination. Their results suggest that the number of colposcopies will increase by about 1/3 during the 1st round of HPV-based screening. During subsequent rounds, the number of colposcopies are expected to decrease by about 1/3 from current rates, at least partially due to the role of vaccination. [591]

These models may be underestimating the effects of the transition from cytology-based to HPV-based screening, particularly since real world evidence suggests that colposcopy rates have increased by a factor of 2-3 with the implementation of HPV-based screening. It is also possible that jurisdictions that are early adopters of HPV-based screening have taken a more cautious approach in detecting and diagnosing CIN2+, thus increasing colposcopy rates.

In the BC based FOCAL trial, the intervention cohort received an HPV screen at both study entrance and exit (after 48 months). Longer term follow-up results with this cohort suggest that, after an initial increase in colposcopy referral rates associated with HPV-based screening, these rates will decrease significantly and then will level out over time, leading to cumulative referral rates similar to cytology-based screening programs. The authors note that the initial higher volume of colposcopies can be managed by thoughtful implementation of an HPV-based screening program, including the introduction of screening to cohorts by birth year, so that healthcare systems are not overwhelmed.[592]

In the Netherlands, HPV-based screening was implemented on January 1, 2017, Colposcopy referral rates were 2.9% that year, increasing to 3.1% in 2018 before declining modestly to 3.0% in 2019 and 2020 and 2.7% in 2021, the fifth year following implementation of HPV-based screening.[593]

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[589] Coldman A, Phillips N, van Niekerk D et al. Projected impact of HPV and LBC primary testing on rates of referral for colposcopy in a Canadian cervical cancer screening program. *Journal of Obstetrics and Gynaecology Canada.* 2015; 37(5): 412-20.

[590] Smith M, Gertig D, Hall M et al. Transitioning from cytology-based screening to HPV-based screening at longer intervals: Implications for resource use. *BJOG: An International Journal of Obstetrics and Gynaecology*. 2016; 16: 147

[591] Pesola F, Rebolj M, Leeson S et al. Introducing human papillomavirus (HPV) primary testing in the age of HPV vaccination: Projected impact on colposcopy services in Wales. *BJOG: An International Journal of Obstetrics and Gynaecology*. 2021; 128: 1226-35.

[592] Gottschlich A, Gondara L, Smith L et al. Evidence for a decrease in colposcopy referral post-introduction of primary screening with human papillomavirus testing in British Columbia. *Article in preparation*.

[593] Netherlands Comprehensive Cancer Organization. *National Monitoring of the Cervical Cancer Screening Programme in the Netherlands 2021*. Available online at https://www.rivm.nl/en/documenten/monitor-national-cervical-cancer-screening-programme-2021. Accessed April 2023.

Early Results from the Primary HPV Screening Program in Australia

In December of 2017, Australia's National Cervical Screening Program shifted from cytology-based screening to HPV-based screening. For context, Australia commenced its HPV vaccination program in 2007, with coverage of approximately 70% of the eligible population.[594] As noted earlier, BC commenced its vaccination program in September of 2008 and has also achieved vaccination coverage of 65-70%. In addition, the screening coverage rate for females ages 25-69 from 2018-2021 in Australia was 71.6%[595] compared with 68% in BC in 2018 (see Figure 4, both rates are adjusted for hysterectomies).

Based on the first six months of experience with primary HPV screening at a large community-based general pathology laboratory in Sydney, Australia, 7.91% of samples tested positive for an oncogenic HPV (see Table 26).[596] A total of 3,397 (2.17%) tested positive for HPV16 or 18. Of these 3,397, 63.6% (2,161) had no cervical abnormality based on reflex LBC, 21.0% (715) had a low grade cervical abnormality and 521 (15.3%) had a high grade cervical abnormality. A total of 8,990 (5.74%) tested positive for hrHPV other than HPV16 or 18. Of these 8,990, 64.8% (5825) had no cervical abnormality, 28.9% (2,600) had a low grade cervical abnormality and 565 (6.3%) had a high grade cervical abnormality (see Table 26).

Table 26: Age-Specific Prevalance of Oncogenic HPV and Cervical Abnormality
Based on Primary HPV Screening Tests and Reflex LBC
Australia, December 2017 to May 2018

				Abnormality After HPV16/18+								Abnormality After Other hrHPV+							
Age	Screening	HPV16/18+		None		Low Grade*		High Grade#		Other hrHPV+		None		Low Grade*		High Grade#		Total HPV+	
Group	Tests	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
25-29	16,368	306	*1.87%*	153	*50.0%*	88	*28.8%*	65	*21.2%*	2,655	*16.22%*	1,603	*60.4%*	881	*33.2%*	171	*6.4%*	2,961	*18.09%*
30-34	20,216	562	*2.78%*	302	*53.7%*	138	*24.6%*	122	*21.7%*	1,811	*8.96%*	1,117	*61.7%*	551	*30.4%*	143	*7.9%*	2,373	*11.74%*
35-39	19,446	466	*2.40%*	268	*57.5%*	107	*23.0%*	91	*19.5%*	1,112	*5.72%*	699	*62.9%*	334	*30.0%*	79	*7.1%*	1,578	*8.11%*
40-44	18,246	455	*2.49%*	279	*61.3%*	97	*21.3%*	79	*17.4%*	826	*4.53%*	520	*63.0%*	246	*29.8%*	60	*7.3%*	1,281	*7.02%*
45-49	18,739	388	*2.07%*	240	*61.9%*	101	*26.0%*	47	*12.1%*	678	*3.62%*	430	*63.4%*	214	*31.6%*	34	*5.0%*	1,066	*5.69%*
50-54	16,576	340	*2.05%*	231	*67.9%*	68	*20.0%*	41	*12.1%*	575	*3.47%*	390	*67.8%*	151	*26.3%*	34	*5.9%*	915	*5.52%*
55-59	16,745	336	*2.01%*	257	*76.5%*	56	*16.7%*	23	*6.8%*	524	*3.13%*	414	*79.0%*	95	*18.1%*	15	*2.9%*	860	*5.14%*
60-64	14,576	260	*1.78%*	206	*79.2%*	30	*11.5%*	24	*9.2%*	409	*2.81%*	335	*81.9%*	61	*14.9%*	13	*3.2%*	669	*4.59%*
65-69	11,924	207	*1.74%*	164	*79.2%*	26	*12.6%*	17	*8.2%*	300	*2.52%*	234	*78.0%*	55	*18.3%*	11	*3.7%*	507	*4.25%*
70-74	3,847	77	*2.00%*	61	*79.2%*	4	*5.2%*	12	*15.6%*	100	*2.60%*	83	*83.0%*	12	*12.0%*	5	*5.0%*	177	*4.60%*
Total	**156,683**	**3,397**	***2.17%***	**2,161**	***63.6%***	**715**	***21.0%***	**521**	***15.3%***	**8,990**	***5.74%***	**5,825**	***64.8%***	**2,600**	***28.9%***	**565**	***6.3%***	**12,387**	***7.91%***

** Low grade sqaumous intraepithelial lesion (LSIL) or possible LSIL # High grade sqaumous intraepithelial lesion (HSIL), possible HSIL, adenacarcinoma in situ or cancer.*

Based on the results in Table 26, individuals were grouped into low, intermediate and high risk (see Table 27). Low risk indicates that no oncogenic HPV was detected. The recommendation for these individuals is to re-test in 5 years. Intermediate risk indicates that an oncogenic HPV has been detected other than HPV16 or 18 and the reflex LBC result is negative or low grade abnormality. The recommendation for these individuals is to re-test in 12 months. Higher risk indicates that HPV16 or 18 has been detected or other hrHPV has

[594] Machalek D, Garland S, Brotherton J et al. Very low prevalence of vaccine human papillomavirus types among 18- to 35-year old Australian women 9 years following implementation of vaccination. *Journal of Infectious Diseases*. 2018; 217: 1590-1600.

[595] Australian Institute of Health and Welfare. *National Cervical Screening Program Monitoring Report* 2022, catalogue number CAN 149, AIHW, Australian Government. Available online at https://www.aihw.gov.au/getmedia/5c42bc77-589b-42ef-9bbd-fd91890e4920/aihw-can-149-NCSP-2022.pdf.aspx?inline=true. Accessed March 2023.

[596] The samples were tested for HPV types 16/18/31/33/35/39/45/51/52/56/58/59/66/68.

been detected and the reflex LBC result is high grade abnormality. The recommendation for these individuals is immediate referral to colposcopy.[597]

Table 27: Age-Specific Risk Classification
Based on Primary HPV Screening Tests and Reflex LBC
Australia, December 2017 to May 2018

Age Group	Screening Tests	Low Risk		Intermediate Risk		High Risk		Unsatisfactory	
		#	%	#	%	#	%	#	%
25-29	16,389	13,402	*81.77%*	2,484	*15.16%*	478	*2.92%*	25	*0.15%*
30-34	20,239	17,830	*88.10%*	1,668	*8.24%*	710	*3.51%*	31	*0.15%*
35-39	19,469	17,858	*91.73%*	1,033	*5.31%*	552	*2.84%*	26	*0.13%*
40-44	18,260	16,962	*92.89%*	766	*4.19%*	516	*2.83%*	16	*0.09%*
45-49	18,760	17,665	*94.16%*	644	*3.43%*	428	*2.28%*	23	*0.12%*
50-54	16,588	15,653	*94.36%*	541	*3.26%*	378	*2.28%*	16	*0.10%*
55-59	16,753	15,871	*94.74%*	509	*3.04%*	358	*2.14%*	15	*0.09%*
60-64	14,590	13,893	*95.22%*	396	*2.71%*	280	*1.92%*	21	*0.14%*
65-69	11,942	11,405	*95.50%*	289	*2.42%*	222	*1.86%*	26	*0.22%*
70-74	3,850	3,663	*95.14%*	95	*2.47%*	84	*2.18%*	6	*0.16%*
Total	**156,840**	**144,202**	***91.94%***	**8,425**	***5.37%***	**4,006**	***2.55%***	**205**	***0.13%***

Based on the results in Table 27, repeat testing after 12 months was recommended for 5.37% and immediate referral to colposcopy was recommended for 2.55%.

Results similar to those in Table 27 are shown for all of Australia in 2021 in Table 28.[598]

Table 28: Age-Specific Risk Classification
Based on Primary HPV Screening Tests and Reflex LBC
Australia, 2021

Age Group	Screening Tests	Low Risk		Intermediate Risk		High Risk		Unsatisfactory	
		#	%	#	%	#	%	#	%
25-29	111,351	89,925	*80.8%*	18,550	*16.66%*	2,552	*2.29%*	324	*0.29%*
30-34	77,145	66,988	*86.8%*	7,427	*9.63%*	2,495	*3.23%*	235	*0.30%*
35-39	67,954	61,393	*90.3%*	4,362	*6.42%*	1,974	*2.90%*	225	*0.33%*
40-44	53,586	48,809	*91.1%*	2,898	*5.41%*	1,719	*3.21%*	160	*0.30%*
45-49	49,224	45,426	*92.3%*	2,297	*4.67%*	1,356	*2.75%*	145	*0.29%*
50-54	41,487	38,446	*92.7%*	1,762	*4.25%*	1,129	*2.72%*	150	*0.36%*
55-59	33,604	31,195	*92.8%*	1,322	*3.93%*	907	*2.70%*	180	*0.54%*
60-64	28,386	26,362	*92.9%*	1,057	*3.72%*	805	*2.84%*	162	*0.57%*
65-69	20,898	19,457	*93.1%*	738	*3.53%*	583	*2.79%*	120	*0.57%*
70-74	18,523	17,431	*94.1%*	516	*2.79%*	470	*2.54%*	106	*0.57%*
Total	**502,158**	**445,432**	***88.7%***	**40,929**	***8.15%***	**13,990**	***2.79%***	**1,807**	***0.36%***

[597] Farnsworth A, Roberts J, Garland S et al. Detection of high-grade cervical disease among women referred directly to colposcopy after a positive HPV screening test varies with age and cytology findings. *International Journal of Cancer*. 2020; 147: 3068-74.

[598] Australian Institute of Health and Welfare. *National Cervical Screening Program Monitoring Report* 2022, catalogue number CAN 149, AIHW, Australian Government. Available online at https://www.aihw.gov.au/getmedia/5c42bc77-589b-42ef-9bbd-fd91890e4920/aihw-can-149-NCSP-2022.pdf.aspx?inline=true. Accessed March 2023.

Clinically Preventable Burden – HPV-Based Screening

BC Birth Cohort of 40,000

HPV Model Assumptions

In modelling the CPB of moving to HPV-based screening in a BC birth cohort of 40,000 (20,000 females), we made the following assumptions:

- The age-specific screening rate would remain the same as the cytology-based screening model except that screening would now take place once every 5 years rather than once every 3 years.
- The age-specific proportion of unsatisfactory screens would be the same as observed in Australia in 2021 (see Table 28).
- The age-specific risk classification (intermediate- and high-risk) would be the same as in Australia in 2021 (see Table 28).
- Of those at intermediate risk, the following proportion would receive a second screen within 12 months, based on results from BC in 2018 (see Table 8):[599]
    - Ages 25-29 – 85.1%
    - Ages 30-39 – 84.5%
    - Ages 40-49 – 85.4%
    - Ages 50-59 – 86.6%
    - Ages 60-69 – 88.5%
- Of those at intermediate risk with a second screen, the following proportion would receive a colposcopy within one year, based on results from BC in 2018 (see Table 8):[600]
    - Ages 25-29 – 13.6%
    - Ages 30-39 – 14.2%
    - Ages 40-49 – 12.2%
    - Ages 50-59 – 11.6%
    - Ages 60-69 – 8.6%
- Of those at high risk based on the initial screen, the following proportion would receive a colposcopy within one year, based on results from BC in 2018 (see Table 8):[601]
    - Ages 25-29 – 98.1%
    - Ages 30-39 – 98.5%
    - Ages 40-49 – 89.3%
    - Ages 50-59 – 71.1%
    - Ages 60-69 – 67.7%
- The age-specific proportion of screens resulting in a high grade abnormality (CIN2+) requiring treatment is as follows, based on results from Australia in 2021:[602]
    - Ages 25-29 – 2.00%

[599] BC Cancer Cervix Screening. *BC Cancer Cervix Screening 2018 Program Results*. March 2020. Available online at http://www.bccancer.bc.ca/screening/Documents/Cervix-Program-Results-2018.pdf. Accessed April 2023.
[600] Ibid.
[601] Ibid.
[602] Australian Institute of Health and Welfare. *National Cervical Screening Program Monitoring Report* 2022 catalogue number CAN 149, AIHW, Australian Government. Table A11.1. Available online at https://www.aihw.gov.au/getmedia/5c42bc77-589b-42ef-9bbd-fd91890e4920/aihw-can-149-NCSP-2022.pdf.aspx?inline=true. Accessed April 2023.

    - Ages 30-34 – 2.47%
    - Ages 35-39 – 2.12%
    - Ages 40-44 – 1.88%
    - Ages 45-49 – 1.26%
    - Ages 50-54 – 0.88%
    - Ages 55-59 – 0.82%
    - Ages 60-64 – 0.79%
    - Ages 65-59 – 0.66%
- A treatment recurrence rate of 6.7%.[603]
- HPV-based screening would result in an overall reduction in the incidence of SCC of 20.9% and of all other cancers of 69.1%, compared with conventional cytology (see Table 25). These reductions would vary by age, with no change between the ages of 25-29, a 70.9% reduction between ages 30-34, a 30.9% reduction between ages 35-49 and a 31.6% reduction after age 50 (see Table 25).
- The proportion of individuals with cervical cancer who die would remain the same as in the cytology-based screening model.

HPV Model Results

The above assumptions were used in the HPV model in a BC birth cohort of 20,000 females between the ages of 25 and 69 for screening, and to age 74 for cervical cancer incidence and mortality (see Table 29).

Within this cohort, we would expect 101,328 initial screens with an additional 389 repeat screens due to unsatisfactory samples and 5,764 follow-up screens within a year following an intermediate risk classification (see Table 29). The total number of screens (107,481) is 37.2% (63,749) lower than the 171,230 screens with cytology-based screening (see Table 9).

A total of 6,742 females would receive an intermediate risk screening result and 5,764 would return in approximately a year for a follow-up (repeat) screen. Of these 5,764 females, 735 (12.8%) would go on to receive a colposcopy. A total of 2,880 females would receive an original high risk screening result. Of these, 2,450 (85.1%) would receive a colposcopy (see Table 29). The total number of colposcopies (3,185) is 24.0% (616) higher than the 2,569 colposcopies with cytology-based screening (see Table 9).

A total of 1,523 females would ultimately be diagnosed with CIN2+ and would receive treatment. 102 (6.7%) of these females would have follow-up treatment due to the failure of their original treatment (see Table 29). The total number of treatments for CIN2+ (1,625) is 23.0% (304) higher than the 1,321 colposcopies with cytology-based screening (see Table 9).

Of the 1,523 females with a diagnosis of CIN2+, 64.6 would ultimately be diagnosed with an invasive cervical cancer (see Table 29). This number is 34.5% lower (34.0) than the 98.6 invasive cervical cancer expected with cytology-based screening (see Table 5).

Of the 64.6 females diagnosed with cancer, 16.8 will die from their cervical cancer, losing an average of 31.3 life years (see Table 29). This number is 32.8% lower (8.0) than the 24.8 deaths due to cervical cancer expected with cytology-based screening (see Table 6).

[603] Arbyn M, Redman C, Verdoodt F et al. Incomplete excision of cervical precancer as a predictor of treatment failure: A systematic review and meta-analysis. *Lancet Oncology*. 2017; 18: 1665-79.

Table 29: Screening for Cervical Cancer

Primary hrHPV-Based Screening

in a British Columbia Birth Cohort of 20,000 Women

	Females				*Screening*						*Screening Results by Risk*				*12-Month*	
	in Birth	***Hysterectomies***		Potential		# Up To	Annual	Unsatisfactory		Intermediate		High		***Follow-up***	
Age	Cohort	%	#	Cohort	Rate	Date	Screens	%	#	%	#	%	#	*%*	#
25	19,843	0.5%	89	19,754	57%	11,260	2,252	0.29%	7	16.7%	375	2.3%	52	85.1%	319
26	19,834	0.5%	104	19,730	57%	11,246	2,249	0.29%	7	16.7%	375	2.3%	52	85.1%	319
27	19,825	0.6%	119	19,706	57%	11,233	2,247	0.29%	7	16.7%	374	2.3%	51	85.1%	318
28	19,816	0.7%	134	19,682	57%	11,219	2,244	0.29%	7	16.7%	374	2.3%	51	85.1%	318
29	19,806	0.8%	149	19,657	57%	11,205	2,241	0.29%	7	16.7%	373	2.3%	51	85.1%	318
30	19,796	1.0%	202	19,594	69%	13,520	2,704	0.30%	8	9.6%	260	3.2%	87	84.5%	220
31	19,785	1.5%	306	19,479	69%	13,440	2,688	0.30%	8	9.6%	259	3.2%	87	84.5%	219
32	19,773	2.1%	410	19,364	69%	13,361	2,672	0.30%	8	9.6%	257	3.2%	86	84.5%	217
33	19,761	2.6%	513	19,248	69%	13,281	2,656	0.30%	8	9.6%	256	3.2%	86	84.5%	216
34	19,749	3.1%	617	19,132	69%	13,201	2,640	0.30%	8	9.6%	254	3.2%	85	84.5%	215
35	19,736	3.7%	720	19,015	69%	13,121	2,624	0.33%	9	6.4%	168	2.9%	76	84.5%	142
36	19,722	4.2%	824	18,899	69%	13,040	2,608	0.33%	9	6.4%	167	2.9%	76	84.5%	141
37	19,708	4.7%	927	18,781	69%	12,959	2,592	0.33%	9	6.4%	166	2.9%	75	84.5%	141
38	19,693	5.2%	1,030	18,663	69%	12,878	2,576	0.33%	9	6.4%	165	2.9%	75	84.5%	140
39	19,677	5.8%	1,132	18,545	69%	12,796	2,559	0.33%	8	6.4%	164	2.9%	74	84.5%	139
40	19,661	7.1%	1,392	18,269	69%	12,606	2,521	0.30%	8	5.4%	136	3.2%	81	85.4%	116
41	19,643	8.4%	1,651	17,993	69%	12,415	2,483	0.30%	7	5.4%	134	3.2%	80	85.4%	115
42	19,625	9.7%	1,909	17,716	69%	12,224	2,445	0.30%	7	5.4%	132	3.2%	78	85.4%	113
43	19,605	11.1%	2,167	17,438	69%	12,032	2,406	0.30%	7	5.4%	130	3.2%	77	85.4%	111
44	19,584	12.4%	2,424	17,160	69%	11,840	2,368	0.30%	7	5.4%	128	3.2%	76	85.4%	109
45	19,561	13.7%	2,681	16,881	69%	11,648	2,330	0.29%	7	4.7%	109	2.8%	64	85.4%	93
46	19,537	14.3%	2,787	16,750	69%	11,558	2,312	0.29%	7	4.7%	108	2.8%	64	85.4%	92
47	19,511	14.8%	2,892	16,619	69%	11,467	2,293	0.29%	7	4.7%	107	2.8%	63	85.4%	91
48	19,484	15.4%	2,997	16,486	69%	11,376	2,275	0.29%	7	4.7%	106	2.8%	63	85.4%	91
49	19,454	15.9%	3,102	16,352	69%	11,283	2,257	0.29%	7	4.7%	105	2.8%	62	85.4%	90
50	19,422	16.5%	3,205	16,217	70%	11,352	2,270	0.36%	8	4.2%	96	2.7%	62	86.6%	83
51	19,388	17.1%	3,308	16,080	70%	11,256	2,251	0.36%	8	4.2%	96	2.7%	61	86.6%	83
52	19,352	17.6%	3,411	15,941	70%	11,159	2,232	0.36%	8	4.2%	95	2.7%	61	86.6%	82
53	19,312	18.2%	3,512	15,800	70%	11,060	2,212	0.36%	8	4.2%	94	2.7%	60	86.6%	81
54	19,270	18.7%	3,612	15,658	70%	10,960	2,192	0.36%	8	4.2%	93	2.7%	60	86.6%	81
55	19,224	19.3%	3,711	15,513	70%	10,859	2,172	0.54%	12	3.9%	85	2.7%	59	86.6%	74
56	19,174	20.5%	3,933	15,241	70%	10,669	2,134	0.54%	11	3.9%	84	2.7%	58	86.6%	73
57	19,121	21.7%	4,154	14,967	70%	10,477	2,095	0.54%	11	3.9%	82	2.7%	57	86.6%	71
58	19,063	22.9%	4,372	14,691	70%	10,284	2,057	0.54%	11	3.9%	81	2.7%	56	86.6%	70
59	19,000	24.1%	4,587	14,413	70%	10,089	2,018	0.54%	11	3.9%	79	2.7%	54	86.6%	69
60	18,932	25.4%	4,800	14,132	72%	10,175	2,035	0.57%	12	3.7%	76	2.8%	58	88.5%	67
61	18,858	26.6%	5,009	13,848	72%	9,971	1,994	0.57%	11	3.7%	74	2.8%	57	88.5%	66
62	18,777	27.8%	5,215	13,562	72%	9,765	1,953	0.57%	11	3.7%	73	2.8%	55	88.5%	64
63	18,689	29.0%	5,417	13,272	72%	9,556	1,911	0.57%	11	3.7%	71	2.8%	54	88.5%	63
64	18,593	30.2%	5,614	12,979	72%	9,345	1,869	0.57%	11	3.7%	70	2.8%	53	88.5%	62
65	18,489	31.4%	5,806	12,683	72%	9,131	1,826	0.57%	10	3.5%	64	2.8%	51	88.5%	57
66	18,375	32.6%	5,993	12,382	72%	8,915	1,783	0.57%	10	3.5%	63	2.8%	50	88.5%	56
67	18,250	33.8%	6,173	12,077	72%	8,695	1,739	0.57%	10	3.5%	61	2.8%	49	88.5%	54
68	18,113	35.0%	6,346	11,767	72%	8,472	1,694	0.57%	10	3.5%	60	2.8%	47	88.5%	53
69	17,963	36.2%	6,511	11,452	72%	8,246	1,649	0.57%	9	3.5%	58	2.8%	46	88.5%	52
70	17,799	36.2%	6,451												
71	17,619	36.2%	6,386												
72	17,421	36.2%	6,314												
73	17,204	36.2%	6,235												
74	16,966	36.2%	6,149												
Total							**101,328**	**0.38%**	**389**	**6.65%**	**6,742**	**2.84%**	**2,880**	**85.5%**	**5,764**

Table 29: Screening for Cervical Cancer (continued)

Primary hrHPV-Based Screening

in a British Columbia Birth Cohort of 20,000 Women

Age	Females in Birth Cohort	*Colposcopies by Risk* Intermediate %	Intermediate #	High %	High #	*CIN2+* %	*CIN2+* #	Treatment Recurrence 6.7%	*Incidence of CC*	*Mortality Due to CC* #	LE	LYL
25	19,843	13.6%	43	98.1%	51	2.00%	45	3.0	0.6	0.1	60.5	6.2
26	19,834	13.6%	43	98.1%	51	2.00%	45	3.0	0.9	0.1	59.6	6.1
27	19,825	13.6%	43	98.1%	51	2.00%	45	3.0	1.4	0.1	58.6	6.0
28	19,816	13.6%	43	98.1%	50	2.00%	45	3.0	1.2	0.1	57.6	5.9
29	19,806	13.6%	43	98.1%	50	2.00%	45	3.0	1.6	0.1	56.6	5.8
30	19,796	14.2%	31	98.5%	86	2.47%	67	4.5	0.7	0.1	55.7	3.3
31	19,785	14.2%	31	98.5%	86	2.47%	67	4.5	0.7	0.1	54.7	3.3
32	19,773	14.2%	31	98.5%	85	2.47%	66	4.4	0.7	0.1	53.7	3.2
33	19,761	14.2%	31	98.5%	85	2.47%	66	4.4	0.7	0.1	52.8	3.2
34	19,749	14.2%	31	98.5%	84	2.47%	65	4.4	0.7	0.1	51.8	3.1
35	19,736	14.2%	20	98.5%	75	2.12%	56	3.7	1.7	0.2	50.8	10.2
36	19,722	14.2%	20	98.5%	75	2.12%	55	3.7	1.7	0.2	49.9	10.0
37	19,708	14.2%	20	98.5%	74	2.12%	55	3.7	1.7	0.2	48.9	9.8
38	19,693	14.2%	20	98.5%	74	2.12%	55	3.7	1.7	0.2	47.9	9.6
39	19,677	14.2%	20	98.5%	73	2.12%	54	3.6	1.7	0.2	47.0	9.4
40	19,661	12.2%	14	89.3%	72	1.88%	47	3.2	1.8	0.3	46.0	13.5
41	19,643	12.2%	14	89.3%	71	1.88%	47	3.1	1.8	0.3	45.1	13.2
42	19,625	12.2%	14	89.3%	70	1.88%	46	3.1	1.8	0.3	44.1	12.9
43	19,605	12.2%	14	89.3%	69	1.88%	45	3.0	1.8	0.3	43.1	12.7
44	19,584	12.2%	13	89.3%	68	1.88%	45	3.0	1.8	0.3	42.2	12.4
45	19,561	12.2%	11	89.3%	57	1.26%	29	2.0	1.8	0.4	41.2	14.9
46	19,537	12.2%	11	89.3%	57	1.26%	29	1.9	1.8	0.4	40.3	14.5
47	19,511	12.2%	11	89.3%	56	1.26%	29	1.9	1.8	0.4	39.3	14.2
48	19,484	12.2%	11	89.3%	56	1.26%	29	1.9	1.8	0.4	38.4	13.8
49	19,454	12.2%	11	89.3%	56	1.26%	28	1.9	1.8	0.4	37.4	13.4
50	19,422	11.6%	10	71.1%	44	0.88%	20	1.3	1.3	0.4	36.5	16.2
51	19,388	11.6%	10	71.1%	44	0.88%	20	1.3	1.3	0.4	35.6	15.8
52	19,352	11.6%	9	71.1%	43	0.88%	20	1.3	1.3	0.4	34.6	15.4
53	19,312	11.6%	9	71.1%	43	0.88%	20	1.3	1.3	0.4	33.7	14.9
54	19,270	11.6%	9	71.1%	42	0.88%	19	1.3	1.3	0.4	32.8	14.5
55	19,224	11.6%	9	71.1%	42	0.82%	18	1.2	1.3	0.4	31.9	13.6
56	19,174	11.6%	8	71.1%	41	0.82%	17	1.2	1.3	0.4	30.9	13.2
57	19,121	11.6%	8	71.1%	40	0.82%	17	1.1	1.3	0.4	30.0	12.8
58	19,063	11.6%	8	71.1%	39	0.82%	17	1.1	1.3	0.4	29.1	12.3
59	19,000	11.6%	8	71.1%	39	0.82%	16	1.1	1.3	0.4	28.2	11.9
60	18,932	8.6%	6	67.7%	39	0.79%	16	1.1	1.2	0.4	27.3	11.8
61	18,858	8.6%	6	67.7%	38	0.79%	16	1.1	1.2	0.4	26.4	11.3
62	18,777	8.6%	6	67.7%	37	0.79%	15	1.0	1.2	0.4	25.5	10.9
63	18,689	8.6%	5	67.7%	37	0.79%	15	1.0	1.2	0.4	24.6	10.5
64	18,593	8.6%	5	67.7%	36	0.79%	15	1.0	1.2	0.4	23.8	10.1
65	18,489	8.6%	5	67.7%	34	0.66%	12	0.8	1.2	0.5	22.9	11.4
66	18,375	8.6%	5	67.7%	34	0.66%	12	0.8	1.2	0.5	22.0	10.9
67	18,250	8.6%	5	67.7%	33	0.66%	11	0.8	1.2	0.5	21.2	10.4
68	18,113	8.6%	5	67.7%	32	0.66%	11	0.7	1.2	0.5	20.3	9.9
69	17,963	8.6%	4	67.7%	31	0.66%	11	0.7	1.1	0.5	19.5	9.4
70	17,799								0.9	0.6	18.7	10.6
71	17,619								0.9	0.6	17.9	10.0
72	17,421								0.9	0.6	17.1	9.4
73	17,204								0.9	0.5	16.3	8.9
74	16,966								0.9	0.5	15.5	8.4
Total		**12.8%**	**735**	**85.1%**	**2,450**	**1.50%**	**1,523**	**102**	**64.6**	**16.8**	**31.3**	**525**

Quality-Adjusted Life Years Lost with HPV-Based Screening

- The diagnosis and treatment phase for cervical cancer lasts an average of 4.8 months[604] and is associated with a utility loss of 0.288 (95% CI of 0.193 to 0.399).[605]
- The ongoing, controlled phase (remission) for cervical cancer is associated with a utility loss of 0.049 (95% CI of 0.031 to 0.072).[606]
- The metastatic phase for cervical cancer lasts an average of 9.2 months[607] and is associated with a utility loss of 0.451 (95% CI of 0.307 to 0.600).[608]

In a BC birth cohort of 20,000 females, HPV-based screening would be associated with 64.6 incident cervical cancers and 16.8 deaths (see Table 29).

Applying the above changes in quality of life (QoL) related with the various phases of cervical cancer treatment suggests that the incident cervical cancers are associated with 125 QALYs lost while the 16.8 deaths are associated with 525 QALYs lost (see Table 30).

The total 650 QALYs lost with an HPV-based screening program compare to 978 QALYS lost (195 associated with incident cervical cancers and 783 with deaths) with a cytology-based screening program (see Table 19).

[604] Fitzmaurice C, Allen C, Barber R et al. Global, regional, and national cancer incidence, mortality, years of life lost, years lived with disability, and disability-adjusted life-years for 32 cancer groups, 1990 to 2015: a systematic analysis for the global burden of disease study. *Journal of American Medical Association Oncology*. 2017; 3(4): 524-48.
[605] Institute for Health Metrics and Evaluation. *GBD 2016 sequelae, health states, health state lay descriptions, and disability weights*. Available online at http://ghdx.healthdata.org/record/global-burden-disease-study-2016-gbd-2016-disability-weights. Accessed October 2017.
[606] Fitzmaurice C, Allen C, Barber R et al. Global, regional, and national cancer incidence, mortality, years of life lost, years lived with disability, and disability-adjusted life-years for 32 cancer groups, 1990 to 2015: a systematic analysis for the global burden of disease study. *Journal of American Medical Association Oncology*. 2017; 3(4): 524-48.
[607] Ibid.
[608] Institute for Health Metrics and Evaluation. *GBD 2016 sequelae, health states, health state lay descriptions, and disability weights*. Available online at http://ghdx.healthdata.org/record/global-burden-disease-study-2016-gbd-2016-disability-weights. Accessed October 2017.

Table 30: Screening for Cervical Cancer
hrHPV Model - QALYs Lost
in a British Columbia Birth Cohort of 20,000 Women

Age	Females in Birth Cohort	Incident Cervical Cancers	D&T QALYs Lost	RP QALYs Lost	MP QALYs Lost	QALYs Lost	Deaths	LE	LYL	***Total QALYs Lost***
25	19,843	0.6	0.1	1.7	0.0	1.8	0.1	60.5	6.2	**8.0**
26	19,834	0.9	0.1	2.4	0.0	2.6	0.1	59.6	6.1	**8.7**
27	19,825	1.4	0.2	4.2	0.0	4.4	0.1	58.6	6.0	**10.4**
28	19,816	1.2	0.2	3.4	0.0	3.6	0.1	57.6	5.9	**9.5**
29	19,806	1.6	0.2	4.4	0.0	4.6	0.1	56.6	5.8	**10.4**
30	19,796	0.7	0.1	2.0	0.0	2.1	0.1	55.7	3.3	**5.5**
31	19,785	0.7	0.1	2.0	0.0	2.1	0.1	54.7	3.3	**5.4**
32	19,773	0.7	0.1	2.0	0.0	2.1	0.1	53.7	3.2	**5.3**
33	19,761	0.7	0.1	1.9	0.0	2.0	0.1	52.8	3.2	**5.2**
34	19,749	0.7	0.1	1.9	0.0	2.0	0.1	51.8	3.1	**5.1**
35	19,736	1.7	0.2	4.2	0.1	4.5	0.2	50.8	10.2	**14.7**
36	19,722	1.7	0.2	4.1	0.1	4.4	0.2	49.9	10.0	**14.4**
37	19,708	1.7	0.2	4.0	0.1	4.3	0.2	48.9	9.8	**14.1**
38	19,693	1.7	0.2	4.0	0.1	4.3	0.2	47.9	9.6	**13.9**
39	19,677	1.7	0.2	3.9	0.1	4.2	0.2	47.0	9.4	**13.6**
40	19,661	1.8	0.2	3.9	0.1	4.3	0.3	46.0	13.5	**17.8**
41	19,643	1.8	0.2	3.8	0.1	4.2	0.3	45.1	13.2	**17.5**
42	19,625	1.8	0.2	3.8	0.1	4.1	0.3	44.1	12.9	**17.1**
43	19,605	1.8	0.2	3.7	0.1	4.0	0.3	43.1	12.7	**16.7**
44	19,584	1.8	0.2	3.6	0.1	3.9	0.3	42.2	12.4	**16.3**
45	19,561	1.8	0.2	3.3	0.1	3.7	0.4	41.2	14.9	**18.6**
46	19,537	1.8	0.2	3.3	0.1	3.6	0.4	40.3	14.5	**18.2**
47	19,511	1.8	0.2	3.2	0.1	3.6	0.4	39.3	14.2	**17.7**
48	19,484	1.8	0.2	3.1	0.1	3.5	0.4	38.4	13.8	**17.3**
49	19,454	1.8	0.2	3.0	0.1	3.4	0.4	37.4	13.4	**16.8**
50	19,422	1.3	0.2	1.8	0.2	2.2	0.4	36.5	16.2	**18.5**
51	19,388	1.3	0.2	1.8	0.2	2.2	0.4	35.6	15.8	**18.0**
52	19,352	1.3	0.2	1.7	0.2	2.1	0.4	34.6	15.4	**17.5**
53	19,312	1.3	0.2	1.7	0.2	2.1	0.4	33.7	14.9	**17.0**
54	19,270	1.3	0.2	1.6	0.2	2.0	0.4	32.8	14.5	**16.5**
55	19,224	1.3	0.2	1.6	0.2	2.0	0.4	31.9	13.6	**15.6**
56	19,174	1.3	0.2	1.6	0.2	1.9	0.4	30.9	13.2	**15.1**
57	19,121	1.3	0.2	1.5	0.2	1.9	0.4	30.0	12.8	**14.6**
58	19,063	1.3	0.2	1.5	0.2	1.8	0.4	29.1	12.3	**14.2**
59	19,000	1.3	0.2	1.4	0.2	1.8	0.4	28.2	11.9	**13.7**
60	18,932	1.2	0.2	1.3	0.2	1.7	0.4	27.3	11.8	**13.4**
61	18,858	1.2	0.2	1.3	0.2	1.6	0.4	26.4	11.3	**13.0**
62	18,777	1.2	0.2	1.2	0.2	1.6	0.4	25.5	10.9	**12.5**
63	18,689	1.2	0.2	1.2	0.2	1.5	0.4	24.6	10.5	**12.0**
64	18,593	1.2	0.2	1.1	0.2	1.5	0.4	23.8	10.1	**11.5**
65	18,489	1.2	0.2	1.0	0.2	1.3	0.5	22.9	11.4	**12.7**
66	18,375	1.2	0.2	0.9	0.2	1.3	0.5	22.0	10.9	**12.2**
67	18,250	1.2	0.2	0.9	0.2	1.3	0.5	21.2	10.4	**11.7**
68	18,113	1.2	0.2	0.8	0.2	1.2	0.5	20.3	9.9	**11.1**
69	17,963	1.1	0.2	0.8	0.2	1.2	0.5	19.5	9.4	**10.6**
70	17,799	0.9	0.1	0.4	0.3	0.8	0.6	18.7	10.6	**11.4**
71	17,619	0.9	0.1	0.4	0.3	0.8	0.6	17.9	10.0	**10.8**
72	17,421	0.9	0.1	0.4	0.3	0.8	0.6	17.1	9.4	**10.2**
73	17,204	0.9	0.1	0.4	0.3	0.8	0.5	16.3	8.9	**9.7**
74	16,966	0.9	0.1	0.3	0.2	0.7	0.5	15.5	8.4	**9.1**
Total		**64.6**	**8.9**	**109**	**7.1**	**125**	**16.8**	**31.3**	**525**	**650**

Note: QALYs = Quality-adjusted life years; D&T = Diagnosis and treatment phase; RP = Remission phase; MP = Metastatic phase; LE = Life expectancy; LYL = Life years lost

Potential Harms – Reduction in Quality of Life Associated with a Diagnosis

- Screening with a low grade abnormality diagnosis is associated with a utility loss of 0.0231 for a period of 12 months.[609]
- Diagnosis and treatment for CIN2+ is associated with a utility loss of 0.066 for a period of 20 months.[610]

Table 31: Screening for Cervical Cancer
hrHPV Model - Harms
in a British Columbia Birth Cohort of 20,000 Females

Age	Females in Birth Cohort	# with ASCUS / LSIL	QALYs Lost	# with Diagnosed CIN2+	QALYs Lost	**Total QALYs Lost**
25	19,843	375	9.5	45	5.4	14.9
26	19,834	375	9.5	45	5.4	14.9
27	19,825	374	9.5	45	5.4	14.9
28	19,816	374	9.4	45	5.4	14.9
29	19,806	373	9.4	45	5.4	14.9
30	19,796	260	6.8	67	8.3	15.0
31	19,785	259	6.7	67	8.2	15.0
32	19,773	257	6.7	66	8.2	14.9
33	19,761	256	6.6	66	8.1	14.8
34	19,749	254	6.6	65	8.1	14.7
35	19,736	168	4.4	56	6.9	11.3
36	19,722	167	4.3	55	6.8	11.2
37	19,708	166	4.3	55	6.8	11.1
38	19,693	165	4.3	55	6.8	11.0
39	19,677	164	4.3	54	6.7	11.0
40	19,661	136	3.7	47	6.1	9.8
41	19,643	134	3.6	47	6.0	9.7
42	19,625	132	3.6	46	5.9	9.5
43	19,605	130	3.5	45	5.8	9.4
44	19,584	128	3.5	45	5.7	9.2
45	19,561	109	2.9	29	3.8	6.7
46	19,537	108	2.9	29	3.7	6.7
47	19,511	107	2.9	29	3.7	6.6
48	19,484	106	2.9	29	3.7	6.6
49	19,454	105	2.8	28	3.7	6.5
50	19,422	96	2.7	20	2.7	5.4
51	19,388	96	2.7	20	2.7	5.4
52	19,352	95	2.7	20	2.6	5.3
53	19,312	94	2.6	20	2.6	5.3
54	19,270	93	2.6	19	2.6	5.2
55	19,224	85	2.4	18	2.4	4.8
56	19,174	84	2.4	17	2.3	4.7
57	19,121	82	2.3	17	2.3	4.6
58	19,063	81	2.3	17	2.3	4.5
59	19,000	79	2.2	16	2.2	4.5
60	18,932	76	2.2	16	2.2	4.4
61	18,858	74	2.1	16	2.2	4.3
62	18,777	73	2.1	15	2.1	4.2
63	18,689	71	2.1	15	2.1	4.1
64	18,593	70	2.0	15	2.0	4.1
65	18,489	64	1.9	12	1.7	3.5
66	18,375	63	1.8	12	1.6	3.4
67	18,250	61	1.8	11	1.6	3.3
68	18,113	60	1.7	11	1.5	3.3
69	17,963	58	1.7	11	1.5	3.2
Total		**6,742**	**179**	**1,523**	**194**	**373**

[609] Simonella L, Howard K, Canfell K. A survey of population-based utility scores for cervical cancer prevention. *BMC Research Notes*. 2014; 7: 899

[610] Insinga R, Glass A, Myers E et al. Abnormal outcomes following cervical cancer screening: event duration and health utility loss. *Medical Decision Making*. 2007; 27(4): 414-22.

The diagnosis and treatment of cervical cancer precursors in a BC birth cohort of 20,000 females based on HPV-based screening is associated with a loss of 373 QALYs (see Table 31). This compares with a loss of 239 QALYs associated with cytology-based screening (see Table 19).

Potential Harms – Premature Births

As noted previously, excisional and ablative treatment for CIN increases the risk of a subsequent premature birth. In calculating this risk and the QALYs lost associated with it, we have used the same approach for the HPV-based screening model as for the cytology-based screening model.

As noted previously, we would expect 23,815 live births in a BC birth cohort of 20,000 females. In the birth cohort, 1,204 females between the ages of 25 and 49 would receive treatment for CIN2+ with an HPV-based screening program (see Table 32). Based on the differences in the rate of preterm births with or without LEEP treatment for CIN2+, we would expect an additional 41.1 babies to be preterm attributable to treatment (see Table 32). Of these 41.1 babies, 4.9 would be expected to be extremely preterm (gestational age < 28 completed weeks), 5.1 (10.0 – 4.9) would be expected to be very preterm (gestational age < 32 completed weeks) and 31.1 (41.1 – 4.9 – 5.1) would be expected to be late preterm (gestational age < 37 completed weeks) (see Table 32).

Table 32: Treatment for CIN and the Risk of Preterm Birth

					# of Preterm Births (PTB)								
	Females in Birth	Fertility Rate per	# of Live	Tmt for CIN2+	*< 37 weeks*			*<32-34 weeks*			*<28-30 weeks*		
Age	Cohort	1,000	Births	(Table 29)	No Tmt	TMT	Due to Tmt	No Tmt	TMT	Due to Tmt	No Tmt	TMT	Due to Tmt
25	19,843	71.6	1,422	45.1	2.1	3.7	1.5	0.6	0.9	0.4	0.1	0.3	0.2
26	19,834	71.6	1,421	45.1	2.1	3.6	1.5	0.6	0.9	0.4	0.1	0.3	0.2
27	19,825	71.6	1,420	45.0	2.1	3.6	1.5	0.5	0.9	0.4	0.1	0.3	0.2
28	19,816	71.6	1,420	45.0	2.1	3.6	1.5	0.5	0.9	0.4	0.1	0.3	0.2
29	19,806	71.6	1,419	44.9	2.1	3.6	1.5	0.5	0.9	0.4	0.1	0.3	0.2
30	19,796	99.5	1,970	66.9	3.1	5.4	2.3	0.8	1.4	0.6	0.2	0.4	0.3
31	19,785	99.5	1,969	66.5	3.1	5.4	2.3	0.8	1.4	0.6	0.2	0.4	0.3
32	19,773	99.5	1,968	66.1	3.1	5.3	2.3	0.8	1.4	0.5	0.2	0.4	0.3
33	19,761	99.5	1,967	65.7	3.1	5.3	2.2	0.8	1.3	0.5	0.2	0.4	0.3
34	19,749	99.5	1,966	65.3	3.1	5.3	2.2	0.8	1.3	0.5	0.2	0.4	0.3
35	19,736	57.1	1,126	55.6	2.6	4.5	1.9	0.7	1.1	0.5	0.1	0.4	0.2
36	19,722	57.1	1,125	55.2	2.6	4.5	1.9	0.7	1.1	0.5	0.1	0.4	0.2
37	19,708	57.1	1,125	54.9	2.6	4.4	1.9	0.7	1.1	0.5	0.1	0.4	0.2
38	19,693	57.1	1,124	54.5	2.6	4.4	1.9	0.7	1.1	0.5	0.1	0.4	0.2
39	19,677	57.1	1,123	54.2	2.5	4.4	1.8	0.7	1.1	0.4	0.1	0.4	0.2
40	19,661	12.0	235	47.4	2.2	3.8	1.6	0.6	1.0	0.4	0.1	0.3	0.2
41	19,643	12.0	235	46.7	2.2	3.8	1.6	0.6	1.0	0.4	0.1	0.3	0.2
42	19,625	12.0	235	46.0	2.2	3.7	1.6	0.6	0.9	0.4	0.1	0.3	0.2
43	19,605	12.0	235	45.3	2.1	3.7	1.5	0.6	0.9	0.4	0.1	0.3	0.2
44	19,584	12.0	235	44.5	2.1	3.6	1.5	0.5	0.9	0.4	0.1	0.3	0.2
45	19,561	0.8	15	29.2	1.4	2.4	1.0	0.4	0.6	0.2	0.1	0.2	0.1
46	19,537	0.8	15	29.0	1.4	2.3	1.0	0.4	0.6	0.2	0.1	0.2	0.1
47	19,511	0.8	15	28.8	1.3	2.3	1.0	0.4	0.6	0.2	0.1	0.2	0.1
48	19,484	0.8	15	28.6	1.3	2.3	1.0	0.3	0.6	0.2	0.1	0.2	0.1
49	19,454	0.8	15	28.3	1.3	2.3	1.0	0.3	0.6	0.2	0.1	0.2	0.1
Total			**23,815**	**1,204**	**56.4**	**97.4**	**41.1**	**14.7**	**24.7**	**10.0**	**3.0**	**7.9**	**4.9**

To estimate the effect of premature birth on mortality in the children born to a BC birth cohort of 20,000 females we first assumed that half of the 38 premature births would be male and half female. We then calculated the number of expected deaths by age if the births had been full term. The next step involved calculating the expected number of deaths by level of prematurity, sex and age based on the hazard ratios in Table 15. We assumed that the hazard ratio indicated for ages 30-45 years would remain constant through to age 85. Excess deaths due to prematurity were calculated by subtracting the number of expected deaths if full term from the number of expected of deaths if born premature. The life expectancy by sex and age was applied to these excess deaths to calculate life years lost.

The estimated number of excess deaths due to prematurity are associated with 122.2 life years lost, 45.8 in males (see Table 33) and 76.4 in females (see Table 34).

In addition, we would expect 25.6 QALYs lost associated with babies born VLBW, 12.9 QALYs lost in males and 12.7 QALYs lost in females (see Table 35).

Table 33: Excess Preterm Births, Deaths and Life Years Lost in Males
Due to Local Treatment for CIN in Their Mothers

Age	Males in Birth Cohort	Deaths	% Dying	LE	Number Alive 35-37	32-34	<28-30	Expected # of Deaths if *Full Term* 35-37	32-34	<28-30	Expected # of Deaths if *Premature* 35-37	32-34	<28-30	Excess # of Deaths Due to *Premature Birth* 35-37	32-34	<28-30	Life Years Lost Due to *Premature Birth* 35-37	32-34	<28-30	Total
0	20,000			79.9	**15.53**	**2.53**	**2.47**													
1	19,921	79	0.39%	79.3	15.39	2.51	2.39	0.06	0.01	0.01	0.14	0.02	0.07	0.08	0.01	0.06	6.56	1.07	5.15	**12.77**
2	19,918	4	0.02%	78.3	15.38	2.50	2.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.03	0.07	**0.26**
3	19,915	3	0.01%	77.3	15.38	2.50	2.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.02	0.05	**0.20**
4	19,913	2	0.01%	76.3	15.38	2.50	2.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.02	0.04	**0.16**
5	19,911	2	0.01%	75.3	15.38	2.50	2.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.01	0.04	**0.14**
6	19,909	1	0.01%	74.3	15.37	2.50	2.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.01	0.02	**0.10**
7	19,908	1	0.01%	73.3	15.37	2.50	2.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.01	0.02	**0.10**
8	19,907	1	0.01%	72.3	15.37	2.50	2.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.01	0.02	**0.10**
9	19,906	1	0.01%	71.3	15.37	2.50	2.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.01	0.02	**0.07**
10	19,904	1	0.01%	70.3	15.37	2.50	2.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.01	**0.03**
11	19,903	1	0.01%	69.3	15.37	2.50	2.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.01	**0.03**
12	19,902	1	0.01%	68.3	15.36	2.50	2.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.01	**0.03**
13	19,900	2	0.01%	67.3	15.36	2.50	2.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.01	**0.04**
14	19,898	2	0.01%	66.3	15.36	2.50	2.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.01	0.01	**0.05**
15	19,896	3	0.01%	65.3	15.36	2.50	2.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.01	0.02	**0.07**
16	19,891	4	0.02%	64.4	15.35	2.50	2.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.01	0.03	**0.11**
17	19,885	6	0.03%	63.4	15.35	2.50	2.38	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.11	0.02	0.04	**0.16**
18	19,876	9	0.05%	62.4	15.34	2.50	2.38	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.15	0.02	0.05	**0.23**
19	19,864	11	0.06%	61.4	15.33	2.49	2.38	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.19	0.03	0.06	**0.28**
20	19,851	14	0.07%	60.5	15.31	2.49	2.38	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.19	0.03	0.04	**0.26**
21	19,835	16	0.08%	59.5	15.30	2.49	2.37	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.22	0.04	0.05	**0.30**
22	19,817	18	0.09%	58.6	15.28	2.49	2.37	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.24	0.04	0.05	**0.33**
23	19,796	20	0.10%	57.7	15.26	2.48	2.37	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.27	0.04	0.06	**0.37**
24	19,775	22	0.11%	56.7	15.24	2.48	2.36	0.02	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.29	0.05	0.06	**0.39**
25	19,751	23	0.12%	55.8	15.21	2.48	2.36	0.02	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.30	0.05	0.06	**0.41**
26	19,727	24	0.12%	54.8	15.19	2.47	2.36	0.02	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.31	0.05	0.06	**0.42**
27	19,702	25	0.13%	53.9	15.16	2.47	2.35	0.02	0.00	0.00	0.03	0.00	0.00	0.01	0.00	0.00	0.31	0.05	0.06	**0.43**
28	19,676	26	0.13%	53.0	15.14	2.46	2.35	0.02	0.00	0.00	0.03	0.00	0.00	0.01	0.00	0.00	0.32	0.05	0.07	**0.44**
29	19,649	27	0.14%	52.1	15.11	2.46	2.34	0.02	0.00	0.00	0.03	0.00	0.00	0.01	0.00	0.00	0.32	0.05	0.07	**0.44**
30	19,621	28	0.14%	51.1	15.08	2.46	2.34	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.18	0.03	0.03	**0.24**
31	19,593	28	0.14%	50.2	15.06	2.45	2.34	0.02	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.19	0.03	0.03	**0.24**
32	19,564	29	0.15%	49.3	15.03	2.45	2.33	0.02	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.19	0.03	0.03	**0.24**
33	19,535	29	0.15%	48.4	15.01	2.44	2.33	0.02	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.19	0.03	0.03	**0.24**
34	19,505	30	0.15%	47.4	14.98	2.44	2.32	0.02	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.19	0.03	0.03	**0.24**
35	19,474	31	0.16%	46.5	14.95	2.43	2.32	0.02	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.19	0.03	0.03	**0.25**
36	19,442	32	0.16%	45.6	14.92	2.43	2.32	0.02	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.19	0.03	0.03	**0.25**
37	19,409	33	0.17%	44.7	14.89	2.42	2.31	0.03	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.19	0.03	0.03	**0.25**
38	19,375	34	0.18%	43.7	14.86	2.42	2.31	0.03	0.00	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.20	0.03	0.03	**0.25**
39	19,339	35	0.18%	42.8	14.83	2.41	2.30	0.03	0.00	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.20	0.03	0.03	**0.26**
40	19,303	37	0.19%	41.9	14.80	2.41	2.30	0.03	0.00	0.00	0.03	0.01	0.01	0.00	0.00	0.00	0.20	0.03	0.03	**0.26**
41	19,264	38	0.20%	41.0	14.76	2.40	2.29	0.03	0.00	0.00	0.03	0.01	0.01	0.00	0.00	0.00	0.20	0.03	0.03	**0.27**
42	19,225	40	0.21%	40.1	14.73	2.40	2.29	0.03	0.00	0.00	0.04	0.01	0.01	0.01	0.00	0.00	0.21	0.03	0.03	**0.27**
43	19,183	41	0.22%	39.1	14.69	2.39	2.28	0.03	0.01	0.00	0.04	0.01	0.01	0.01	0.00	0.00	0.21	0.03	0.03	**0.27**
44	19,140	43	0.23%	38.2	14.65	2.39	2.27	0.03	0.01	0.01	0.04	0.01	0.01	0.01	0.00	0.00	0.22	0.04	0.03	**0.28**
45	19,094	46	0.24%	37.3	14.61	2.38	2.27	0.03	0.01	0.01	0.04	0.01	0.01	0.01	0.00	0.00	0.22	0.04	0.03	**0.29**
46	19,047	48	0.25%	36.4	14.57	2.37	2.26	0.04	0.01	0.01	0.04	0.01	0.01	0.01	0.00	0.00	0.23	0.04	0.03	**0.29**
47	18,996	50	0.26%	35.5	14.52	2.36	2.25	0.04	0.01	0.01	0.05	0.01	0.01	0.01	0.00	0.00	0.23	0.04	0.03	**0.30**
48	18,943	53	0.28%	34.6	14.47	2.36	2.25	0.04	0.01	0.01	0.05	0.01	0.01	0.01	0.00	0.00	0.24	0.04	0.03	**0.31**
49	18,887	56	0.30%	33.7	14.42	2.35	2.24	0.04	0.01	0.01	0.05	0.01	0.01	0.01	0.00	0.00	0.25	0.04	0.03	**0.32**
50	18,827	60	0.32%	32.8	14.37	2.34	2.23	0.05	0.01	0.01	0.05	0.01	0.01	0.01	0.00	0.00	0.26	0.04	0.04	**0.33**
51	18,763	64	0.34%	31.9	14.31	2.33	2.22	0.05	0.01	0.01	0.06	0.01	0.01	0.01	0.00	0.00	0.27	0.04	0.04	**0.34**
52	18,695	68	0.36%	31.0	14.25	2.32	2.21	0.05	0.01	0.01	0.06	0.01	0.01	0.01	0.00	0.00	0.28	0.04	0.04	**0.36**
53	18,622	73	0.39%	30.2	14.19	2.31	2.20	0.06	0.01	0.01	0.07	0.01	0.01	0.01	0.00	0.00	0.28	0.05	0.04	**0.37**
54	18,545	78	0.42%	29.3	14.12	2.30	2.19	0.06	0.01	0.01	0.07	0.01	0.01	0.01	0.00	0.00	0.30	0.05	0.04	**0.38**
55	18,461	83	0.45%	28.4	14.04	2.29	2.18	0.06	0.01	0.01	0.07	0.01	0.01	0.01	0.00	0.00	0.31	0.05	0.04	**0.40**
56	18,372	89	0.48%	27.5	13.96	2.27	2.17	0.07	0.01	0.01	0.08	0.01	0.01	0.01	0.00	0.00	0.32	0.05	0.04	**0.41**
57	18,277	95	0.52%	26.7	13.88	2.26	2.16	0.07	0.01	0.01	0.09	0.01	0.01	0.01	0.00	0.00	0.33	0.05	0.05	**0.43**
58	18,175	102	0.56%	25.8	13.79	2.24	2.14	0.08	0.01	0.01	0.09	0.01	0.01	0.01	0.00	0.00	0.34	0.06	0.05	**0.45**
59	18,065	110	0.61%	25.0	13.69	2.23	2.13	0.08	0.01	0.01	0.10	0.02	0.01	0.01	0.00	0.00	0.36	0.06	0.05	**0.46**
60	17,947	118	0.66%	24.1	13.58	2.21	2.11	0.09	0.01	0.01	0.11	0.02	0.02	0.02	0.00	0.00	0.37	0.06	0.05	**0.48**
61	17,820	127	0.71%	23.3	13.47	2.19	2.09	0.10	0.02	0.02	0.11	0.02	0.02	0.02	0.00	0.00	0.38	0.06	0.05	**0.50**
62	17,684	136	0.77%	22.5	13.35	2.17	2.07	0.10	0.02	0.02	0.12	0.02	0.02	0.02	0.00	0.00	0.40	0.06	0.05	**0.52**
63	17,537	147	0.84%	21.7	13.22	2.15	2.05	0.11	0.02	0.02	0.13	0.02	0.02	0.02	0.00	0.00	0.41	0.07	0.06	**0.54**
64	17,379	158	0.91%	20.9	13.08	2.13	2.03	0.12	0.02	0.02	0.14	0.02	0.02	0.02	0.00	0.00	0.43	0.07	0.06	**0.55**
65	17,208	171	0.99%	20.1	12.93	2.10	2.01	0.13	0.02	0.02	0.15	0.02	0.02	0.02	0.00	0.00	0.44	0.07	0.06	**0.58**
66	17,024	184	1.08%	19.3	12.76	2.08	1.99	0.14	0.02	0.02	0.16	0.03	0.02	0.02	0.00	0.00	0.46	0.07	0.06	**0.60**
67	16,826	198	1.18%	18.5	12.59	2.05	1.96	0.15	0.02	0.02	0.18	0.03	0.03	0.03	0.00	0.00	0.47	0.08	0.06	**0.61**
68	16,612	214	1.29%	17.7	12.40	2.02	1.93	0.16	0.03	0.03	0.19	0.03	0.03	0.03	0.00	0.00	0.49	0.08	0.07	**0.64**
69	16,381	231	1.41%	17.0	12.19	1.98	1.90	0.17	0.03	0.03	0.20	0.03	0.03	0.03	0.00	0.00	0.50	0.08	0.07	**0.66**
70	16,132	249	1.54%	16.2	11.97	1.95	1.86	0.19	0.03	0.03	0.22	0.04	0.03	0.03	0.01	0.00	0.52	0.08	0.07	**0.68**
71	15,863	269	1.69%	15.5	11.73	1.91	1.83	0.20	0.03	0.03	0.24	0.04	0.04	0.03	0.01	0.00	0.53	0.09	0.07	**0.69**
72	15,573	290	1.86%	14.8	11.48	1.87	1.79	0.22	0.04	0.03	0.26	0.04	0.04	0.04	0.01	0.01	0.55	0.09	0.08	**0.71**
73	15,260	313	2.05%	14.1	11.20	1.82	1.75	0.24	0.04	0.04	0.28	0.04	0.04	0.04	0.01	0.01	0.56	0.09	0.08	**0.73**
74	14,923	337	2.26%	13.4	10.91	1.78	1.70	0.25	0.04	0.04	0.30	0.05	0.05	0.04	0.01	0.01	0.58	0.09	0.08	**0.75**
75	14,560	363	2.49%	12.7	10.59	1.72	1.65	0.27	0.04	0.04	0.32	0.05	0.05	0.05	0.01	0.01	0.59	0.10	0.08	**0.76**
76	14,170	390	2.75%	12.0	10.25	1.67	1.60	0.29	0.05	0.05	0.34	0.06	0.05	0.05	0.01	0.01	0.60	0.10	0.08	**0.78**
77	13,751	419	3.05%	11.4	9.88	1.61	1.54	0.31	0.05	0.05	0.37	0.06	0.06	0.05	0.01	0.01	0.60	0.10	0.08	**0.79**
78	13,301	450	3.38%	10.8	9.49	1.55	1.48	0.33	0.05	0.05	0.39	0.06	0.06	0.06	0.01	0.01	0.61	0.10	0.08	**0.79**
79	12,820	481	3.75%	10.1	9.08	1.48	1.42	0.36	0.06	0.06	0.42	0.07	0.06	0.06	0.01	0.01	0.61	0.10	0.08	**0.80**
80	12,306	514	4.18%	9.5	8.63	1.41	1.35	0.38	0.06	0.06	0.44	0.07	0.07	0.06	0.01	0.01	0.61	0.10	0.08	**0.80**
81	11,759	547	4.65%	9.0	8.16	1.33	1.28	0.40	0.07	0.06	0.47	0.08	0.07	0.07	0.01	0.01	0.61	0.10	0.08	**0.79**
82	11,179	580	5.19%	8.4	7.67	1.25	1.20	0.42	0.07	0.07	0.50	0.08	0.08	0.07	0.01	0.01	0.60	0.10	0.08	**0.79**
83	10,565	614	5.81%	7.9	7.15	1.16	1.12	0.45	0.07	0.07	0.52	0.08	0.08	0.08	0.01	0.01	0.59	0.10	0.08	**0.77**
84	9,919	646	6.51%	7.3	6.60	1.07	1.04	0.47	0.08	0.07	0.54	0.09	0.08	0.08	0.01	0.01	0.58	0.09	0.08	**0.75**
85	9,244	676	7.31%	6.8	6.04	0.98	0.95	0.48	0.08	0.08	0.56	0.09	0.09	0.08	0.01	0.01	0.56	0.09	0.08	**0.73**
Total								**8.03**	**1.31**	**1.25**	**9.50**	**1.55**	**1.52**	**1.47**	**0.24**	**0.26**	**31.6**	**5.1**	**9.1**	**45.8**

Table 34: Excess Preterm Births, Deaths and Life Years Lost in Females Due to Local Treatment for CIN in Their Mothers

Age	Females in Birth Cohort	Deaths	% Dying	LE	Number Alive 35-37	32-34	<28-30	Expected # of Deaths if *Full Term* 35-37	32-34	<28-30	Expected # of Deaths if *Premature* 35-37	32-34	<28-30	Excess # of Deaths Due to *Premature Birth* 35-37	32-34	<28-30	Life Years Lost Due to *Premature Birth* 35-37	32-34	<28-30	Total
0	20,000			84.9	**15.53**	**2.53**	**2.47**													
1	19,933	67	0.34%	84.2	15.37	2.50	2.38	0.05	0.01	0.01	0.16	0.03	0.09	0.11	0.02	0.08	9.39	1.53	6.80	**17.72**
2	19,929	4	0.02%	83.2	15.36	2.50	2.38	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.26	0.04	0.10	**0.40**
3	19,926	3	0.01%	82.2	15.36	2.50	2.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.03	0.07	**0.29**
4	19,924	2	0.01%	81.3	15.36	2.50	2.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.03	0.06	**0.25**
5	19,922	2	0.01%	80.3	15.35	2.50	2.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.02	0.05	**0.18**
6	19,920	2	0.01%	79.3	15.35	2.50	2.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.02	0.04	**0.16**
7	19,919	1	0.01%	78.3	15.35	2.50	2.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.01	0.03	**0.14**
8	19,918	1	0.01%	77.3	15.35	2.50	2.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.01	0.03	**0.12**
9	19,917	1	0.01%	76.3	15.34	2.50	2.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.01	0.03	**0.12**
10	19,915	1	0.01%	75.3	15.34	2.50	2.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.01	0.03	**0.11**
11	19,914	1	0.01%	74.3	15.34	2.50	2.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.01	0.03	**0.11**
12	19,913	1	0.01%	73.3	15.34	2.50	2.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.01	0.03	**0.11**
13	19,911	2	0.01%	72.3	15.34	2.50	2.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.02	0.04	**0.15**
14	19,910	2	0.01%	71.3	15.33	2.50	2.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.02	0.04	**0.16**
15	19,907	2	0.01%	70.3	15.33	2.50	2.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.02	0.05	**0.20**
16	19,904	3	0.02%	69.3	15.32	2.49	2.37	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.19	0.03	0.07	**0.30**
17	19,900	4	0.02%	68.3	15.32	2.49	2.36	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.25	0.04	0.10	**0.38**
18	19,894	6	0.03%	67.4	15.31	2.49	2.36	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.31	0.05	0.12	**0.48**
19	19,888	6	0.03%	66.4	15.30	2.49	2.36	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.34	0.05	0.13	**0.52**
20	19,881	7	0.03%	65.4	15.29	2.49	2.36	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.17	0.03	0.03	**0.22**
21	19,874	7	0.03%	64.4	15.28	2.49	2.36	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.17	0.03	0.03	**0.22**
22	19,867	7	0.04%	63.5	15.27	2.49	2.36	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.18	0.03	0.03	**0.24**
23	19,859	8	0.04%	62.5	15.27	2.49	2.35	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.19	0.03	0.03	**0.25**
24	19,851	8	0.04%	61.5	15.26	2.48	2.35	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.19	0.03	0.03	**0.25**
25	19,843	8	0.04%	60.5	15.25	2.48	2.35	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.19	0.03	0.03	**0.25**
26	19,834	9	0.04%	59.6	15.24	2.48	2.35	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.20	0.03	0.03	**0.27**
27	19,825	9	0.05%	58.6	15.23	2.48	2.35	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.20	0.03	0.03	**0.27**
28	19,816	9	0.05%	57.6	15.22	2.48	2.35	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.21	0.03	0.03	**0.27**
29	19,806	10	0.05%	56.6	15.20	2.48	2.35	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.21	0.03	0.03	**0.28**
30	19,796	10	0.05%	55.7	15.19	2.47	2.34	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.15	0.02	0.09	**0.27**
31	19,785	11	0.06%	54.7	15.18	2.47	2.34	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.16	0.03	0.09	**0.28**
32	19,773	11	0.06%	53.7	15.17	2.47	2.34	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.16	0.03	0.09	**0.29**
33	19,761	12	0.06%	52.8	15.16	2.47	2.33	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.17	0.03	0.10	**0.30**
34	19,749	13	0.06%	51.8	15.14	2.47	2.33	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.18	0.03	0.10	**0.30**
35	19,736	13	0.07%	50.8	15.13	2.46	2.33	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.18	0.03	0.10	**0.31**
36	19,722	14	0.07%	49.9	15.12	2.46	2.32	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.18	0.03	0.10	**0.32**
37	19,708	14	0.07%	48.9	15.10	2.46	2.32	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.19	0.03	0.11	**0.32**
38	19,693	15	0.08%	47.9	15.09	2.46	2.31	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.19	0.03	0.11	**0.34**
39	19,677	16	0.08%	47.0	15.07	2.45	2.31	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.20	0.03	0.11	**0.34**
40	19,661	16	0.08%	46.0	15.05	2.45	2.31	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.20	0.03	0.12	**0.35**
41	19,643	18	0.09%	45.1	15.04	2.45	2.30	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.21	0.03	0.12	**0.37**
42	19,625	19	0.09%	44.1	15.02	2.44	2.30	0.01	0.00	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.22	0.04	0.13	**0.38**
43	19,605	20	0.10%	43.1	15.00	2.44	2.29	0.02	0.00	0.00	0.02	0.00	0.01	0.01	0.00	0.00	0.23	0.04	0.13	**0.40**
44	19,584	21	0.11%	42.2	14.97	2.44	2.28	0.02	0.00	0.00	0.02	0.00	0.01	0.01	0.00	0.00	0.24	0.04	0.14	**0.42**
45	19,561	23	0.12%	41.2	14.95	2.43	2.28	0.02	0.00	0.00	0.02	0.00	0.01	0.01	0.00	0.00	0.25	0.04	0.14	**0.43**
46	19,537	24	0.12%	40.3	14.93	2.43	2.27	0.02	0.00	0.00	0.03	0.00	0.01	0.01	0.00	0.00	0.26	0.04	0.15	**0.45**
47	19,511	26	0.13%	39.3	14.90	2.43	2.27	0.02	0.00	0.00	0.03	0.00	0.01	0.01	0.00	0.00	0.27	0.04	0.15	**0.47**
48	19,484	28	0.14%	38.4	14.87	2.42	2.26	0.02	0.00	0.00	0.03	0.00	0.01	0.01	0.00	0.00	0.28	0.05	0.16	**0.49**
49	19,454	30	0.15%	37.4	14.84	2.42	2.25	0.02	0.00	0.00	0.03	0.00	0.01	0.01	0.00	0.00	0.30	0.05	0.17	**0.51**
50	19,422	32	0.16%	36.5	14.81	2.41	2.24	0.02	0.00	0.00	0.03	0.01	0.01	0.01	0.00	0.00	0.31	0.05	0.18	**0.54**
51	19,388	34	0.18%	35.6	14.77	2.40	2.23	0.03	0.00	0.00	0.04	0.01	0.01	0.01	0.00	0.01	0.32	0.05	0.18	**0.56**
52	19,352	37	0.19%	34.6	14.73	2.40	2.22	0.03	0.00	0.00	0.04	0.01	0.01	0.01	0.00	0.01	0.34	0.06	0.19	**0.59**
53	19,312	39	0.20%	33.7	14.69	2.39	2.21	0.03	0.00	0.00	0.04	0.01	0.01	0.01	0.00	0.01	0.35	0.06	0.20	**0.61**
54	19,270	43	0.22%	32.8	14.65	2.38	2.20	0.03	0.01	0.00	0.04	0.01	0.01	0.01	0.00	0.01	0.37	0.06	0.21	**0.64**
55	19,224	46	0.24%	31.9	14.60	2.38	2.19	0.03	0.01	0.01	0.05	0.01	0.01	0.01	0.00	0.01	0.39	0.06	0.22	**0.67**
56	19,174	49	0.26%	30.9	14.55	2.37	2.18	0.04	0.01	0.01	0.05	0.01	0.01	0.01	0.00	0.01	0.41	0.07	0.23	**0.70**
57	19,121	53	0.28%	30.0	14.50	2.36	2.16	0.04	0.01	0.01	0.05	0.01	0.01	0.01	0.00	0.01	0.43	0.07	0.24	**0.74**
58	19,063	58	0.30%	29.1	14.44	2.35	2.15	0.04	0.01	0.01	0.06	0.01	0.02	0.02	0.00	0.01	0.45	0.07	0.25	**0.77**
59	19,000	63	0.33%	28.2	14.37	2.34	2.13	0.05	0.01	0.01	0.06	0.01	0.02	0.02	0.00	0.01	0.47	0.08	0.26	**0.81**
60	18,932	68	0.36%	27.3	14.30	2.33	2.11	0.05	0.01	0.01	0.07	0.01	0.02	0.02	0.00	0.01	0.49	0.08	0.27	**0.85**
61	18,858	74	0.39%	26.4	14.23	2.32	2.09	0.06	0.01	0.01	0.08	0.01	0.02	0.02	0.00	0.01	0.52	0.08	0.29	**0.89**
62	18,777	81	0.43%	25.5	14.15	2.30	2.07	0.06	0.01	0.01	0.08	0.01	0.02	0.02	0.00	0.01	0.55	0.09	0.30	**0.93**
63	18,689	88	0.47%	24.6	14.06	2.29	2.05	0.07	0.01	0.01	0.09	0.01	0.02	0.02	0.00	0.01	0.57	0.09	0.31	**0.98**
64	18,593	96	0.52%	23.8	13.96	2.27	2.03	0.07	0.01	0.01	0.10	0.02	0.02	0.03	0.00	0.01	0.60	0.10	0.33	**1.03**
65	18,489	105	0.57%	22.9	13.85	2.25	2.00	0.08	0.01	0.01	0.11	0.02	0.03	0.03	0.00	0.02	0.63	0.10	0.34	**1.08**
66	18,375	114	0.62%	22.0	13.73	2.24	1.97	0.09	0.01	0.01	0.12	0.02	0.03	0.03	0.00	0.02	0.66	0.11	0.36	**1.13**
67	18,250	125	0.68%	21.2	13.61	2.22	1.94	0.09	0.02	0.01	0.13	0.02	0.03	0.03	0.01	0.02	0.70	0.11	0.37	**1.19**
68	18,113	137	0.76%	20.3	13.47	2.19	1.91	0.10	0.02	0.01	0.14	0.02	0.03	0.04	0.01	0.02	0.73	0.12	0.39	**1.24**
69	17,963	150	0.83%	19.5	13.32	2.17	1.87	0.11	0.02	0.02	0.15	0.02	0.04	0.04	0.01	0.02	0.77	0.12	0.41	**1.30**
70	17,799	164	0.92%	18.7	13.15	2.14	1.83	0.12	0.02	0.02	0.17	0.03	0.04	0.04	0.01	0.02	0.80	0.13	0.42	**1.36**
71	17,619	180	1.02%	17.9	12.97	2.11	1.79	0.13	0.02	0.02	0.18	0.03	0.04	0.05	0.01	0.02	0.84	0.14	0.44	**1.42**
72	17,421	198	1.13%	17.1	12.77	2.08	1.74	0.15	0.02	0.02	0.20	0.03	0.05	0.05	0.01	0.03	0.88	0.14	0.45	**1.47**
73	17,204	217	1.26%	16.3	12.55	2.04	1.69	0.16	0.03	0.02	0.22	0.04	0.05	0.06	0.01	0.03	0.92	0.15	0.47	**1.53**
74	16,966	238	1.40%	15.5	12.32	2.00	1.63	0.18	0.03	0.02	0.24	0.04	0.05	0.06	0.01	0.03	0.96	0.16	0.48	**1.59**
75	16,704	261	1.56%	14.7	12.06	1.96	1.57	0.19	0.03	0.03	0.26	0.04	0.06	0.07	0.01	0.03	0.99	0.16	0.49	**1.65**
76	16,417	287	1.75%	14.0	11.77	1.92	1.51	0.21	0.03	0.03	0.28	0.05	0.06	0.07	0.01	0.04	1.03	0.17	0.50	**1.70**
77	16,102	315	1.96%	13.2	11.46	1.87	1.44	0.23	0.04	0.03	0.31	0.05	0.07	0.08	0.01	0.04	1.07	0.17	0.51	**1.75**
78	15,757	346	2.19%	12.5	11.12	1.81	1.37	0.25	0.04	0.03	0.34	0.06	0.07	0.09	0.01	0.04	1.10	0.18	0.52	**1.80**
79	15,378	379	2.46%	11.8	10.75	1.75	1.29	0.27	0.04	0.03	0.37	0.06	0.08	0.10	0.02	0.04	1.13	0.18	0.52	**1.84**
80	14,963	415	2.77%	11.1	10.35	1.68	1.21	0.30	0.05	0.04	0.40	0.07	0.08	0.10	0.02	0.05	1.16	0.19	0.52	**1.87**
81	14,510	453	3.12%	10.5	9.91	1.61	1.12	0.32	0.05	0.04	0.44	0.07	0.09	0.11	0.02	0.05	1.18	0.19	0.52	**1.89**
82	14,016	494	3.53%	9.8	9.44	1.54	1.03	0.35	0.06	0.04	0.47	0.08	0.09	0.12	0.02	0.05	1.20	0.20	0.51	**1.90**
83	13,478	538	3.99%	9.2	8.93	1.45	0.94	0.38	0.06	0.04	0.51	0.08	0.09	0.13	0.02	0.05	1.21	0.20	0.49	**1.90**
84	12,895	583	4.52%	8.6	8.39	1.37	0.84	0.40	0.07	0.04	0.55	0.09	0.10	0.14	0.02	0.06	1.21	0.20	0.48	**1.88**
85	12,264	631	5.14%	8.0	7.80	1.27	0.74	0.43	0.07	0.04	0.58	0.09	0.10	0.15	0.02	0.06	1.21	0.20	0.45	**1.85**
Total								**5.63**	**0.92**	**0.72**	**7.73**	**1.26**	**1.73**	**2.10**	**0.34**	**1.01**	**45.2**	**7.4**	**23.9**	**76.4**

Table 35: Quality-adjusted Life Years Lost Due to VLBW
Due to Local Treatment for CIN in Their Mothers

	Males			*Females*			
		Very Low Birth Weight			*Very Low Birth Weight*		**Total**
Age	LE	# Alive	QALYs Lost	LE	# Alive	QALYs Lost	**QALYs Lost**
0	79.9	2.47	0.16	84.9	2.47	0.16	0.32
1	79.3	2.39	0.16	84.2	2.38	0.16	0.31
2	78.3	2.39	0.16	83.2	2.38	0.16	0.31
3	77.3	2.39	0.16	82.2	2.38	0.16	0.31
4	76.3	2.39	0.16	81.3	2.38	0.16	0.31
5	75.3	2.39	0.16	80.3	2.37	0.16	0.31
6	74.3	2.39	0.16	79.3	2.37	0.16	0.31
7	73.3	2.39	0.16	78.3	2.37	0.16	0.31
8	72.3	2.39	0.16	77.3	2.37	0.16	0.31
9	71.3	2.39	0.16	76.3	2.37	0.16	0.31
10	70.3	2.39	0.16	75.3	2.37	0.16	0.31
11	69.3	2.39	0.16	74.3	2.37	0.16	0.31
12	68.3	2.39	0.16	73.3	2.37	0.16	0.31
13	67.3	2.39	0.16	72.3	2.37	0.16	0.31
14	66.3	2.39	0.16	71.3	2.37	0.16	0.31
15	65.3	2.39	0.16	70.3	2.37	0.16	0.31
16	64.4	2.39	0.16	69.3	2.37	0.16	0.31
17	63.4	2.38	0.16	68.3	2.36	0.16	0.31
18	62.4	2.38	0.16	67.4	2.36	0.16	0.31
19	61.4	2.38	0.16	66.4	2.36	0.15	0.31
20	60.5	2.38	0.16	65.4	2.36	0.15	0.31
21	59.5	2.37	0.16	64.4	2.36	0.15	0.31
22	58.6	2.37	0.16	63.5	2.36	0.15	0.31
23	57.7	2.37	0.16	62.5	2.35	0.15	0.31
24	56.7	2.36	0.16	61.5	2.35	0.15	0.31
25	55.8	2.36	0.15	60.5	2.35	0.15	0.31
26	54.8	2.36	0.15	59.6	2.35	0.15	0.31
27	53.9	2.35	0.15	58.6	2.35	0.15	0.31
28	53.0	2.35	0.15	57.6	2.35	0.15	0.31
29	52.1	2.34	0.15	56.6	2.35	0.15	0.31
30	51.1	2.34	0.16	55.7	2.34	0.16	0.32
31	50.2	2.34	0.16	54.7	2.34	0.16	0.32
32	49.3	2.33	0.16	53.7	2.34	0.16	0.31
33	48.4	2.33	0.16	52.8	2.33	0.16	0.31
34	47.4	2.32	0.16	51.8	2.33	0.16	0.31
35	46.5	2.32	0.16	50.8	2.33	0.16	0.31
36	45.6	2.32	0.16	49.9	2.32	0.16	0.31
37	44.7	2.31	0.16	48.9	2.32	0.16	0.31
38	43.7	2.31	0.16	47.9	2.31	0.16	0.31
39	42.8	2.30	0.16	47.0	2.31	0.16	0.31
40	41.9	2.30	0.16	46.0	2.31	0.16	0.32
41	41.0	2.29	0.16	45.1	2.30	0.16	0.32
42	40.1	2.29	0.16	44.1	2.30	0.16	0.32
43	39.1	2.28	0.16	43.1	2.29	0.16	0.32
44	38.2	2.27	0.16	42.2	2.28	0.16	0.32
45	37.3	2.27	0.16	41.2	2.28	0.16	0.32
46	36.4	2.26	0.16	40.3	2.27	0.16	0.32
47	35.5	2.25	0.16	39.3	2.27	0.16	0.32
48	34.6	2.25	0.16	38.4	2.26	0.16	0.32
49	33.7	2.24	0.16	37.4	2.25	0.16	0.32
50	32.8	2.23	0.16	36.5	2.24	0.16	0.33
51	31.9	2.22	0.16	35.6	2.23	0.16	0.33
52	31.0	2.21	0.16	34.6	2.22	0.16	0.32
53	30.2	2.20	0.16	33.7	2.21	0.16	0.32
54	29.3	2.19	0.16	32.8	2.20	0.16	0.32
55	28.4	2.18	0.16	31.9	2.19	0.16	0.32
56	27.5	2.17	0.16	30.9	2.18	0.16	0.32
57	26.7	2.16	0.16	30.0	2.16	0.16	0.32
58	25.8	2.14	0.16	29.1	2.15	0.16	0.31
59	25.0	2.13	0.16	28.2	2.13	0.16	0.31
60	24.1	2.11	0.16	27.3	2.11	0.16	0.32
61	23.3	2.09	0.16	26.4	2.09	0.16	0.31
62	22.5	2.07	0.16	25.5	2.07	0.16	0.31
63	21.7	2.05	0.15	24.6	2.05	0.15	0.31
64	20.9	2.03	0.15	23.8	2.03	0.15	0.30
65	20.1	2.01	0.15	22.9	2.00	0.15	0.30
66	19.3	1.99	0.15	22.0	1.97	0.15	0.30
67	18.5	1.96	0.15	21.2	1.94	0.15	0.29
68	17.7	1.93	0.14	20.3	1.91	0.14	0.29
69	17.0	1.90	0.14	19.5	1.87	0.14	0.28
70	16.2	1.86	0.15	18.7	1.83	0.14	0.29
71	15.5	1.83	0.14	17.9	1.79	0.14	0.29
72	14.8	1.79	0.14	17.1	1.74	0.14	0.28
73	14.1	1.75	0.14	16.3	1.69	0.13	0.27
74	13.4	1.70	0.13	15.5	1.63	0.13	0.26
75	12.7	1.65	0.13	14.7	1.57	0.12	0.26
76	12.0	1.60	0.13	14.0	1.51	0.12	0.25
77	11.4	1.54	0.12	13.2	1.44	0.11	0.24
78	10.8	1.48	0.12	12.5	1.37	0.11	0.23
79	10.1	1.42	0.11	11.8	1.29	0.10	0.21
80	9.5	1.35	0.12	11.1	1.21	0.10	0.22
81	9.0	1.28	0.11	10.5	1.12	0.10	0.21
82	8.4	1.20	0.10	9.8	1.03	0.09	0.19
83	7.9	1.12	0.10	9.2	0.94	0.08	0.18
84	7.3	1.04	0.09	8.6	0.84	0.07	0.16
85	6.8	0.95	0.08	8.0	0.74	0.06	0.15
Total			**12.9**			**12.7**	**25.6**

Summary of CPB

Based on the assumptions above, the CPB associated with an HPV-based cervical cancer screening program in a BC birth cohort of 20,000 females is 4,215 (see Table 36).

Table 36: Calculation of Clinically Preventable Burden for Cervical Cancer With hrHPV-Based Screening

In a BC Birth Cohort of 40,000

Row	Variable	Base Case	Data Source
	Without Cytology-Based Screening		
a	Estimated number of cervical cancers	305	Table 5
b	QALYs lost due to cervical cancers	375	Table 7
c	Estimated number of deaths due to cervical cancers	163	Table 6
d	Life-years lost per death from cervical cancers	30.8	= e / c
e	Total life-years lost due to deaths from cervical cancers	5,011	Table 7
f	**Total QALYs Lost**	**5,386**	= b + e
	With hrHPV-Based Screening		
g	Estimated number of cervical cancers	64.6	Table 29
h	QALYs lost due to cervical cancers	125	Table 30
i	Estimated number of deaths due to cervical cancers	16.8	Table 29
j	Life-years lost per death from cervical cancers	31.3	= k / i
k	Total life-years lost due to deaths from cervical cancers	525	Table 30
l	**Total QALYs Lost**	**650**	= h + k
	Harms Associated with Screening & Treatment		
m	Reduction in quality of life associated with a CIN diagnosis	373	Table 31
n	Premature births associated with treatment	41.1	Table 32
o	Reduction in life years lived due to premature birth	122	Tables 33 & 34
p	Reduction in QALYs due to premature birth	26	Table 35
q	**Total QALYs lost due to harms**	**520**	= m + o + p
	Clinically Preventable Burden		
r	CPB associated with cytology-based screening	**4,215**	= f - l - q

√ = Estimates from the literature

We also modified a key assumption and recalculated the CPB as follows:

- Assume the disutility associated with the diagnosis and treatment phase for cervical cancer of 0.288 is reduced to 0.193, the disutility associated with the ongoing, controlled phase (remission) for cervical cancer is reduced from 0.049 to 0.031 and the disutility associated with the metastatic phase for cervical cancer is reduced from 0.451 to 0.307: **CPB = 4,261**.
- Assume the disutility associated with the diagnosis and treatment phase for cervical cancer of 0.288 is increased to 0.399, the disutility associated with the ongoing, controlled phase (remission) for cervical cancer is increased from 0.049 to 0.072 and the disutility associated with the metastatic phase for cervical cancer is increased from 0.451 to 0.600: **CPB = 4,158**.

Cost-Effectiveness – HPV-Based Screening

Unit Costs

In calculating the cost-effectiveness of HPV-based screening, we used the same unit costs as for the cytology-based screening model with the exception of the cost estimate for HPV testing.

- Cost estimates for HPV testing are based on Popadiuk et al. who estimated costs (in 2008 CAD) to be $87.70 per test, which included consultation, tray, and kit with lab interpretation fees, costing $33.70, $10.99, and $43.10 respectively.[611] We updated this estimate to $108 in 2022 CAD.

Costs Associated with HPV-Based Screening for Cervical Cancer

HPV-based screening between the ages of 25 and 69 in a BC birth cohort of 20,000 females would be associated with 101,717 screens. These screens would be associated with $11.0 million in healthcare costs and $7.6 million in patient time costs (see Table 37). The estimated 3,185 colposcopies would be associated with $0.9 million in healthcare costs and $1.0 million in patient time costs. The estimated 1,625 treatments for CIN 2+ would be associated with $2.2 million in healthcare costs and $0.5 million in patient time costs. Finally, the estimated 41 premature births attributable to treatment for CIN2+ would be associated $1.1 million in healthcare costs (see Table 37).

[611] Popadiuk C, Gauvreau C, Bhavsar M et al. Using the Cancer Risk Management Model to evaluate the health and economic impacts of cytology compared with human papillomavirus DNA testing for primary cervical cancer screening in Canada. *Current Oncology*. 2016; 23(Supp.1): S56-S63.

Table 37: Costs Associated with Screening for Cervical Cancer

hrHPV-Based Screening Model

in a British Columbia Birth Cohort of 20,000 Females

	Females		Cost of Screening		Colposcopies			Treatment for CIN2+			Pre-term Births	
Age	in Birth Cohort	# of Screens	HC System	Patient	#	HC System $	Patient $	#	HC System $	Patient $	#	HC System $
25	19,843	2,258	$243,915	$167,850	94	$26,637	$26,232	48	$66,039	$13,425	1.5	$39,919
26	19,834	2,256	$243,623	$167,649	94	$26,605	$26,201	48	$65,960	$13,409	1.5	$39,871
27	19,825	2,253	$243,329	$167,447	94	$26,573	$26,169	48	$65,881	$13,392	1.5	$39,823
28	19,816	2,250	$243,030	$167,241	94	$26,540	$26,137	48	$65,800	$13,376	1.5	$39,774
29	19,806	2,247	$242,727	$167,032	94	$26,507	$26,104	48	$65,718	$13,359	1.5	$39,724
30	19,796	2,712	$292,917	$201,570	117	$33,212	$32,707	71	$97,886	$19,898	2.3	$59,169
31	19,785	2,696	$291,198	$200,388	117	$33,017	$32,515	71	$97,311	$19,782	2.3	$58,821
32	19,773	2,680	$289,476	$199,202	116	$32,822	$32,323	71	$96,736	$19,665	2.3	$58,473
33	19,761	2,664	$287,746	$198,012	115	$32,625	$32,130	70	$96,158	$19,547	2.2	$58,124
34	19,749	2,648	$286,010	$196,817	115	$32,429	$31,936	70	$95,577	$19,429	2.2	$57,773
35	19,736	2,633	$284,345	$195,671	95	$26,963	$26,554	59	$81,300	$16,527	1.9	$49,143
36	19,722	2,617	$282,597	$194,469	95	$26,798	$26,391	59	$80,800	$16,425	1.9	$48,841
37	19,708	2,600	$280,844	$193,262	94	$26,632	$26,227	59	$80,299	$16,323	1.9	$48,538
38	19,693	2,584	$279,081	$192,049	94	$26,464	$26,062	58	$79,795	$16,221	1.9	$48,233
39	19,677	2,568	$277,312	$190,832	93	$26,297	$25,897	58	$79,289	$16,118	1.8	$47,927
40	19,661	2,529	$273,097	$187,931	86	$24,460	$24,088	51	$69,384	$14,104	1.6	$41,940
41	19,643	2,490	$268,962	$185,086	85	$24,090	$23,724	50	$68,333	$13,891	1.6	$41,305
42	19,625	2,452	$264,820	$182,236	84	$23,719	$23,358	49	$67,281	$13,677	1.6	$40,669
43	19,605	2,414	$260,670	$179,380	82	$23,347	$22,992	48	$66,226	$13,463	1.5	$40,032
44	19,584	2,375	$256,509	$176,516	81	$22,974	$22,625	48	$65,169	$13,248	1.5	$39,393
45	19,561	2,336	$252,329	$173,639	69	$19,423	$19,128	31	$42,786	$8,698	1.0	$25,862
46	19,537	2,318	$250,381	$172,299	68	$19,273	$18,980	31	$42,455	$8,630	1.0	$25,663
47	19,511	2,300	$248,417	$170,948	68	$19,122	$18,832	31	$42,122	$8,563	1.0	$25,462
48	19,484	2,282	$246,435	$169,584	67	$18,970	$18,681	30	$41,786	$8,494	1.0	$25,258
49	19,454	2,263	$244,432	$168,205	66	$18,815	$18,530	30	$41,447	$8,425	1.0	$25,053
50	19,422	2,279	$246,084	$169,342	54	$15,165	$14,934	21	$29,332	$5,963		
51	19,388	2,259	$244,006	$167,912	53	$15,037	$14,808	21	$29,084	$5,912		
52	19,352	2,240	$241,901	$166,463	53	$14,907	$14,681	21	$28,833	$5,861		
53	19,312	2,220	$239,767	$164,995	52	$14,776	$14,551	21	$28,579	$5,810		
54	19,270	2,200	$237,600	$163,504	52	$14,642	$14,420	21	$28,321	$5,757		
55	19,224	2,183	$235,810	$162,273	50	$14,217	$14,001	19	$25,956	$5,276		
56	19,174	2,145	$231,678	$159,429	49	$13,968	$13,755	19	$25,501	$5,184		
57	19,121	2,107	$227,516	$156,564	48	$13,717	$13,508	18	$25,043	$5,091		
58	19,063	2,068	$223,319	$153,677	48	$13,464	$13,259	18	$24,581	$4,997		
59	19,000	2,029	$219,089	$150,765	47	$13,209	$13,008	18	$24,115	$4,902		
60	18,932	2,047	$221,035	$152,105	45	$12,694	$12,501	17	$23,598	$4,797		
61	18,858	2,006	$216,600	$149,053	44	$12,439	$12,250	17	$23,124	$4,701		
62	18,777	1,964	$212,120	$145,970	43	$12,182	$11,997	17	$22,646	$4,604		
63	18,689	1,922	$207,589	$142,852	42	$11,922	$11,741	16	$22,162	$4,505		
64	18,593	1,880	$203,006	$139,698	41	$11,658	$11,481	16	$21,673	$4,406		
65	18,489	1,837	$198,372	$136,509	39	$11,155	$10,985	13	$17,505	$3,559		
66	18,375	1,793	$193,669	$133,273	38	$10,890	$10,725	12	$17,090	$3,474		
67	18,250	1,749	$188,898	$129,990	38	$10,622	$10,460	12	$16,669	$3,389		
68	18,113	1,704	$184,054	$126,656	37	$10,349	$10,192	12	$16,242	$3,302		
69	17,963	1,659	$179,132	$123,269	36	$10,073	$9,920	12	$15,808	$3,213		
Total		**101,717**	**$10,985,446**	**$7,559,614**	**3,185**	**$901,395**	**$887,699**	**1,625**	**$2,227,400**	**$452,791**	**41**	**$1,064,789**

Costs Avoided with HPV-Based Screening for Cervical Cancer

HPV-based screening between the ages of 25 and 69 in a BC birth cohort of 20,000 females is associated with an estimated reduction of 240 incident cervical cancers and 146 deaths attributable to cervical cancers, compared with no screening (see Table 38). Each incident cervical cancer is associated with $41,118 in healthcare costs while each death attributable to cervical cancer is associated with $50,961 in health care costs. The avoidance of the incident cancers is associated with $9.9 million in healthcare costs avoided while the avoidance of the deaths due to cervical cancer is associated with $7.4 million in healthcare costs avoided (see Table 38).

Table 38: Costs Avoided with Screening for Cervical Cancer

hrHPV-Based Screening Model

in a British Columbia Birth Cohort of 20,000 Females

Age	Females in Birth Cohort	*Incident Cervical Cancers*				*Deaths Due to Cervical Cancer*			
		No Screening	Screening	Avoided	HC System $	No Screening	Screening	Avoided	HC System $
25	19,843	1.2	0.6	0.6	$24,760	0.3	0.1	0.2	$11,529
26	19,834	1.7	0.9	0.8	$33,823	0.3	0.1	0.2	$11,524
27	19,825	2.8	1.4	1.4	$56,597	0.3	0.1	0.2	$11,519
28	19,816	2.4	1.2	1.2	$47,618	0.3	0.1	0.2	$11,514
29	19,806	3.0	1.6	1.5	$61,327	0.3	0.1	0.2	$11,508
30	19,796	4.5	0.7	3.8	$155,221	0.9	0.1	0.8	$43,143
31	19,785	4.5	0.7	3.8	$155,135	0.9	0.1	0.8	$43,119
32	19,773	4.5	0.7	3.8	$155,045	0.9	0.1	0.8	$43,094
33	19,761	4.5	0.7	3.8	$154,951	0.9	0.1	0.8	$43,068
34	19,749	4.5	0.7	3.8	$154,853	0.9	0.1	0.8	$43,040
35	19,736	4.5	1.7	2.8	$114,274	1.6	0.2	1.4	$71,085
36	19,722	4.5	1.7	2.8	$114,196	1.6	0.2	1.4	$71,036
37	19,708	4.5	1.7	2.8	$114,113	1.6	0.2	1.4	$70,985
38	19,693	4.5	1.7	2.8	$114,026	1.6	0.2	1.4	$70,931
39	19,677	4.5	1.7	2.8	$113,936	1.6	0.2	1.4	$70,875
40	19,661	6.5	1.8	4.7	$193,232	2.7	0.3	2.4	$124,588
41	19,643	6.5	1.8	4.7	$193,059	2.7	0.3	2.4	$124,476
42	19,625	6.5	1.8	4.7	$192,876	2.7	0.3	2.4	$124,359
43	19,605	6.5	1.8	4.7	$192,682	2.7	0.3	2.4	$124,233
44	19,584	6.5	1.8	4.7	$192,473	2.7	0.3	2.4	$124,099
45	19,561	6.5	1.8	4.7	$192,251	4.0	0.4	3.6	$185,547
46	19,537	6.4	1.8	4.7	$192,013	4.0	0.4	3.6	$185,318
47	19,511	6.4	1.8	4.7	$191,760	4.0	0.4	3.6	$185,073
48	19,484	6.4	1.8	4.7	$191,489	4.0	0.4	3.6	$184,811
49	19,454	6.4	1.8	4.6	$191,198	4.0	0.4	3.6	$184,530
50	19,422	7.4	1.3	6.1	$251,346	4.0	0.4	3.5	$179,813
51	19,388	7.4	1.3	6.1	$250,906	4.0	0.4	3.5	$179,499
52	19,352	7.4	1.3	6.1	$250,433	4.0	0.4	3.5	$179,160
53	19,312	7.4	1.3	6.1	$249,923	4.0	0.4	3.5	$178,795
54	19,270	7.3	1.3	6.1	$249,372	3.9	0.4	3.5	$178,401
55	19,224	7.3	1.3	6.1	$248,779	4.1	0.4	3.7	$187,236
56	19,174	7.3	1.3	6.0	$248,140	4.1	0.4	3.7	$186,755
57	19,121	7.3	1.3	6.0	$247,448	4.1	0.4	3.7	$186,235
58	19,063	7.3	1.3	6.0	$246,698	4.1	0.4	3.6	$185,670
59	19,000	7.2	1.3	6.0	$245,885	4.1	0.4	3.6	$185,058
60	18,932	7.9	1.2	6.7	$273,652	5.2	0.4	4.8	$243,098
61	18,858	7.8	1.2	6.6	$272,580	5.2	0.4	4.8	$242,146
62	18,777	7.8	1.2	6.6	$271,415	5.2	0.4	4.7	$241,111
63	18,689	7.8	1.2	6.6	$270,143	5.1	0.4	4.7	$239,981
64	18,593	7.7	1.2	6.5	$268,758	5.1	0.4	4.7	$238,751
65	18,489	7.7	1.2	6.5	$267,246	5.1	0.5	4.6	$236,248
66	18,375	7.6	1.2	6.5	$265,595	5.1	0.5	4.6	$234,789
67	18,250	7.6	1.2	6.4	$263,789	5.1	0.5	4.6	$233,192
68	18,113	7.5	1.2	6.4	$261,811	5.0	0.5	4.5	$231,444
69	17,963	7.5	1.1	6.3	$259,646	5.0	0.5	4.5	$229,529
70	17,799	6.9	0.9	6.0	$247,034	4.8	0.6	4.2	$215,944
71	17,619	6.9	0.9	5.9	$244,533	4.8	0.6	4.2	$213,758
72	17,421	6.8	0.9	5.9	$241,791	4.7	0.6	4.1	$211,360
73	17,204	6.7	0.9	5.8	$238,779	4.6	0.5	4.1	$208,727
74	16,966	6.6	0.9	5.7	$235,473	4.6	0.5	4.0	$205,837
Total		**305**	**65**	**240**	**$9,864,083**	**163**	**16.8**	**146**	**$7,427,540**

Summary of CE

Based on these assumptions, the CE associated with HPV-based screening of females ages 25 to 69 years of age for cervical cancer as currently performed in BC would be $2,502 / QALY (Table 39, row w).

Table 39: Summary of CE Estimate for Cervical Cancer Screening With hrHPV-Based Screening

In a BC Birth Cohort of 40,000

Row	Variable	Base Case	Data Source
	Cost of Screening and Treatment		
a	Estimated number of screens	101,717	Table 37
b	Cost of Screening - Healthcare	$10,985,446	Table 37
c	Cost of Screening - Patient time	$7,559,614	Table 37
d	Estimated number of colposcopies	3,185	Table 37
e	Cost of colposcopies - Healthcare	$901,395	Table 37
f	Cost of colposcopies - Patient time	$887,699	Table 37
g	Estimated number of treatments for CIN2+	1,625	Table 37
h	Cost of treatments for CIN2+ - Healthcare	$2,227,400	Table 37
i	Cost of treatments for CIN2+ - Patient time	$452,791	Table 37
j	Estimated number of premature births attributable to treatment for CIN2+	41	Table 37
k	Costs attributable to preterm births	$1,064,789	Table 37
l	**Total cost of screening and treatment**	**$24,079,134**	= b + c + e + f + h + i + k
	Costs Avoided		
m	Deaths prevented	146	Table 38
n	Costs avoided due to deaths prevented	-$7,427,540	Table 38
o	# of cervical cancers avoided	240	Table 38
p	Costs avoided due to cervical cancers prevented	-$9,864,083	Table 38
q	**Total costs avoided**	**-$17,291,623**	= n + p
	Calculating CE		
r	Net costs	$6,787,511	= l + q
s	CPB undiscounted	4,215	Table 36
t	CE undiscounted	$1,610	= r / s
u	**Net Costs (1.5% discount)**	**$7,063,044**	Calculated
v	**CPB (1.5% discount)**	**2,823**	Calculated
w	**CE ($/QALY Saved)**	**$2,502**	= u / v

√ = Estimates from the literature

We also modified a number of key assumptions and recalculated the CE as follows:

- Assume the disutility associated with the diagnosis and treatment phase for cervical cancer of 0.288 is reduced to 0.193, the disutility associated with the ongoing, controlled phase (remission) for cervical cancer is reduced from 0.049 to 0.031 and the disutility associated with the metastatic phase for cervical cancer is reduced from 0.451 to 0.307: CE = $2,472.
- Assume the disutility associated with the diagnosis and treatment phase for cervical cancer of 0.288 is increased to 0.399, the disutility associated with the ongoing, controlled phase (remission) for cervical cancer is increased from 0.049 to 0.072 and the disutility associated with the metastatic phase for cervical cancer is increased from 0.451 to 0.600: CE = $2,542.

- Assume that unit costs are at the lower end of the 95% CI. The cost per HPV screen is reduced from $108 to $81, the cost per colposcopy is reduced from $283 to $200, the cost per treatment for CIN2+ is reduced from $1,371 to $1,271, the cost per cervical cancer avoided is reduced from $41,118 to $39,410 and the cost per death due to cervical cancer avoided is reduced from $50,961 to $47,410: **CE = $1,865**.
- Assume that unit costs are at the higher end of the 95% CI. The cost per HPV screen is increased from $108 to $135, the cost per colposcopy is increased from $283 to $444, the cost per treatment for CIN2+ is increased from $1,371 to $1,447, the cost per cervical cancer avoided is increased from $41,118 to $42,824 and the cost per death due to cervical cancer avoided is increased from $50,961 to $54,510: **CE = $3,198**.

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with cytology-based cervical cancer screening is estimated to be 2,823 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $2,502 per QALY (see Table 40).

Table 40: HPV-Based Screening for Cervical Cancer in a Birth Cohort of 40,000
Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Gap between 0% and Current BC Screening Rate (69%)			
1.5% Discount Rate	**2,823**	2,779	2,858
3% Discount Rate	1,912	1,877	1,939
0% Discount Rate	4,215	4,158	4,261
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$2,502**	$1,865	$3,198
3% Discount Rate	$3,583	$2,816	$4,419
0% Discount Rate	$1,610	$1,077	$2,193
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$109	Cost-saving	$805
3% Discount Rate	$835	$68	$1,671
0% Discount Rate	Cost-saving	Cost-saving	$81

Comparison of No Screening, Cytology-Based Screening and HPV-Based Screening

Table 41 provides an overview of interventions, potential harms, costs and QALYs lost/gained associated with moving from no screening to cytology-based screening and then to HPV-based screening in a BC birth cohort of 20,000 females ages 25 to 69 years of age.

Moving from no screening to cytology-based screening is associated with 2,700 QALYs gained at a net cost of $13.7 million for a cost per QALY gained of $5,077.[612]

Moving from no screening to HPV-based screening is associated with 2,823 QALYs gained at a net cost of $7.1 million for a cost per QALY gained of $2,502.[613]

Thus HPV-based screening is both more effective (higher CPB - number of QALYs gained) and less costly (lower CE – cost per QALY gained) than cytology-based screening.

Table 41: Screening for Cervical Cancers
Comparison of No Screening, Cytology-Based Screening and HPV-Based Screening
In a BC Birth Cohort of 40,000 (20,000 Females)

	No Screening	Cytology-Based Screening	No to Cytology-Based Screening		HPV-Based Screening	No to HPV-Based Screening		Cytology- to HPV-Based Screening	
			Change	% Change		Change	% Change	Change	% Change
Incident Cervical Cancers	305	99	-206	-68%	65	-240	-79%	-34	-34%
Deaths due to Cervical Cancer	163	25	-138	-85%	17	-146	-90%	-8	-32%
QALYs Lost	5,386	978	-4,409	-82%	650	-4,736	-88%	-327	-33%
Interventions									
# of Screens		171,230			101,717			-69,513	-41%
# of Colposcopies		2,569			3,185			616	24%
# of Treatments for CIN2+		1,321			1,625			303	23%
Cost of Interventions *(in $millions)*									
Screening		$26.25			$18.55			-$7.71	-29%
Colposcopies		$1.44			$1.79			$0.35	24%
Treatments for CIN2+		$2.18			$2.68			$0.50	23%
Harms									
Abnormality Diagnoses		5,044			6,742			1,698	34%
Treatment for CIN2+		1,321			1,625			303	23%
Pre-term births		38			41			4	9%
QALYs Lost Due to Harms									
Abnormality Diagnoses		119			179			60	50%
Treatment for CIN2+		120			194			73	61%
Pre-term births		135			148			13	9%
Cost Associated with Harms (in $millions)									
Pre-term births		$0.97			$1.06			$0.09	9%
Cervical Cancers Avoided									
Incident Cervical Cancers		206			240			34	16%
Deaths due to Cervical Cancer		138			146			8	6%
Costs Avoided (in $millions)									
Incident Cervical Cancers		-$8.47			-$9.86			-$1.40	16%
Deaths due to Cervical Cancer		-$7.02			-$7.43			-$0.41	6%
Net Costs (in $millions - 0% discount rate)		$15.36			$6.79			-$8.57	-56%
CPB (Net QALYs Gained - 0% discount rate)		4,034			4,215			181	4%
CE ($ / *QALY Saved* - 0% discount rate)		$3,808			$1,610			-$2,198	-58%
Net Costs (in $millions - 1.5% discount rate)		***$13.71***			***$7.06***			**-$6.64**	**-48%**
CPB (Net QALYs Gained - 1.5% discount rate)		***2,700***			***2,823***			**123**	**5%**
CE ($ / *QALY Saved* - 1.5% discount rate)		***$5,077***			***$2,502***			**-$2,575**	**-51%**

[612] Based on a discount rate of 1.5%.
[613] Ibid.

United States Preventive Services Task Force Recommendations (2021)

The USPSTF recommends screening for colorectal cancer in all adults aged 50 to 75 years. (A recommendation)

The USPSTF recommends screening for colorectal cancer in adults aged 45 to 49 years. (B recommendation)

The USPSTF recommends that clinicians selectively offer screening for colorectal cancer in adults aged 76 to 85 years. Evidence indicates that the net benefit of screening all persons in this age group is small. In determining whether this service is appropriate in individual cases, patients and clinicians should consider the patient's overall health, prior screening history, and preferences. (C recommendation)[614]

Canadian Task Force on Preventive Health Care (2016)

The CTFPHC recommends screening adults aged 60 to 74 years for colorectal cancer with FOBT (gFOBT or FIT) every two years or flexible sigmoidoscopy every 10 years. (Strong recommendation; moderate-quality evidence)

The CTFPHC recommends screening adults aged 50 to 59 years for colorectal cancer with FOBT (gFOBT or FIT) every two years or flexible sigmoidoscopy every 10 years. (Weak recommendation; moderate-quality evidence)

The CTFPHC recommends not screening adults aged 75 years and older for colorectal cancer. (Weak recommendation; low-quality evidence)

The CTFPHC recommends not using colonoscopy as a screening tool for colorectal cancer. (Weak recommendation; low-quality evidence)[615]

Best in the World

- In 2012, colorectal cancer (CRC) screening rates in Canada for the population **ages 50-74** averaged 55.2%, ranging from a low of 49.6% in BC to a high of 64.1% in Ontario. A further 21.5% of those **ages 45-49** received CRC screening.[616]
- In the US, screening in adults ages 50-75 who have health insurance has increased from 50.4% in 2011 to 69.7% in 2019.[617]
- In the US in 2018, 68.8% of adults ages 50-75 were up to date with CRC screening test use, ranging from a low of 57.8% in Wyoming to a high of 76.5% in Massachusetts. The percentage up to date was 63.3% among those aged 50–64 years and 79.2% among respondents aged 65–75 years.[618]

[614] US Preventive Services Task Force. Screening for colorectal cancer: US Preventive Services Task Force Recommendation statement. *JAMA*. 2021; 325(19): 1965-1977.
[615] Canadian Task Force on Preventive Health Care. Recommendations on screening for colorectal cancer. *Canadian Medical Association Journal*. 2016; 188(5): 340-8.
[616] Singh H, Bernstein C, Samadder J et al. Screening rates for colorectal cancer in Canada: A cross-sectional study. *CMAJ Open*. 2016; 3(2): E149-E157.
[617] Fisher D, Princic N, Miller-Wilson L et al. Utilization of a colorectal cancer screening test among individuals with average risk. *JAMA Network Open*. 2021; 4(9):e2122269.
[618] Joseph D, King J, Dowling N et al. Vital signs: Colorectal cancer screening test use — United States, 2018. *Morbidity and Mortality Weekly Report*. 2020; 69(10): 253-9.

- Guo et al. report a CRC screening rate of 77.1% in 2008-10 in a German population ages 50 to 75.[619]

- For modelling purposes, we assume that the ***best in the world*** screening rate is 77%.

Current Screening Rates in BC

- The BC Colon Cancer Screening Program started in 2013. In 2019, 34.5% of the BC age eligible (50-74) population had received a fecal immunochemical test (FIT) within the past 30 months.[620] The 34.5% does not account for those screened outside of the program so the actual rate is likely higher. In 2012, for example, 49.6% of British Columbians ages 50-74 self-reported being up-to-date on their CRC screening.[621]

- For modelling purposes, we assume that the current BC screening rate is 50%, and reduced this to 35% in the sensitivity analysis.

Modelling the Clinically Preventable Burden

In this section, we will calculate the Clinically Preventable Burden (CPB) associated with screening for colorectal cancer in adults ages 45-75 in a British Columbia birth cohort of 40,000, based on current recommendations by the USPSTF.[622]

In estimating CPB, we made the following assumptions:

Defining and Estimating the Population at Risk

Incidence of Colorectal Cancer in BC

- In 2018, 2,945 new cases of CRC (an incidence rate of 58.9 / 100,000) and 1,115 deaths attributable to CRC (a mortality rate of 22.3 / 100,000) were observed in BC (Table 1).[623]

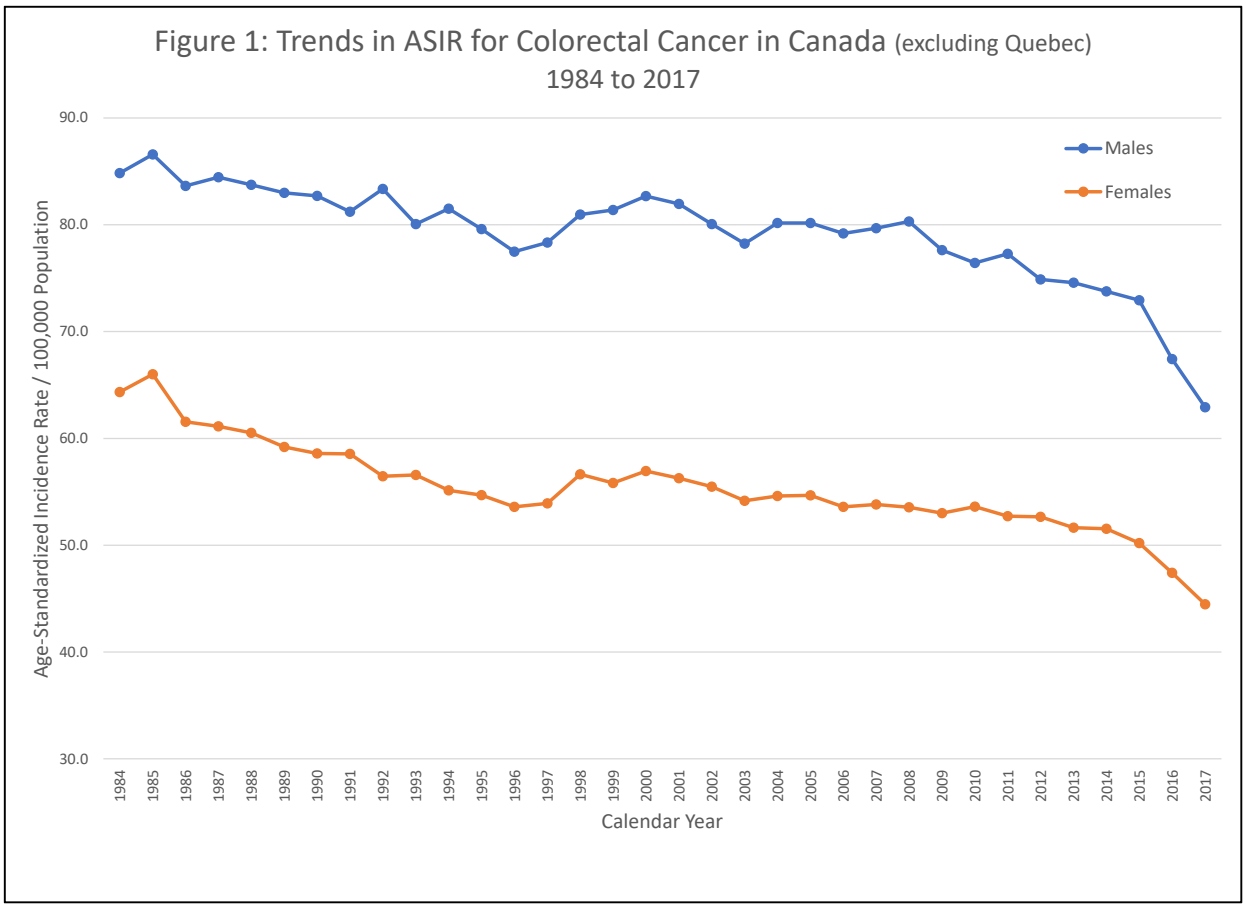
[619] Guo F, Chen, C, Schottker B et al. Changes in colorectal cancer screening use after introduction of alternative screening offer in Germany: Prospective cohort study. *International Journal of Cancer*. 2020; 146: 2423-32.
[620] BC Cancer Colon Screening. *2019 Program Results*. March 202. Available online at http://www.bccancer.bc.ca/screening/Documents/Colon-Program-Results-2019.pdf. Accessed November 2021.
[621] Singh H, Bernstein C, Samadder J et al. Screening rates for colorectal cancer in Canada: A cross-sectional study. *CMAJ Open*. 2016; 3(2): E149-E157.
[622] US Preventive Services Task Force. Screening for colorectal cancer: US Preventive Services Task Force Recommendation statement. *JAMA*. 2021; 325(19): 1965-1977.
[623] BC Cancer. Statistics by Cancer Type – Colorectal. Available online at http://www.bccancer.bc.ca/statistics-and-reports-site/Documents/Cancer_Type_Colorectal_2018_20210305.pdf. Accessed November 2021.

Table 1: Colorectal Cancer in British Columbia
Incidence and Mortality in 2018

Age Group	New Cases			Incidence Rate / 100,000			Deaths			Mortality Rate / 100,000		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
0-19	5	0	0	0.2	0.2	0.2	0	0	0	0.0	0.0	0.0
20-39	50	40	85	6.7	5.6	6.2	5	5	10	0.4	0.7	0.6
40-59	295	280	575	43.8	39.8	41.8	95	50	145	13.7	7.7	10.6
60-79	860	645	1,505	172.2	120.2	145.3	310	185	500	62.4	34.7	48.1
80+	370	405	775	391.2	314.7	347.0	220	245	460	230.0	191.5	207.8
Total	**1,575**	**1,370**	**2,945**	**63.6**	**54.2**	**58.9**	**625**	**490**	**1,115**	**25.2**	**19.5**	**22.3**

Source BC Cancer. Statitics by Cancer Type - Colorectal

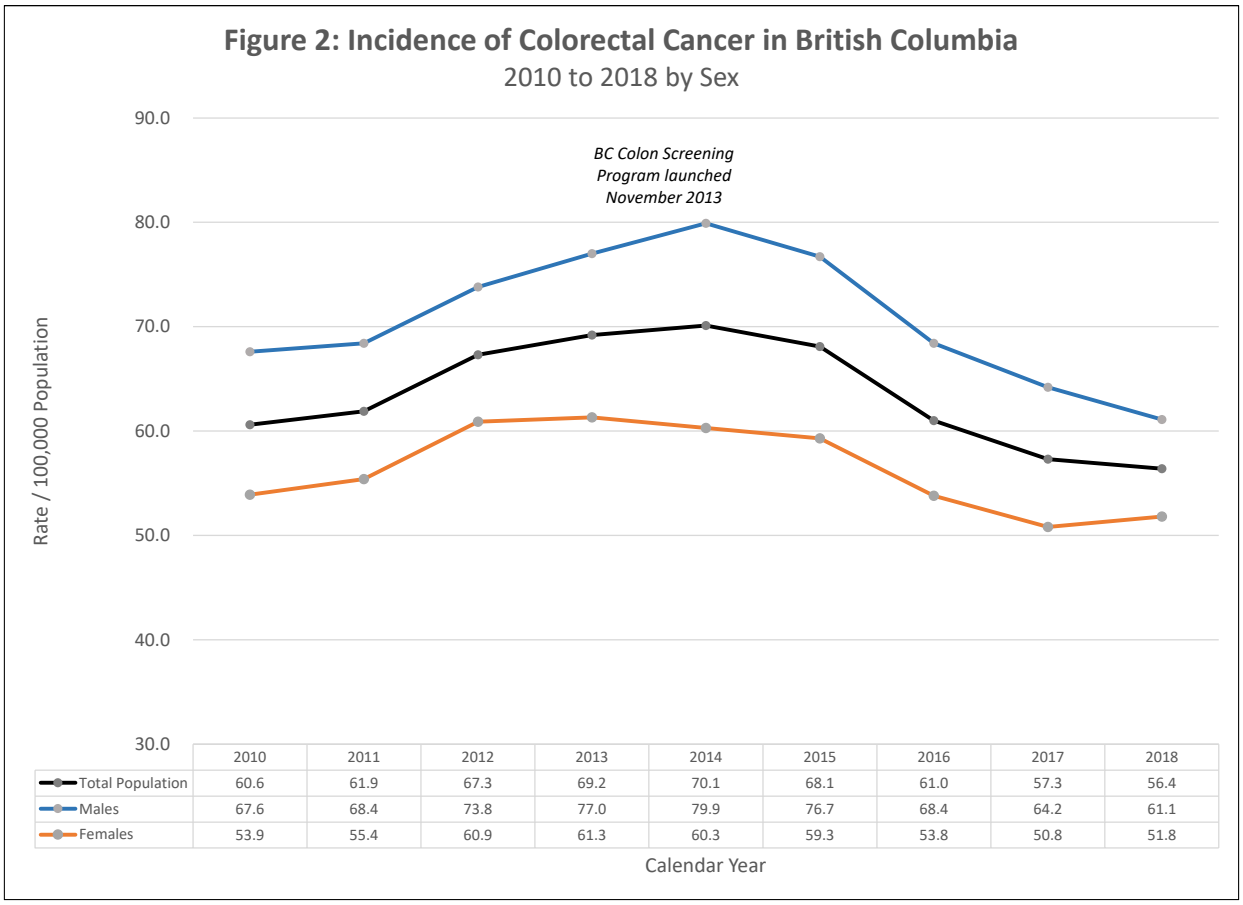
- In Canada, the age-standardized incidence rate (ASIR) of CRC has decreased by 3.6% per year between 2013 and 2017 (3.4% in females and 4.3% in males) (Figure 1). "The recent decline in colorectal cancer rates is likely due in part to increased screening for the disease…. Between 2007 and 2016, Yukon and every province in Canada (except Quebec) implemented organized colorectal cancer screening programs."[624]



[624] Canadian Cancer Statistics Advisory Committee in collaboration with the Canadian Cancer Society, Statistics Canada and the Public Health Agency of Canada. *Canadian Cancer Statistics 2021*. Toronto, ON: Canadian Cancer Society; 2021.

- The observed decline in incidence, however, is not seen in younger individuals. In the US, the incidence of CRC has increased annually by 0.5% to 1.3% in the 45 to 54 year age cohort.[625]
- In Canada, Brenner et al have observed that the incidence of colon cancer has generally been decreasing in those over the age of 50 since the mid-1980s. In those ages 40-49, however, there has been an annual percent change (APC) of +1.66% between 2003 and 2012. While overall incidence rates are lower in even younger cohorts, they observed a +6.24% APC in those ages 20-29 and +2.11% in those ages 30-39. The authors suggest that this increase in colon cancer incidence in younger cohorts is likely due to a combination of poor diet, sedentary behavior, physical inactivity, and consequential excess bodyweight.[626]
- In BC, Howren et al. found a significant increase in the APC of CRC between 1986 and 2016 in 40-49 year-old men of 1.86% (95% CI of 1.19 to 2.53%). Much of this increase was driven by increasing rates of rectal cancer. The more modest APC in women ages 40-49 of 0.12% was not statistically significant (95% CI of -0.54 to 0.79%).[627]
- The Canadian Association of Gastroenterology and the Canadian Digestive Health Foundation published a guideline for colorectal cancer screening in 2004,[628] in which a recommendation was made for colonoscopy among Canadians aged 50 and above. Brenner et al found that the post-guideline slope changes were significant for colon cancer (-1.85 per 100,000, $p < 0.001$) and rectal cancer (-0.66 per 100,000, $p = 0.004$) in those over the age of 50 but not in those under 50 years of age.[629]
- In BC, the Colon Screening Program was launched in November of 2013. The incidence rate of CRC in the province increased between 2010 and 2014, before decreasing through 2018 (Figure 2).[630]
- For modelling purposes, we first want to estimate the incidence of CRC **in the absence of a co-ordinated CRC screening program** and then model how this would change **in the presence of a fully mature CRC screening program**. We have assumed that using 2014 incidence rates (the high point in Figure 2) would approximate the number of new cases **in the absence of a co-ordinated CRC screening program**.

[625] Siegel R, Fedewa S, Anderson W et al. Colorectal cancer incidence patterns in the United States, 1974 – 2013. *Journal of the National Cancer Institute*. 2017; 108(8).
[626] Brenner D, Ruan Y, Shaw E et al. Increasing colorectal cancer incidence trends among younger adults in Canada. *Preventive Medicine*. 2017; 105: 345-9.
[627] Howren A, Sayre E, Loree J et al. Trends in the incidence of young-onset colorectal cancer with a focus on years approaching screening age: A population-based longitudinal study. *Journal of the National Cancer Institute*. 2021; 113(7): 863-8.
[628] Leddin D, Hunt R, Champion M et al. Canadian Association of Gastroenterology and the Canadian Digestive Health Foundation: Guidelines on colon cancer screening. *Canadian Journal of Gastroenterology*. 2004; 18 (2): 93-99.
[629] Brenner D, Ruan Y, Shaw E et al. Increasing colorectal cancer incidence trends among younger adults in Canada. *Preventive Medicine*. 2017; 105: 345-9.
[630] Statistics Canada. Table 13-10-0111-01. Number and rates of new cases of primary cancer, by cancer type, age group and sex. Available online at https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=1310011101. Accessed November 2021.



	2010	2011	2012	2013	2014	2015	2016	2017	2018
Total Population	60.6	61.9	67.3	69.2	70.1	68.1	61.0	57.3	56.4
Males	67.6	68.4	73.8	77.0	79.9	76.7	68.4	64.2	61.1
Females	53.9	55.4	60.9	61.3	60.3	59.3	53.8	50.8	51.8

- For modelling purposes, we used the age- and sex-specific incidence rates from 2014 to estimate the number of new CRC cases in a BC birth cohort of 40,000 between the ages of 45 (the onset of proposed CRC screening) and age 79 (**approximately 4 years after the cessation of proposed CRC screening**). As noted in Table 2, there would be an estimated 1,804 new CRC cases BC birth cohort of 40,000 between the ages of 45 and age 79 (756 in females and 1,048 in males).
- **While screening would occur between the ages of 45 and 75**, using age 79 as the end point in the model assumes that screening to age 75 will be protective to age 79. That is, the benefits of screening will continue for a further 4 years after the cessation of screening at age 75.

Table 2: Estimated New Cases of Colorectal Cancer

Between the Ages of 45 and 79

In a British Columbia Birth Cohort of 40,000

In the Absence of a Co-ordinated Screening Program

	Female			***Male***			***Total Population***		
		Incidence			Incidence			Incidence	
Age	**Total Life Years**	Rate / 100,000	Estimated New CRC	**Total Life Years**	Rate / 100,000	Estimated New CRC	**Total Life Years**	Rate / 100,000	Estimated New CRC
45	19,561	17.4	3.4	19,094	42.1	8.0	38,656	29.6	11.4
46	19,537	17.4	3.4	19,047	42.1	8.0	38,584	29.6	11.4
47	19,511	17.4	3.4	18,996	42.1	8.0	38,508	29.6	11.4
48	19,484	17.4	3.4	18,943	42.1	8.0	38,427	29.6	11.4
49	19,454	17.4	3.4	18,887	42.1	8.0	38,341	29.6	11.3
50	19,422	50.1	9.7	18,827	57.1	10.8	38,249	53.5	20.5
51	19,388	50.1	9.7	18,763	57.1	10.7	38,151	53.5	20.4
52	19,352	50.1	9.7	18,695	57.1	10.7	38,046	53.5	20.4
53	19,312	50.1	9.7	18,622	57.1	10.6	37,934	53.5	20.3
54	19,270	50.1	9.7	18,545	57.1	10.6	37,814	53.5	20.2
55	19,224	61.5	11.8	18,461	104.5	19.3	37,685	82.6	31.1
56	19,174	61.5	11.8	18,372	104.5	19.2	37,547	82.5	31.0
57	19,121	61.5	11.8	18,277	104.5	19.1	37,398	82.5	30.9
58	19,063	61.5	11.7	18,175	104.5	19.0	37,238	82.5	30.7
59	19,000	61.5	11.7	18,065	104.5	18.9	37,065	82.5	30.6
60	18,932	102.4	19.4	17,947	171.5	30.8	36,879	136.0	50.2
61	18,858	102.4	19.3	17,820	171.5	30.6	36,678	136.0	49.9
62	18,777	102.4	19.2	17,684	171.5	30.3	36,461	135.9	49.6
63	18,689	102.4	19.1	17,537	171.5	30.1	36,226	135.9	49.2
64	18,593	102.4	19.0	17,379	171.5	29.8	35,972	135.8	48.8
65	18,489	141.0	26.1	17,208	205.0	35.3	35,697	171.9	61.3
66	18,375	141.0	25.9	17,024	205.0	34.9	35,399	171.8	60.8
67	18,250	141.0	25.7	16,826	205.0	34.5	35,075	171.7	60.2
68	18,113	141.0	25.5	16,612	205.0	34.1	34,725	171.6	59.6
69	17,963	141.0	25.3	16,381	205.0	33.6	34,344	171.5	58.9
70	17,799	211.6	37.7	16,132	328.6	53.0	33,930	267.2	90.7
71	17,619	211.6	37.3	15,863	328.6	52.1	33,481	267.0	89.4
72	17,421	211.6	36.9	15,573	328.6	51.2	32,994	266.8	88.0
73	17,204	211.6	36.4	15,260	328.6	50.1	32,464	266.6	86.5
74	16,966	211.6	35.9	14,923	328.6	49.0	31,889	266.4	84.9
75	16,704	277.7	46.4	14,560	408.3	59.4	31,265	338.5	105.8
76	16,417	277.7	45.6	14,170	408.3	57.9	30,587	338.2	103.4
77	16,102	277.7	44.7	13,751	408.3	56.1	29,853	337.9	100.9
78	15,757	277.7	43.8	13,301	408.3	54.3	29,058	337.5	98.1
79	15,378	277.7	42.7	12,820	408.3	52.3	28,198	337.1	95.0
Total	***642,278***	**118**	**756**	***598,538***	**175**	**1,048**	***1,240,816***	**145**	**1,804**

Colorectal Cancer Diagnosis by Stage

- A variety of staging systems for CRC have been used over time and between jurisdictions. The International Cancer Benchmarking Partnership (ICBP) spent significant time and effort developing an algorithm to convert disparate staging systems into a staging system using localised / regional / distant categories.[631] Data on CRC diagnosis by stage from Alberta and Manitoba between 2004 and 2007 produced by the ICBP is summarized on Table 3 using the localised / regional / distant categories as well as Dukes' Stage (a system more familiar to CRC clinicians).[632]

Table 3: Colorectal Cancer Diagnosis by Stage
Alberta and Manitoba, 2004 - 2007

	Cancer of the Colon			Cancer of the Rectum			Colorectal Cancer		
Stage	N	Mean Age	%	N	Mean Age	%	N	Mean Age	%
Localised	2,305	71.3	42.5%	1,983	68.4	41.6%	4,288	70.0	42.1%
Regional	1,707	70.2	31.5%	1,678	65.9	35.2%	3,385	68.1	33.2%
Distant	1,408	68.9	26.0%	1,111	65.6	23.3%	2,519	67.4	24.7%
Total	**5,420**	**70.3**	**100.0%**	**4,772**	**66.9**	**100.0%**	**10,192**	**68.7**	**100.0%**
Dukes' Stage									
A	951	70.8	17.5%	1,050	68.3	22.0%	2,001	69.5	19.6%
B	1,654	71.4	30.5%	1,108	68.4	23.2%	2,762	70.2	27.1%
C	1,407	70.2	26.0%	1,503	65.7	31.5%	2,910	67.9	28.6%
D	1,408	68.9	26.0%	1,111	65.6	23.3%	2,519	67.4	24.7%
Total	**5,420**	**70.3**	**100.0%**	**4,772**	**66.9**	**100.0%**	**10,192**	**68.7**	**100.0%**

- The original Dukes' stages were based on rectal cancers with 'A' meaning growth confined to the rectum with no extra-rectal spread or lymphatic metastasis, 'B' meaning spread by direct continuity into extra-rectal tissues with no lymphatic metastasis, 'C1' meaning only the regional lymph nodes contained metastasis and 'C2' meaning more extensive lymphatic spread.[633] Over time, 'C2' began to be designated as 'D' or 'Distant Spread'.
- While not provided in the data available from the ICBP, the CRC stage at diagnosis appears to be similar for males and females, regardless of the staging system used, as indicated in the following two bullet points.
- The following CRC diagnosis by stage and sex is based on 188,868 patients diagnosed with CRC in the US between 1992 and 2001:[634]

[631] Walters S, Maringe C, Butler J et al. Comparability of stage data in cancer registries in six countries: Lessons from the International Cancer Benchmarking Partnership. *International Journal of Cancer*. 2013; 132: 676-85.
[632] Maringe C, Walters S, Rachet B et al. Stage at diagnosis and colorectal cancer survival in six high-income countries: A population based study of patients diagnosed during 2000-2007. *Acta Oncologica*. 2013; 52(5): 919-32.
[633] Dukes C, Bussey H. The spread of rectal cancer and its effect on prognosis. *British Journal of Cancer*. 1958; 12(3): 309-20.
[634] Cress R, Morris C, Ellison G et al. Secular changes in colorectal cancer incidence by subsite, stage at diagnosis, and race/ethnicity, 1992 – 2001. *Cancer*. 2006; 107(5): 1142-52.

Stage at Diagnosis[635]		Male	Female
In situ	3.4%	2.9%	
Invasive	48.3%	48.6%	
Localized	20.4%	19.7%	
Regional/distant	27.9%	28.8%	

- The following CRC diagnosis by stage and sex is based on 34,011 patients diagnosed with CRC in England in 2012.[636]

Stage at Diagnosis[637]	Male	Female
I	18.2%	16.3%
II	27.1%	28.7%
III	30.9%	30.2%
IV	23.9%	24.8%

- In Denmark between 1985 and 1995, 456 CRCs were detected in the **unscreened population** by stage as follows:[638]

  Dukes' A – 54 (11.8%)

  Dukes' B – 177 (38.8%)

  Dukes' C – 111 (24.3%)

  Distant Spread – 114 (25.0%)

- In a chart review of 700 **unscreened patients** in the Ottawa hospital system with a diagnosis of CRC during 1991/92, the stage at diagnosis was as follows:[639]

  Dukes' A – 91 (13.0%)

  Dukes' B – 231 (33.0%)

  Dukes' C – 189 (27.0%)

  Distant Spread – 189 (27.0%)

[635] "**In situ** tumors were defined as non-invasive tumors that had not penetrated the basement membrane; **localized** tumors were those confined entirely to the organ of origin; **regional** tumors were those that extended into surrounding organs and tissues (or regional lymph nodes); and **distant** tumors were those that had spread to remote organs or lymph nodes. Regional and distant stages were subsequently combined into a single group to represent cases with a "late-stage" diagnosis."

[636] White A, Ironmonger L, Steele R et al. A review of sex-related differences in colorectal cancer incidence, screening uptake, routes to diagnosis, cancer stage and survival in the UK. *BMC Cancer*. 2018; 18: 906.

[637] Based on the Tumor Node Metastasis (TNM) staging classification system.

[638] Kronborg O, Fenger C, Olsen J et al. Randomised study of screening for colorectal cancer with faecal-occult-blood test. *The Lancet*. 1996; 348: 1467-71.

[639] Flanagan W, Petit C, Berthelot J et al. Potential impact of population-based colorectal cancer screening in Canada. *Chronic Diseases in Canada*. 2003; 24(4): 81-8.

- We combined the results in the **control groups (unscreened population)** from three early RCTs assessing the effectiveness of screening with FOBT.[640,641,642] For the 1,634 CRCs in the three control groups, the stage at diagnosis was as follows:

  Dukes' A – 237 (14.5%)

  Dukes' B – 582 (35.3%)

  Dukes' C – 457 (28.0%)

  Distant Spread – 358 (21.9%)

- Applying the proportions above to the new CRC cases from Table 2, Table 4 estimates the stage of new CRC cases in a BC birth cohort of 40,000 diagnosed between the ages of 45 and age 79, by sex and stage. Of the 1,804 new CRCs, 262 would be Dukes' stage A, 643 would be Dukes stage B, 505 would be Dukes' stage C and 395 would have distant spread. The stage of the CRC at diagnosis has a significant effect on subsequent patient mortality.

[640] Mandel J, Bond J, Church T et al. Reducing mortality from colorectal cancer by screening for fecal occult blood. *New England Journal of Medicine*. 1993; 328: 1365-71.
[641] Kronborg O, Fender C, Olsen J et al. Randomised study of screening for colorectal cancer with faecal-occult-blood test. *The Lancet*. 1996; 348(9040): 1467-71.
[642] Hardcastle J, Chamberlain J, Robinson M et al. Randomised controlled trial of faecal-occult-blood screening for colorectal cancer. *The Lancet.* 1996; 348(9040): 1472-77.

Table 4: Estimated New Cases of Colorectal Cancer by Dukes' Stage

Between the Ages of 45 and 79

In a British Columbia Birth Cohort of 40,000

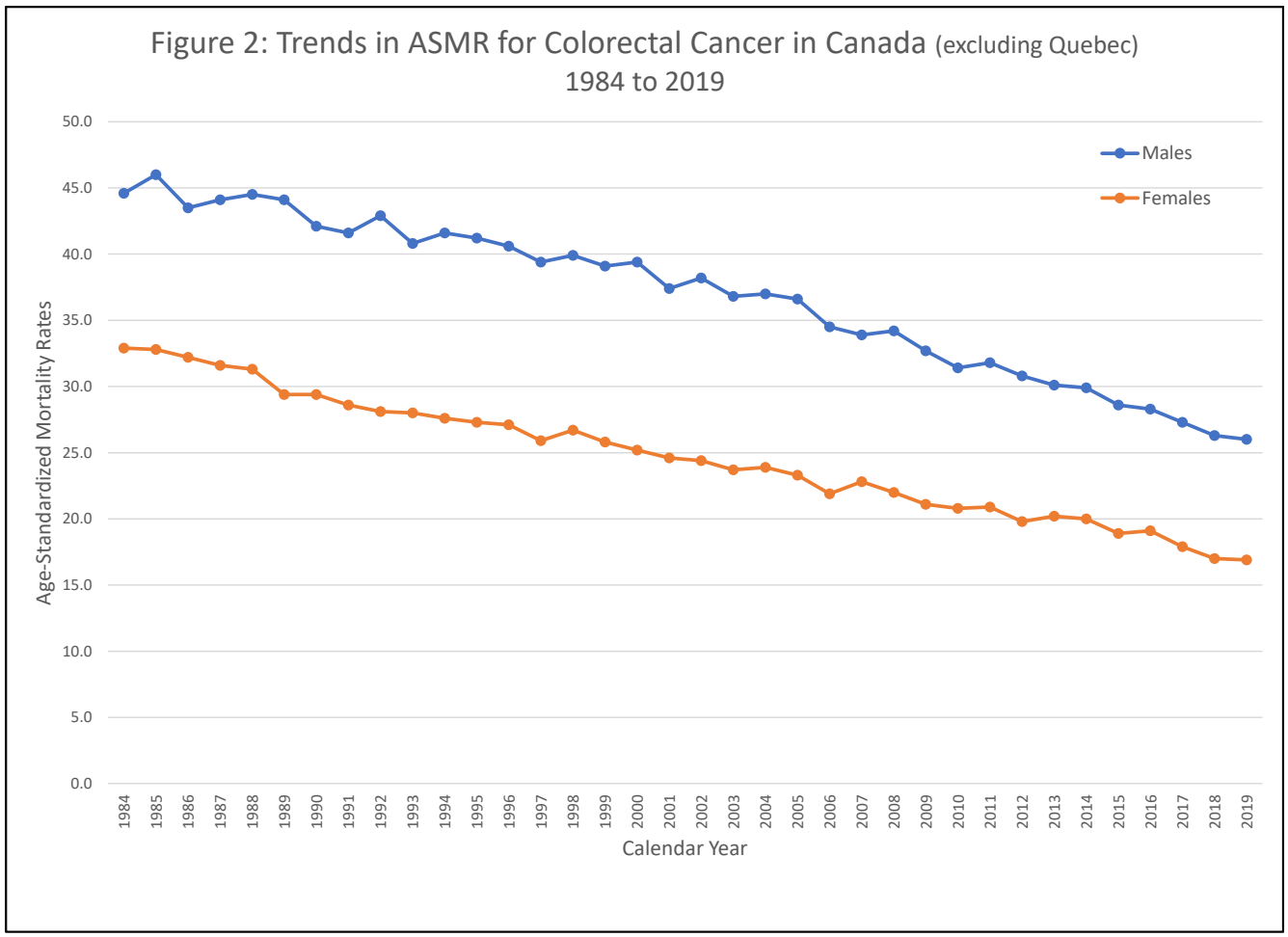
In the Absence of a Co-ordinated Screening Program

	Female					*Male*					*Total Population*				
	Estimated	**New CRC by Stage**				Estimated	**New CRC by Stage**				Estimated	**New CRC by Stage**			
Age	New CRC	A	B	C	Distant	New CRC	A	B	C	Distant	New CRC	A	B	C	Distant
45	3.4	0.5	1.2	1.0	0.7	8.0	1.2	2.9	2.2	1.8	11.4	1.7	4.1	3.2	2.5
46	3.4	0.5	1.2	1.0	0.7	8.0	1.2	2.9	2.2	1.8	11.4	1.7	4.1	3.2	2.5
47	3.4	0.5	1.2	0.9	0.7	8.0	1.2	2.8	2.2	1.8	11.4	1.7	4.1	3.2	2.5
48	3.4	0.5	1.2	0.9	0.7	8.0	1.2	2.8	2.2	1.7	11.4	1.6	4.0	3.2	2.5
49	3.4	0.5	1.2	0.9	0.7	8.0	1.2	2.8	2.2	1.7	11.3	1.6	4.0	3.2	2.5
50	9.7	1.4	3.5	2.7	2.1	10.8	1.6	3.8	3.0	2.4	20.5	3.0	7.3	5.7	4.5
51	9.7	1.4	3.5	2.7	2.1	10.7	1.6	3.8	3.0	2.3	20.4	3.0	7.3	5.7	4.5
52	9.7	1.4	3.5	2.7	2.1	10.7	1.5	3.8	3.0	2.3	20.4	3.0	7.3	5.7	4.5
53	9.7	1.4	3.4	2.7	2.1	10.6	1.5	3.8	3.0	2.3	20.3	2.9	7.2	5.7	4.4
54	9.7	1.4	3.4	2.7	2.1	10.6	1.5	3.8	3.0	2.3	20.2	2.9	7.2	5.7	4.4
55	11.8	1.7	4.2	3.3	2.6	19.3	2.8	6.9	5.4	4.2	31.1	4.5	11.1	8.7	6.8
56	11.8	1.7	4.2	3.3	2.6	19.2	2.8	6.8	5.4	4.2	31.0	4.5	11.0	8.7	6.8
57	11.8	1.7	4.2	3.3	2.6	19.1	2.8	6.8	5.3	4.2	30.9	4.5	11.0	8.6	6.8
58	11.7	1.7	4.2	3.3	2.6	19.0	2.8	6.8	5.3	4.2	30.7	4.5	10.9	8.6	6.7
59	11.7	1.7	4.2	3.3	2.6	18.9	2.7	6.7	5.3	4.1	30.6	4.4	10.9	8.5	6.7
60	19.4	2.8	6.9	5.4	4.2	30.8	4.5	11.0	8.6	6.7	50.2	7.3	17.9	14.0	11.0
61	19.3	2.8	6.9	5.4	4.2	30.6	4.4	10.9	8.5	6.7	49.9	7.2	17.8	13.9	10.9
62	19.2	2.8	6.8	5.4	4.2	30.3	4.4	10.8	8.5	6.6	49.6	7.2	17.7	13.9	10.9
63	19.1	2.8	6.8	5.4	4.2	30.1	4.4	10.7	8.4	6.6	49.2	7.1	17.5	13.8	10.8
64	19.0	2.8	6.8	5.3	4.2	29.8	4.3	10.6	8.3	6.5	48.8	7.1	17.4	13.7	10.7
65	26.1	3.8	9.3	7.3	5.7	35.3	5.1	12.6	9.9	7.7	61.3	8.9	21.9	17.2	13.4
66	25.9	3.8	9.2	7.2	5.7	34.9	5.1	12.4	9.8	7.6	60.8	8.8	21.7	17.0	13.3
67	25.7	3.7	9.2	7.2	5.6	34.5	5.0	12.3	9.6	7.6	60.2	8.7	21.5	16.8	13.2
68	25.5	3.7	9.1	7.1	5.6	34.1	4.9	12.1	9.5	7.5	59.6	8.6	21.2	16.7	13.1
69	25.3	3.7	9.0	7.1	5.5	33.6	4.9	12.0	9.4	7.4	58.9	8.5	21.0	16.5	12.9
70	37.7	5.5	13.4	10.5	8.3	53.0	7.7	18.9	14.8	11.6	90.7	13.2	32.3	25.4	19.9
71	37.3	5.4	13.3	10.4	8.2	52.1	7.6	18.6	14.6	11.4	89.4	13.0	31.8	25.0	19.6
72	36.9	5.3	13.1	10.3	8.1	51.2	7.4	18.2	14.3	11.2	88.0	12.8	31.4	24.6	19.3
73	36.4	5.3	13.0	10.2	8.0	50.1	7.3	17.9	14.0	11.0	86.5	12.6	30.8	24.2	19.0
74	35.9	5.2	12.8	10.0	7.9	49.0	7.1	17.5	13.7	10.7	84.9	12.3	30.3	23.8	18.6
75	46.4	6.7	16.5	13.0	10.2	59.4	8.6	21.2	16.6	13.0	105.8	15.4	37.7	29.6	23.2
76	45.6	6.6	16.2	12.8	10.0	57.9	8.4	20.6	16.2	12.7	103.4	15.0	36.8	28.9	22.7
77	44.7	6.5	15.9	12.5	9.8	56.1	8.1	20.0	15.7	12.3	100.9	14.6	35.9	28.2	22.1
78	43.8	6.3	15.6	12.2	9.6	54.3	7.9	19.3	15.2	11.9	98.1	14.2	34.9	27.4	21.5
79	42.7	6.2	15.2	11.9	9.4	52.3	7.6	18.6	14.6	11.5	95.0	13.8	33.9	26.6	20.8
Total	**756**	**110**	**269**	**211**	**166**	**1,048**	**152**	**373**	**293**	**230**	**1,804**	**262**	**643**	**505**	**395**

Trend in Mortality Rate Due to Colorectal Cancer in Canada

- In Canada, the mortality rates for CRC in males have declined -1.0% per year between 1984 and 2004, and then further declining by -2.3% per year between 2005 and 2019. In females, the rate initially declined -1.7% per year, but since 2014 the rate of decline has nearly doubled, lowering mortality -3.4% per year. “Part of this decline may be driven by the decrease in incidence and improvements in treatment.

Given the strong connection between stage at diagnosis and survival for colorectal cancer, participation in colorectal cancer screening programs may be an additional factor contributing to the more rapid rate of decline observed in colorectal cancer mortality in recent years."[643]



[643] Canadian Cancer Statistics Advisory Committee in collaboration with the Canadian Cancer Society, Statistics Canada and the Public Health Agency of Canada. *Canadian Cancer Statistics 2021*. Toronto, ON: Canadian Cancer Society; 2021.

- In 2017, the observed 1-, 3-, and 5-year survival rate in BC following a diagnosis of CRC **by stage** is summarized in Table 5.[644]

Table 5: Survival Rates Following CRC in BC
By Stage in 2017

Stage	1-Year	3-Year	5-Year
I	96.3%	90.8%	84.0%
II	91.9%	82.1%	72.5%
III	89.8%	73.5%	62.7%
IV	49.3%	19.9%	11.9%

- Based on data from ICBP for Alberta and Manitoba between 2004 and 2007, 1- and 3-year net survival **by stage and age** is summarized on Table 6.[645]

Table 6: Colorectal Cancer Survival
By Age and Stage
Alberta and Manitoba, 2004 - 2007

		Cancer of the Colon		Cancer of the Rectum		Colorectal Cancer	
Stage	Age Group	1 Yr	3 Yr	1 Yr	3 Yr	1 Yr	3 Yr
A							
	15-49	99.0%	96.7%	99.4%	97.5%	99.2%	97.1%
	50-69	98.2%	96.1%	98.4%	95.5%	98.3%	95.8%
	70-99	93.2%	92.4%	95.6%	91.9%	94.5%	92.1%
	All Ages	**95.4%**	**94.0%**	**97.1%**	**94.0%**	**96.3%**	**94.0%**
B							
	15-49	97.7%	91.7%	99.3%	96.1%	98.3%	93.5%
	50-69	96.1%	90.1%	97.4%	91.2%	96.6%	90.5%
	70-99	90.7%	85.3%	90.5%	80.7%	90.6%	83.5%
	All Ages	**92.7%**	**87.3%**	**94.3%**	**86.6%**	**93.3%**	**87.0%**
C							
	15-49	95.3%	81.8%	97.4%	87.1%	96.4%	84.5%
	50-69	94.0%	81.0%	95.7%	83.0%	94.9%	82.0%
	70-99	82.1%	62.2%	89.3%	75.2%	85.8%	68.9%
	All Ages	**87.4%**	**70.5%**	**93.3%**	**80.3%**	**90.4%**	**75.6%**
Distant							
	15-49	63.5%	26.3%	69.9%	30.6%	66.3%	28.2%
	50-69	52.2%	18.4%	66.0%	29.2%	58.3%	23.2%
	70-99	28.5%	6.4%	46.4%	16.4%	36.4%	10.8%
	All Ages	**41.0%**	**12.9%**	**58.9%**	**24.4%**	**48.9%**	**18.0%**
All Patients							
	15-49	85.6%	70.0%	91.6%	79.4%	88.4%	74.4%
	50-69	83.0%	67.9%	89.2%	76.6%	85.9%	72.0%
	70-99	72.0%	58.6%	79.2%	65.8%	75.4%	62.0%
	All Ages	**76.9%**	**62.8%**	**84.8%**	**71.9%**	**80.6%**	**67.1%**

[644] BC Cancer. *Cancer Survival Rates*. Available online at http://www.bccancer.bc.ca/health-info/disease-system-statistics/cancer-survival-rates. Accessed December 2021.
[645] Maringe C, Walters S, Rachet B et al. Stage at diagnosis and colorectal cancer survival in six high-income countries: A population based study of patients diagnosed during 2000-2007. *Acta Oncologica*. 2013; 52(5): 919-32.

- Table 7 provides the estimated 1-, 3- and 5-year survival following a CRC by age and stage. To produce this information we first calculated the average annual number of new CRC cases in BC between 2014 and 2018 in the 15-49 (N=205), 50-69 (N=1,271) and 70-99 (N=1,559) year age groups.[646] These cases were then distributed to each stage based on the data in Table 3. The overall 1-, 3- and 5-year survival rate was then taken from Table 5. Finally, survival was calculated for each age group based on the data in Table 6.
- Overall 1-year survival following a diagnosis of CRC in BC is estimated at 81.6%, decreasing to 66.0% at year 3 and 57.0% at year 5 (see Table 7).

Table 7: Estimated CRC Survival
By Age and Stage
In British Columbia

		Colorectal Cancer						
	Age		1 Year		3 Year		5 Year	
Stage	Group	N	%	N	%	N	%	N
A								
	15-49	40	99.2%	40	93.8%	38	86.8%	35
	50-69	250	98.3%	245	92.5%	231	85.6%	214
	70-99	306	94.5%	289	89.0%	272	82.3%	252
	All Ages	**596**	**96.3%**	**574**	**90.8%**	**541**	**84.0%**	**501**
B								
	15-49	56	96.8%	54	88.2%	49	77.9%	43
	50-69	344	95.1%	327	85.4%	294	75.4%	260
	70-99	422	89.2%	376	78.7%	332	69.5%	293
	All Ages	**822**	**91.9%**	**756**	**82.1%**	**675**	**72.5%**	**596**
C								
	15-49	59	95.7%	56	82.2%	48	70.1%	41
	50-69	363	94.2%	342	79.8%	290	68.1%	247
	70-99	445	85.2%	380	67.0%	299	57.2%	255
	All Ages	**867**	**89.8%**	**778**	**73.5%**	**637**	**62.7%**	**543**
Distant								
	15-49	51	66.9%	35	31.2%	17	18.7%	10
	50-69	314	58.8%	190	25.6%	84	15.3%	50
	70-99	385	36.7%	145	12.0%	48	7.2%	29
	All Ages	**750**	**49.3%**	**370**	**19.9%**	**149**	**11.9%**	**89**
All Patients								
	15-49	205	90.0%	184	73.9%	151	63.0%	129
	50-69	1,271	86.8%	1,104	70.7%	899	60.7%	771
	70-99	1,559	76.3%	1,190	61.1%	952	53.2%	829
	All Ages	**3,035**	**81.6%**	**2,478**	**66.0%**	**2,002**	**57.0%**	**1,729**

- We then applied the 1-, 3- and 5-year survival rates by age and stage from Table 7 to the estimated number of new CRC by age and stage from Table 4. The estimated number of CRC deaths between the ages of 45 and 79 in a BC birth cohort of 40,000 in the absence of a co-ordinated screening program is 710, with 297 in females and 413 in males (see Table 8).

[646] Statistics Canada. Table 13-10-0111-01. Number and rates of new cases of primary cancer, by cancer type, age group and sex. Available online at https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=1310011101. Accessed November 2021.

Table 8: Estimated Colorectal Cancer Deaths by Dukes' Stage

Between the Ages of 45 and 79

In a British Columbia Birth Cohort of 40,000

In the Absence of a Co-ordinated Screening Program

	Females					*Males*					*Total Population*				
	Dukes' Stage					Dukes' Stage					Dukes' Stage				
Age	A	B	C	Distant	**Total**	A	B	C	Distant	**Total**	A	B	C	Distant	**Total**
45	0.0	0.0	0.0	0.2	0.3	0.0	0.1	0.1	0.6	0.8	0.0	0.1	0.1	0.8	**1.1**
46	0.0	0.1	0.1	0.4	0.6	0.0	0.2	0.2	0.9	1.4	0.1	0.3	0.4	1.3	**2.0**
47	0.0	0.1	0.2	0.5	0.9	0.1	0.3	0.4	1.2	2.0	0.1	0.5	0.6	1.7	**2.9**
48	0.0	0.2	0.2	0.6	1.0	0.1	0.5	0.5	1.3	2.4	0.2	0.7	0.8	1.9	**3.5**
49	0.1	0.3	0.3	0.6	1.2	0.2	0.6	0.7	1.4	2.9	0.2	0.9	1.0	2.0	**4.1**
50	0.1	0.4	0.4	1.2	2.1	0.2	0.7	0.7	1.8	3.5	0.3	1.1	1.1	3.1	**5.6**
51	0.1	0.5	0.5	1.5	2.6	0.2	0.8	0.8	1.9	3.7	0.3	1.3	1.3	3.3	**6.3**
52	0.1	0.6	0.7	1.7	3.1	0.2	0.8	0.9	2.0	3.9	0.3	1.5	1.5	3.6	**7.0**
53	0.2	0.7	0.8	1.7	3.4	0.2	0.9	0.9	2.0	4.0	0.4	1.6	1.7	3.7	**7.4**
54	0.2	0.8	0.9	1.8	3.7	0.2	0.9	1.0	2.0	4.1	0.4	1.8	1.8	3.8	**7.8**
55	0.2	0.9	0.9	2.0	4.0	0.2	1.1	1.1	2.8	5.2	0.5	2.0	2.0	4.7	**9.2**
56	0.2	0.9	0.9	2.1	4.1	0.3	1.2	1.3	3.1	5.8	0.5	2.1	2.2	5.1	**10.0**
57	0.2	1.0	1.0	2.1	4.3	0.3	1.4	1.4	3.4	6.5	0.5	2.3	2.4	5.5	**10.8**
58	0.2	1.0	1.0	2.2	4.4	0.4	1.5	1.6	3.4	6.9	0.6	2.5	2.6	5.6	**11.3**
59	0.2	1.0	1.0	2.2	4.5	0.4	1.7	1.7	3.5	7.3	0.6	2.7	2.8	5.7	**11.8**
60	0.3	1.2	1.2	2.9	5.5	0.4	1.9	1.9	4.6	8.8	0.7	3.0	3.1	7.5	**14.2**
61	0.3	1.3	1.3	3.1	6.0	0.5	2.1	2.1	5.0	9.7	0.8	3.4	3.4	8.1	**15.7**
62	0.3	1.4	1.5	3.4	6.6	0.5	2.3	2.3	5.4	10.5	0.8	3.7	3.8	8.8	**17.2**
63	0.4	1.6	1.6	3.5	7.0	0.6	2.5	2.5	5.5	11.1	0.9	4.0	4.1	9.0	**18.0**
64	0.4	1.7	1.7	3.5	7.3	0.6	2.7	2.7	5.6	11.6	1.0	4.3	4.4	9.1	**18.9**
65	0.4	1.8	1.8	4.2	8.2	0.6	2.7	2.8	6.0	12.2	1.1	4.5	4.6	10.2	**20.4**
66	0.4	1.9	2.0	4.4	8.7	0.7	2.8	2.9	6.2	12.5	1.1	4.7	4.8	10.6	**21.3**
67	0.5	2.0	2.1	4.6	9.2	0.7	2.9	3.0	6.3	12.8	1.2	4.9	5.0	11.0	**22.1**
68	0.5	2.1	2.2	4.7	9.5	0.7	2.9	3.0	6.3	13.0	1.2	5.1	5.2	11.0	**22.5**
69	0.5	2.3	2.3	4.7	9.8	0.7	3.0	3.1	6.3	13.1	1.3	5.3	5.4	11.0	**22.9**
70	0.8	3.2	3.4	7.7	15.1	1.1	4.4	4.7	10.6	20.8	1.8	7.7	8.1	18.2	**35.9**
71	0.8	3.5	3.9	7.7	15.8	1.1	4.8	5.3	10.7	21.9	1.9	8.3	9.2	18.3	**37.7**
72	0.8	3.7	4.3	7.7	16.5	1.2	5.1	5.9	10.7	22.9	2.0	8.9	10.2	18.4	**39.5**
73	0.9	3.9	4.3	7.5	16.6	1.2	5.3	6.0	10.4	22.9	2.1	9.2	10.3	18.0	**39.6**
74	0.9	4.0	4.4	7.4	16.7	1.3	5.5	6.1	10.1	23.0	2.2	9.5	10.4	17.5	**39.6**
75	1.0	4.3	4.8	8.8	18.9	1.4	5.8	6.4	11.5	25.1	2.4	10.2	11.2	20.3	**44.0**
76	1.0	4.5	5.0	8.9	19.5	1.4	5.9	6.5	11.5	25.3	2.4	10.4	11.5	20.4	**44.8**
77	1.1	4.6	5.2	9.1	20.0	1.4	6.0	6.7	11.5	25.5	2.5	10.6	11.9	20.6	**45.5**
78	1.1	4.7	5.2	8.9	20.0	1.4	6.0	6.6	11.2	25.2	2.5	10.7	11.9	20.1	**45.2**
79	1.1	4.8	5.3	8.8	20.0	1.4	6.0	6.6	10.9	24.9	2.6	10.8	11.9	19.7	**44.9**
Total	**15.7**	**67.1**	**72.3**	**142.3**	**297.4**	**21.9**	**93.4**	**100.4**	**197.4**	**413.0**	**37.6**	**160.5**	**172.7**	**339.7**	**710.5**

Calculating Life Years and Quality-Adjusted Life Years Lost

- Whenever feasible, we use disability weights developed for the Global Burden of Disease (GBD) study in calculating changes in QoL associated with a given health state.[647,648] See pages 60-62 of the Reference document for a detailed discussion of how QoL adjustments are calculated and utilized in the LPS modelling.[649]
- Based on data from the GBD, the diagnosis and treatment phase for colorectal cancer lasts an average of 4 months[650] and is associated with a utility loss of -0.288 (95% CI of -0.193 to -0.399).[651] The 95% confidence intervals are used in the sensitivity analysis.
- Based on data from the GBD, the ongoing, controlled phase (remission) for colorectal cancer is associated with a utility loss of -0.049 (95% CI of -0.031 to -0.072).[652] The 95% confidence intervals are used in the sensitivity analysis.
- The metastatic phase for colorectal cancer lasts an average of 2.5 years (30 months)[653] and is associated with a utility loss of -0.451 (95% CI of -0.307 to -0.600).[654] The 95% confidence intervals are used in the sensitivity analysis.
- We assumed everyone diagnosed with cancer is treated during the year of diagnosis and has a reduction in QALYs of 0.96 (0.96 = 0.288 /12 months * 4 months). We assumed that each CRC survivor has an annual QALY reduction of 0.049, including in the first year of treatment. We assumed a reduction in QALYs of 1.128 for individuals in the metastatic phase in the years prior to death (1.128 = 0.451 / 12 months * 30 months). Living with CRC (including the treatment and metastatic phases) between the ages of 45 and 79 in a BC birth cohort of 40,000 in the absence of a co-ordinated screening program is associated with 2,150 QALYs lost, with 899 in females and 1,251 in males (see Table 9).
- To calculate life years lost, we multiplied the number of deaths by age and sex (Table 8) by the remaining life expectancy for that age and sex. The estimated number of life years lost due to CRC deaths between the ages of 45 and 79 in a BC

[647] Salomon JA, Haagsma JA, Davis A et al. Disability weights for the Global Burden of Diseases 2013 study. *The Lancet Global Health*. 2015; 3: e712-e723.
[648] Institute for Health Metrics and Evaluation. *GBD 2016 sequelae, health states, health state lay descriptions, and disability weights*. Available online at http://ghdx.healthdata.org/record/global-burden-disease-study-2016-gbd-2016-disability-weights. Accessed October 2017.
[649] BC Lifetime Prevention Schedule. *Establishing Priorities among Effective Clinical Prevention Services in British Columbia. Reference Document and Key Assumptions. March 2021 Update.* Available online at https://www2.gov.bc.ca/assets/gov/health/about-bc-s-health-care-system/health-priorites/lifetime-prevention-schedule/2021-reference-document.pdf. Accessed February 2022.
[650] Fitzmaurice C, Allen C, Barber R et al. Global, regional, and national cancer incidence, mortality, years of life lost, years lived with disability, and disability-adjusted life-years for 32 cancer groups, 1990 to 2015: a systematic analysis for the global burden of disease study. *Journal of American Medical Association Oncology*. 2017; 3(4): 524-48.
[651] Institute for Health Metrics and Evaluation. *GBD 2016 sequelae, health states, health state lay descriptions, and disability weights*. Available online at http://ghdx.healthdata.org/record/global-burden-disease-study-2016-gbd-2016-disability-weights. Accessed October 2017.
[652] Fitzmaurice C, Allen C, Barber R et al. Global, regional, and national cancer incidence, mortality, years of life lost, years lived with disability, and disability-adjusted life-years for 32 cancer groups, 1990 to 2015: a systematic analysis for the global burden of disease study. *Journal of American Medical Association Oncology*. 2017; 3(4): 524-48.
[653] Dr. Jonathan Loree, Medical Oncologist at BC Cancer. Personal Communication. February 2022.
[654] Institute for Health Metrics and Evaluation. *GBD 2016 sequelae, health states, health state lay descriptions, and disability weights*. Available online at http://ghdx.healthdata.org/record/global-burden-disease-study-2016-gbd-2016-disability-weights. Accessed October 2017.

birth cohort of 40,000 in the absence of a co-ordinated screening program is 12,805, with 5,743 in females and 7,062 in males (see Table 9).

- On average, each CRC death is associated with 18.2 life years lost (12,950 / 710), with 19.4 life years lost per death for females (5,773 / 297) and 17.4 life years lost per death for males (7,177 / 413) (see Tables 8 & 9).

Table 9: Estimated Colorectal Cancer QALYs and Life Years Lost

Between the Ages of 45 and 79
In a British Columbia Birth Cohort of 40,000
In the Absence of a Co-ordinated Screening Program

	Treatment QALYs Lost			Living in Remission QALYs Lost			Metastatic QALYs Lost			Total QALYs Lost			Life Years Lost		
Age	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female	Male	Total
45	0.3	0.8	1.2	0.2	0.4	0.6	0.4	1.0	1.5	1	2	3	14	29	43
46	0.3	0.8	1.2	0.3	0.8	1.1	0.8	1.8	2.6	1	3	5	24	51	75
47	0.3	0.8	1.2	0.5	1.1	1.6	1.1	2.7	3.8	2	5	7	34	72	105
48	0.3	0.8	1.2	0.6	1.5	2.1	1.4	3.2	4.6	2	5	8	40	85	124
49	0.3	0.8	1.2	0.7	1.7	2.5	1.6	3.8	5.4	3	6	9	46	97	143
50	1.0	1.1	2.1	1.2	2.3	3.5	2.9	4.7	7.7	5	8	13	77	113	191
51	1.0	1.1	2.1	1.7	2.7	4.3	3.6	5.0	8.6	6	9	15	93	117	210
52	1.0	1.1	2.1	2.0	3.1	5.1	4.3	5.3	9.6	7	10	17	108	120	228
53	1.0	1.1	2.1	2.4	3.5	5.9	4.7	5.5	10.2	8	10	18	115	120	235
54	1.0	1.1	2.1	2.8	3.9	6.6	5.1	5.6	10.7	9	11	19	122	119	241
55	1.2	2.0	3.2	3.2	4.7	8.0	5.5	7.1	12.6	10	14	24	127	147	274
56	1.2	2.0	3.2	3.7	5.5	9.2	5.7	8.0	13.7	11	15	26	128	161	289
57	1.2	2.0	3.2	4.1	6.3	10.4	5.9	8.9	14.8	11	17	28	129	173	302
58	1.2	1.9	3.1	4.6	7.0	11.6	6.1	9.5	15.5	12	18	30	128	178	306
59	1.2	1.9	3.1	5.0	7.7	12.7	6.2	10.0	16.2	12	20	32	127	182	309
60	2.0	3.2	5.3	6.0	9.2	15.2	7.7	12.4	20.1	16	25	41	149	212	361
61	2.0	3.2	5.2	6.8	10.5	17.3	8.5	13.6	22.2	17	27	45	160	225	385
62	2.0	3.2	5.2	7.6	11.7	19.3	9.4	14.9	24.2	19	30	49	169	237	406
63	2.0	3.2	5.2	8.3	12.9	21.2	9.9	15.6	25.5	20	32	52	172	239	412
64	2.0	3.1	5.1	9.0	14.0	23.1	10.4	16.3	26.7	21	33	55	175	241	416
65	2.7	3.7	6.4	10.1	15.4	25.6	11.6	17.2	28.8	24	36	61	188	245	433
66	2.7	3.7	6.4	11.2	16.8	28.0	12.3	17.7	30.0	26	38	64	192	242	434
67	2.7	3.6	6.3	12.2	18.1	30.3	13.0	18.1	31.2	28	40	68	195	238	433
68	2.7	3.6	6.3	13.2	19.4	32.6	13.4	18.3	31.8	29	41	71	194	230	424
69	2.7	3.5	6.2	14.1	20.7	34.8	13.9	18.5	32.4	31	43	73	191	223	414
70	3.7	5.2	8.9	16.4	23.9	40.3	22.5	31.0	53.4	43	60	103	282	337	619
71	3.7	5.1	8.8	17.8	25.9	43.6	23.6	32.6	56.2	45	64	109	283	339	622
72	3.6	5.0	8.6	19.1	27.7	46.8	24.6	34.1	58.8	47	67	114	282	338	621
73	3.6	4.9	8.5	20.4	29.5	49.8	24.7	34.2	58.9	49	69	117	270	323	593
74	3.5	4.8	8.3	21.6	31.1	52.8	24.8	34.2	59.0	50	70	120	258	307	565
75	4.6	5.8	10.4	23.4	33.4	56.8	28.2	37.4	65.5	56	77	133	279	318	597
76	4.5	5.7	10.1	25.1	35.5	60.6	29.0	37.7	66.7	59	79	137	272	305	577
77	4.4	5.5	9.9	26.7	37.5	64.1	29.7	38.0	67.7	61	81	142	264	290	555
78	4.3	5.3	9.6	28.2	39.3	67.6	29.8	37.6	67.4	62	82	145	251	271	522
79	4.2	5.1	9.3	29.7	41.1	70.8	29.8	37.1	66.9	64	83	147	236	252	489
	76	**106**	**182**	**360**	**526**	**886**	**432**	**599**	**1,031**	**868**	**1,230**	**2,099**	**5,773**	**7,177**	**12,950**

Effectiveness of the Intervention

- The BC Cancer Colon Screening program recommends screening the asymptomatic population ages 50-74 at average risk for CRC with the fecal immunochemical test (FIT) every two years. If the test results are abnormal, proceed to a colonoscopy. If the colonoscopy results are normal, return to screening with the FIT after 10 years. If the individual is age 50-74 but at higher-than-average risk for CRC, screen using colonoscopy every 10 years.[655]
- CRC screening can save lives in two important ways:
  - Screening can prevent colon cancer by finding and removing polyps before they turn into cancer.
  - Screening can find cancers early. Early detection means more treatment options and better outcomes (see Table 7).
- Using the threshold recommended by the manufacturer (20 μg hemoglobin per gram of stool), the pooled sensitivity of FIT for detection of colorectal cancer was 0.74 (95% CI, 0.64-0.83; 9 studies; n = 34 352) and pooled specificity was 0.94 (95% CI, 0.93-0.96; 9 studies; n = 34 352).[656]
- The sensitivity for detection of adenomas measuring 10 mm or larger using **colonoscopy** ranged from 0.89 (95% CI, 0.78-0.96) to 0.95 (95% CI, 0.74-0.99) in 4 studies reviewed by the USPSTF; specificity was reported in a single study as 0.89 (95% CI, 0.86-0.91).[657]
- The BC Colon Screening Program was launched in November of 2013. An analysis of FIT cut-off values completed in June of 2015 for the BC FIT Review Working Group investigated the results of 7,349 individuals in the BC Colon Screening Program who tested positive with FIT (≥50ng/ml) and for whom colonoscopy results were available.[658] A total of 3,680 positive results (any neoplasia) were identified by colonoscopy, yielding a positive predictive value (PPV) of 50.1%. In other words, for every 2 positive FIT results, one true positive result was identified by colonoscopy. The 3,680 positive results included 114 patients with cancer, 1,492 patients with high-risk polyps, 330 patients with multiple low-risk polyps and 1,744 with ≤2 low-risk polyps.
- The PPV would be increased to 54.3% at a cut-off of >75ng/mL and to 56.8% at a cut-off of ≥100 ng/ml. Shifting the cut-off from ≥50 to >75ng/ml, however, would have missed 8% (9) of cancers, 22% (405) of high-risk polyps and 28% (1,040) of all neoplasia. Shifting the cut-off from ≥50 to >100 ng/ml would have missed 13% (15) of cancers, 35% (629) of high-risk polyps and 42% (1,545) of all neoplasia. The FIT Review Working Group recommended leaving the FIT cut-off at ≥50 ng/ml.[659]

[655] BC Cancer Colon Screening. *2019 Program Results*. March 2021. Available online at http://www.bccancer.bc.ca/screening/Documents/Colon-Program-Results-2019.pdf. Accessed November 2021.
[656] US Preventive Services Task Force. Screening for colorectal cancer: US Preventive Services Task Force Recommendation statement. *JAMA*. 2021; 325(19): 1965-1977.
[657] US Preventive Services Task Force. Screening for colorectal cancer: US Preventive Services Task Force Recommendation statement. *JAMA*. 2021; 325(19): 1965-1977.
[658] H. Krueger & Associates Inc. for the BC FIT Review Working Group. *Technical Analysis of Fecal Immunochemical Test (FIT) Cut-off Values*. June 17, 2015.
[659] H. Krueger & Associates Inc. for the BC FIT Review Working Group. *Technical Analysis of Fecal Immunochemical Test (FIT) Cut-off Values*. June 17, 2015.

- As of 2018, BC continues to use a FIT cut-off value of ≥50ng/ml (using the FIT produced by Alfresa Pharma Corporation) while other provinces and territories use cut-off values of between >75 and >175.[660]
- In BC, eligible patients can pick up FIT kits from any public or private lab across the province with a referral from their health care provider. Samples are to be stored in the refrigerator and returned to the lab within 7 days. The results are forwarded to the health care provider who discusses them with the patient. Abnormal results trigger a referral for a colonoscopy.[661]

- For modelling purposes, we have assumed that FIT every two years (as used in BC) is associated with a PPV of 50%.

- Screening for CRC is associated with a 22% (incidence risk ratio [IRR] 0.78, 95% CI 0.74 to 0.83) reduction in CRC incidence.[662]
- Based on the combined results from three early RCTs assessing the effectiveness of screening with FOBT,[663,664,665] the proportion of cases detected early (Dukes' Stage A) more than doubled with screening while the proportion detected late (Distant) was reduced by almost half (see Table10).

Table 10: Shift in CRC Stage Associated with Screening

	Control Group		Screened Group		%
Dukes' Stage	#	%	#	%	Change
A	237	14.5%	420	30.2%	108.2%
B	582	35.6%	432	31.1%	-12.8%
C	457	28.0%	356	25.6%	-8.5%
Distant	358	21.9%	183	13.2%	-40.0%
Total	**1,634**	**100.0%**	**1,391**	**100.0%**	

Change in Incidence and Stage at Diagnosis

- For modelling purposes, we reduced the incidence of CRCs by 22% in the 77% of individuals who would be screened. Within the cohort of 40,000, we then assumed that those who were not screened and were diagnosed with CRC would be proportionally allocated to Dukes' Stage based on the control group data in Table 10 while those who were screened and diagnosed with CRC would be proportionally allocated to Dukes' stage based on the screened group data in Table 10.

[660] Canadian Partnership against Cancer. *Colorectal Cancer Screening in Canada: Environmental Scan*. March 2019. Available online at https://www.partnershipagainstcancer.ca/wp-content/uploads/2019/04/Colorectal-Cancer-Screening-Environmental-Scan_EN_2018_final.pdf. Accessed November 2021.
[661] *BC Cancer Screening – Colon*. Available online at http://www.bccancer.bc.ca/screening/health-professionals/colon/refer. Accessed November 2021.
[662] Knudsen A, Rutter C, Peterse E et al. *Colorectal Cancer Screening: An Updated Decision Analysis for the U.S. Preventive Services Task Force*. Technical Report. Available online at https://www.ncbi.nlm.nih.gov/books/NBK570833/. Accessed January 2022.
[663] Mandel J, Bond J, Church T et al. Reducing mortality from colorectal cancer by screening for fecal occult blood. *New England Journal of Medicine*. 1993; 328: 1365-71.
[664] Kronborg O, Fender C, Olsen J et al. Randomised study of screening for colorectal cancer with faecal-occult-blood test. *The Lancet*. 1996; 348(9040): 1467-71.
[665] Hardcastle J, Chamberlain J, Robinson M et al. Randomised controlled trial of faecal-occult-blood screening for colorectal cancer. *The Lancet*. 1996; 348(9040): 1472-77.

- Based on these assumptions, a co-ordinated CRC screening program that achieved a 77% screening rate in a BC birth cohort of 40,000 would reduce the number of new cases of CRC from 1,804 (see Table 4) to 1,499 (see Table 11), a reduction of 306 (16.9%) in new cases. In addition, the number of cases diagnosed in Dukes' Stage A would increase by 45% (from 262 [Table 4] to 379 [Table 11]), those in Stage B would decrease by 25% (from 643 [Table 4] to 483 [Table 11]), those in Stage C by 24% (from 505 [Table 4] to 385 [Table 11]) and those with distant spread by 36% (from 395 [Table 4] to 251 [Table 11]).

Table 11: Estimated New Cases of Colorectal Cancer by Dukes' Stage
Between the Ages of 45 and 79
In a British Columbia Birth Cohort of 40,000
With a Co-ordinated Screening Program

	Female					*Male*					*Total Population*				
	Estimated	New CRC by Stage				Estimated	New CRC by Stage				Estimated	New CRC by Stage			
Age	New CRC	A	B	C	Distant	New CRC	A	B	C	Distant	New CRC	A	B	C	Distant
45	2.8	0.7	0.9	0.7	0.5	6.7	1.7	2.2	1.7	1.1	9.5	2.4	3.1	2.4	1.6
46	2.8	0.7	0.9	0.7	0.5	6.7	1.7	2.1	1.7	1.1	9.5	2.4	3.1	2.4	1.6
47	2.8	0.7	0.9	0.7	0.5	6.6	1.7	2.1	1.7	1.1	9.5	2.4	3.0	2.4	1.6
48	2.8	0.7	0.9	0.7	0.5	6.6	1.7	2.1	1.7	1.1	9.4	2.4	3.0	2.4	1.6
49	2.8	0.7	0.9	0.7	0.5	6.6	1.7	2.1	1.7	1.1	9.4	2.4	3.0	2.4	1.6
50	8.1	2.0	2.6	2.1	1.4	8.9	2.3	2.9	2.3	1.5	17.0	4.3	5.5	4.4	2.9
51	8.1	2.0	2.6	2.1	1.4	8.9	2.3	2.9	2.3	1.5	17.0	4.3	5.5	4.4	2.8
52	8.1	2.0	2.6	2.1	1.4	8.9	2.2	2.9	2.3	1.5	16.9	4.3	5.5	4.3	2.8
53	8.0	2.0	2.6	2.1	1.3	8.8	2.2	2.8	2.3	1.5	16.9	4.3	5.4	4.3	2.8
54	8.0	2.0	2.6	2.1	1.3	8.8	2.2	2.8	2.3	1.5	16.8	4.3	5.4	4.3	2.8
55	9.8	2.5	3.2	2.5	1.6	16.0	4.1	5.2	4.1	2.7	25.8	6.5	8.3	6.6	4.3
56	9.8	2.5	3.2	2.5	1.6	15.9	4.0	5.1	4.1	2.7	25.7	6.5	8.3	6.6	4.3
57	9.8	2.5	3.1	2.5	1.6	15.9	4.0	5.1	4.1	2.7	25.6	6.5	8.3	6.6	4.3
58	9.7	2.5	3.1	2.5	1.6	15.8	4.0	5.1	4.1	2.6	25.5	6.5	8.2	6.6	4.3
59	9.7	2.5	3.1	2.5	1.6	15.7	4.0	5.1	4.0	2.6	25.4	6.4	8.2	6.5	4.3
60	16.1	4.1	5.2	4.1	2.7	25.6	6.5	8.2	6.6	4.3	41.7	10.5	13.4	10.7	7.0
61	16.0	4.1	5.2	4.1	2.7	25.4	6.4	8.2	6.5	4.3	41.4	10.5	13.4	10.6	6.9
62	16.0	4.0	5.1	4.1	2.7	25.2	6.4	8.1	6.5	4.2	41.2	10.4	13.3	10.6	6.9
63	15.9	4.0	5.1	4.1	2.7	25.0	6.3	8.1	6.4	4.2	40.9	10.3	13.2	10.5	6.9
64	15.8	4.0	5.1	4.1	2.7	24.8	6.3	8.0	6.4	4.2	40.6	10.3	13.1	10.4	6.8
65	21.7	5.5	7.0	5.6	3.6	29.3	7.4	9.4	7.5	4.9	51.0	12.9	16.4	13.1	8.5
66	21.5	5.4	6.9	5.5	3.6	29.0	7.3	9.3	7.5	4.9	50.5	12.8	16.3	13.0	8.5
67	21.4	5.4	6.9	5.5	3.6	28.6	7.2	9.2	7.4	4.8	50.0	12.7	16.1	12.9	8.4
68	21.2	5.4	6.8	5.5	3.6	28.3	7.2	9.1	7.3	4.7	49.5	12.5	16.0	12.7	8.3
69	21.0	5.3	6.8	5.4	3.5	27.9	7.1	9.0	7.2	4.7	48.9	12.4	15.8	12.6	8.2
70	31.3	7.9	10.1	8.0	5.2	44.0	11.1	14.2	11.3	7.4	75.3	19.0	24.3	19.4	12.6
71	31.0	7.8	10.0	8.0	5.2	43.3	11.0	14.0	11.1	7.3	74.3	18.8	23.9	19.1	12.5
72	30.6	7.7	9.9	7.9	5.1	42.5	10.8	13.7	10.9	7.1	73.1	18.5	23.6	18.8	12.3
73	30.2	7.6	9.7	7.8	5.1	41.6	10.5	13.4	10.7	7.0	71.9	18.2	23.2	18.5	12.1
74	29.8	7.5	9.6	7.7	5.0	40.7	10.3	13.1	10.5	6.8	70.5	17.8	22.7	18.1	11.8
75	38.5	9.7	12.4	9.9	6.5	49.4	12.5	15.9	12.7	8.3	87.9	22.2	28.3	22.6	14.7
76	37.9	9.6	12.2	9.7	6.3	48.1	12.2	15.5	12.4	8.1	85.9	21.7	27.7	22.1	14.4
77	37.1	9.4	12.0	9.5	6.2	46.6	11.8	15.0	12.0	7.8	83.8	21.2	27.0	21.5	14.0
78	36.3	9.2	11.7	9.3	6.1	45.1	11.4	14.5	11.6	7.6	81.5	20.6	26.3	20.9	13.7
79	35.5	9.0	11.4	9.1	5.9	43.5	11.0	14.0	11.2	7.3	78.9	20.0	25.4	20.3	13.2
Total	**628**	**159**	**202**	**161**	**105**	**871**	**220**	**281**	**224**	**146**	**1,499**	**379**	**483**	**385**	**251**

Change in Number of Deaths

- We then recalculated the number of deaths based on the number of new cases and the stage at diagnosis associated with the implementation of a co-ordinated CRC screening program that achieved a 77% screening rate in a BC birth cohort of 40,000. The number of deaths would be reduced by 188 or 26.4% (from 710 [Table 8] to 523 [Table 12]).

Table 12: Estimated Colorectal Cancer Deaths by Dukes' Stage

Between the Ages of 45 and 79

In a British Columbia Birth Cohort of 40,000

With a Co-ordinated Screening Program

	Females					***Males***					***Total Population***				
	Dukes' Stage					**Dukes' Stage**					**Dukes' Stage**				
Age	A	B	C	Distant	**Total**	A	B	C	Distant	**Total**	A	B	C	Distant	**Total**
45	0.0	0.0	0.0	0.2	0.2	0.0	0.1	0.1	0.4	0.5	0.0	0.1	0.1	0.5	**0.7**
46	0.0	0.1	0.1	0.2	0.4	0.1	0.2	0.2	0.6	1.0	0.1	0.2	0.3	0.8	**1.4**
47	0.0	0.1	0.1	0.3	0.6	0.1	0.3	0.3	0.8	1.4	0.1	0.4	0.4	1.1	**2.0**
48	0.1	0.2	0.2	0.4	0.8	0.2	0.4	0.4	0.8	1.8	0.2	0.5	0.6	1.2	**2.5**
49	0.1	0.2	0.2	0.4	0.9	0.2	0.5	0.5	0.9	2.1	0.3	0.7	0.7	1.3	**3.0**
50	0.1	0.3	0.3	0.8	1.5	0.2	0.5	0.6	1.2	2.5	0.4	0.8	0.9	1.9	**4.0**
51	0.2	0.4	0.4	0.9	1.9	0.3	0.6	0.6	1.2	2.7	0.4	1.0	1.0	2.1	**4.6**
52	0.2	0.5	0.5	1.1	2.2	0.3	0.6	0.7	1.2	2.8	0.5	1.1	1.2	2.3	**5.1**
53	0.2	0.6	0.6	1.1	2.5	0.3	0.7	0.7	1.3	2.9	0.6	1.2	1.3	2.4	**5.4**
54	0.3	0.6	0.7	1.1	2.7	0.3	0.7	0.7	1.3	3.0	0.6	1.3	1.4	2.4	**5.7**
55	0.3	0.7	0.7	1.3	2.9	0.4	0.8	0.8	1.8	3.8	0.7	1.5	1.5	3.0	**6.7**
56	0.3	0.7	0.7	1.3	3.0	0.4	0.9	1.0	1.9	4.2	0.7	1.6	1.7	3.3	**7.3**
57	0.3	0.7	0.8	1.4	3.2	0.5	1.0	1.1	2.1	4.7	0.8	1.8	1.8	3.5	**7.9**
58	0.3	0.7	0.8	1.4	3.2	0.5	1.1	1.2	2.2	5.0	0.9	1.9	2.0	3.6	**8.3**
59	0.4	0.8	0.8	1.4	3.3	0.6	1.3	1.3	2.2	5.4	0.9	2.0	2.1	3.6	**8.7**
60	0.4	0.9	0.9	1.8	4.0	0.6	1.4	1.4	2.9	6.4	1.0	2.3	2.3	4.7	**10.4**
61	0.4	1.0	1.0	2.0	4.4	0.7	1.6	1.6	3.2	7.0	1.1	2.5	2.6	5.2	**11.4**
62	0.5	1.1	1.1	2.2	4.8	0.8	1.7	1.8	3.4	7.7	1.2	2.8	2.9	5.6	**12.5**
63	0.5	1.2	1.2	2.2	5.1	0.8	1.8	1.9	3.5	8.1	1.4	3.0	3.1	5.7	**13.2**
64	0.6	1.3	1.3	2.3	5.4	0.9	2.0	2.1	3.5	8.5	1.5	3.3	3.4	5.8	**13.9**
65	0.6	1.4	1.4	2.7	6.0	0.9	2.1	2.1	3.8	8.9	1.5	3.4	3.5	6.5	**15.0**
66	0.6	1.4	1.5	2.8	6.4	1.0	2.1	2.2	3.9	9.2	1.6	3.5	3.7	6.7	**15.6**
67	0.7	1.5	1.6	3.0	6.8	1.0	2.2	2.3	4.0	9.4	1.7	3.7	3.9	7.0	**16.2**
68	0.7	1.6	1.7	3.0	7.0	1.0	2.2	2.3	4.0	9.6	1.7	3.8	4.0	7.0	**16.6**
69	0.8	1.7	1.8	3.0	7.2	1.0	2.3	2.3	4.0	9.7	1.8	4.0	4.1	7.0	**16.9**
70	1.1	2.4	2.6	4.9	11.0	1.5	3.3	3.6	6.7	15.2	2.7	5.8	6.2	11.6	**26.2**
71	1.2	2.6	2.9	4.9	11.6	1.6	3.6	4.0	6.8	16.0	2.8	6.2	7.0	11.7	**27.7**
72	1.2	2.8	3.3	4.9	12.2	1.7	3.9	4.5	6.8	16.9	2.9	6.7	7.8	11.7	**29.0**
73	1.3	2.9	3.3	4.8	12.3	1.8	4.0	4.6	6.6	17.0	3.1	6.9	7.9	11.4	**29.3**
74	1.4	3.0	3.3	4.7	12.4	1.9	4.1	4.6	6.4	17.1	3.3	7.1	8.0	11.1	**29.4**
75	1.5	3.3	3.6	5.6	14.0	2.0	4.4	4.9	7.3	18.5	3.5	7.6	8.5	12.9	**32.5**
76	1.5	3.4	3.8	5.7	14.4	2.0	4.4	5.0	7.3	18.8	3.5	7.8	8.8	13.0	**33.1**
77	1.6	3.5	4.0	5.8	14.8	2.0	4.5	5.1	7.3	18.9	3.6	8.0	9.0	13.1	**33.7**
78	1.6	3.5	4.0	5.7	14.8	2.0	4.5	5.1	7.1	18.7	3.6	8.0	9.1	12.8	**33.6**
79	1.6	3.6	4.0	5.6	14.9	2.1	4.5	5.0	6.9	18.5	3.7	8.1	9.1	12.5	**33.4**
Total	**22.7**	**50.4**	**55.2**	**90.5**	**218.8**	**31.7**	**70.2**	**76.6**	**125.5**	**304.0**	**54.4**	**120.6**	**131.8**	**216.0**	**522.8**

Change in Life Years and Quality-Adjusted Life Years Lost

- We then recalculated the number of life years and QALYs lost based on the number of new cases and the stage at diagnosis associated with the implementation of a co-ordinated CRC screening program that achieved a 77% screening rate in a BC birth cohort of 40,000. The number of life years lost would be reduced by 3,442 or 26.6% (from 12,950 [Table 9] to 9,508 [Table 13]) while the QALYs lost would be reduced by 400 or 19.0% (from 2,099 [Table 9] to 1,699 [Table 13]).

Table 13: Estimated Colorectal Cancer QALYs and Life Years Lost

Between the Ages of 45 and 79
In a British Columbia Birth Cohort of 40,000
With a Co-ordinated Screening Program

	Treatment QALYs Lost			Living in Remission QALYs Lost			Metastatic QALYs Lost			Total QALYs Lost			Life Years Lost		
Age	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female	Male	Total
45	0.3	0.7	1.0	0.1	0.4	0.5	0.3	0.7	1.0	1	2	2	9	20	29
46	0.3	0.7	1.0	0.3	0.7	1.0	0.5	1.3	1.8	1	3	4	17	36	52
47	0.3	0.7	1.0	0.4	1.0	1.4	0.8	1.9	2.7	2	4	5	24	51	75
48	0.3	0.7	1.0	0.5	1.3	1.8	1.0	2.3	3.3	2	4	6	29	61	90
49	0.3	0.7	1.0	0.6	1.5	2.2	1.2	2.8	4.0	2	5	7	34	71	105
50	0.8	0.9	1.8	1.1	2.0	3.0	2.1	3.5	5.5	4	6	10	55	82	138
51	0.8	0.9	1.8	1.4	2.3	3.8	2.6	3.7	6.3	5	7	12	67	85	152
52	0.8	0.9	1.8	1.8	2.7	4.5	3.1	3.9	7.0	6	8	13	78	88	166
53	0.8	0.9	1.8	2.1	3.0	5.2	3.4	4.0	7.4	6	8	14	84	88	172
54	0.8	0.9	1.8	2.4	3.4	5.8	3.8	4.1	7.9	7	8	15	90	88	178
55	1.0	1.7	2.7	2.8	4.1	7.0	4.0	5.2	9.2	8	11	19	93	107	199
56	1.0	1.7	2.7	3.2	4.8	8.1	4.2	5.8	10.0	8	12	21	94	117	211
57	1.0	1.7	2.7	3.6	5.5	9.1	4.3	6.5	10.8	9	14	23	95	126	221
58	1.0	1.7	2.7	4.0	6.1	10.2	4.4	6.9	11.4	9	15	24	94	130	225
59	1.0	1.6	2.7	4.4	6.7	11.2	4.6	7.4	11.9	10	16	26	93	134	228
60	1.7	2.8	4.5	5.3	8.1	13.4	5.6	9.0	14.6	13	20	32	108	154	262
61	1.7	2.7	4.5	6.0	9.2	15.2	6.2	9.9	16.1	14	22	36	116	164	280
62	1.7	2.7	4.4	6.7	10.3	17.0	6.8	10.8	17.6	15	24	39	123	173	296
63	1.7	2.7	4.4	7.3	11.3	18.7	7.2	11.4	18.7	16	25	42	126	176	302
64	1.7	2.7	4.4	8.0	12.3	20.3	7.6	12.0	19.7	17	27	44	129	178	306
65	2.3	3.2	5.5	8.9	13.6	22.5	8.5	12.6	21.1	20	29	49	137	180	317
66	2.3	3.1	5.4	9.9	14.8	24.6	9.0	13.0	22.0	21	31	52	141	177	318
67	2.3	3.1	5.4	10.7	16.0	26.7	9.5	13.3	22.8	23	32	55	143	174	318
68	2.3	3.0	5.3	11.6	17.1	28.7	9.9	13.5	23.4	24	34	57	142	169	312
69	2.3	3.0	5.3	12.5	18.2	30.7	10.2	13.7	23.9	25	35	60	141	164	305
70	3.2	4.5	7.7	14.5	21.1	35.6	16.4	22.6	39.1	34	48	82	206	246	453
71	3.2	4.4	7.6	15.7	22.9	38.6	17.3	23.9	41.2	36	51	87	208	248	456
72	3.1	4.4	7.5	16.9	24.5	41.5	18.1	25.1	43.3	38	54	92	208	249	457
73	3.1	4.3	7.4	18.1	26.1	44.2	18.3	25.3	43.6	39	56	95	200	239	439
74	3.1	4.2	7.2	19.2	27.7	46.9	18.4	25.4	43.8	41	57	98	192	228	420
75	3.9	5.1	9.0	20.8	29.7	50.5	20.8	27.6	48.4	46	62	108	206	235	441
76	3.9	4.9	8.8	22.3	31.6	53.9	21.4	27.9	49.3	48	64	112	201	226	426
77	3.8	4.8	8.6	23.8	33.4	57.1	22.0	28.2	50.1	50	66	116	195	215	410
78	3.7	4.6	8.3	25.2	35.1	60.2	22.1	27.9	50.0	51	68	119	186	201	387
79	3.6	4.4	8.1	26.5	36.7	63.2	22.2	27.6	49.7	52	69	121	176	188	363
	66	**91**	**156**	**319**	**465**	**784**	**318**	**441**	**759**	**702**	**997**	**1,699**	**4,239**	**5,269**	**9,508**

Potential Harms Associated with the Intervention(s)

- Complication rates following screening colonoscopy occur at a rate of 0.84 minor bleeds, 1.08 major bleeds (requiring hospitalization), 0.53 perforations and 0.02 deaths per 1,000 colonoscopies.[666]
- To estimate the number of colonoscopies required in a BC birth cohort, we first assumed that 77% of the population ages 45 to 75 would receive a FIT every two years. Furthermore, 12.4% of FIT would return an abnormal result that required a follow-up colonoscopy.[667] Of those referred to a follow-up colonoscopy, 77.4% would receive the colonoscopy.[668] Half (50%) of colonoscopies would find low or high risk polyps or CRC while the other half would return a negative result. Individuals with a negative colonoscopy (i.e., they had a false positive FIT) would not need to be screened by FIT for the next 10 years. Based on these assumptions, 30,843 colonoscopies would be required in the BC birth cohort (see Table 14).
- We then multiplied the volume of colonoscopies by the complication rates noted above to estimate that there would be 26 minor bleeds, 33 major bleeds, 16 perforations and 0.61 death (see Table 14).

[666] Fitzpatrick-Lewis D. Usman A, Ciliska D et al. *Screening for Colorectal Cancer*. Ottawa: Canadian Task Force on Preventive Health Care. 2015. Available online at https://canadiantaskforce.ca/wp-content/uploads/2016/03/crc-screeningfinal031216.pdf. Accessed November 2021.
[667] BC Cancer Colon Screening. *2019 Program Results*. March 2021. Available online at http://www.bccancer.bc.ca/screening/Documents/Colon-Program-Results-2019.pdf. Accessed January 2022.
[668] Ibid.

Table 14: Number of FIT, Colonoscopies and Complications Due to Colonoscopy

Between the Ages of 45 and 75

In a British Columbia Birth Cohort of 40,000

With a Co-ordinated Screening Program

	Female									*Male*									*Total Population*						
			Colonoscopy			Complications						Colonoscopy			Complications						Colonoscopy	Complications			
Age	Total Life Years	FIT #	#	Pos	Neg	Minor Bleed	Major Bleed	Perforation	Death	Total Life Years	FIT #	#	Pos	Neg	Minor Bleed	Major Bleed	Perforation	Death	Total Life Years	FIT #	#	Minor Bleed	Major Bleed	Perforation	Death
45	19,661	7,569	726	363	363	0.6	0.8	0.4	0.01	19,094	7,351	706	353	353	0.6	0.8	0.4	0.01	38,755	14,921	1,432	1.2	1.5	0.8	0.03
46	19,643	7,199	691	345	345	0.6	0.7	0.4	0.01	19,047	6,980	670	335	335	0.6	0.7	0.4	0.01	38,690	14,180	1,361	1.1	1.5	0.7	0.03
47	19,625	6,847	657	329	329	0.6	0.7	0.3	0.01	18,996	6,626	636	318	318	0.5	0.7	0.3	0.01	38,621	13,473	1,293	1.1	1.4	0.7	0.03
48	19,605	6,511	625	312	312	0.5	0.7	0.3	0.01	18,943	6,287	603	302	302	0.5	0.7	0.3	0.01	38,548	12,798	1,228	1.0	1.3	0.7	0.02
49	19,584	6,190	594	297	297	0.5	0.6	0.3	0.01	18,887	5,964	572	286	286	0.5	0.6	0.3	0.01	38,470	12,154	1,166	1.0	1.3	0.6	0.02
50	19,561	5,884	565	282	282	0.5	0.6	0.3	0.01	18,827	5,655	543	271	271	0.5	0.6	0.3	0.01	38,388	11,539	1,107	0.9	1.2	0.6	0.02
51	19,537	5,593	537	268	268	0.5	0.6	0.3	0.01	18,763	5,359	514	257	257	0.4	0.6	0.3	0.01	38,300	10,951	1,051	0.9	1.1	0.6	0.02
52	19,511	5,314	510	255	255	0.4	0.6	0.3	0.01	18,695	5,075	487	244	244	0.4	0.5	0.3	0.01	38,206	10,390	997	0.8	1.1	0.5	0.02
53	19,484	5,049	485	242	242	0.4	0.5	0.3	0.01	18,622	4,804	461	231	231	0.4	0.5	0.2	0.01	38,106	9,852	946	0.8	1.0	0.5	0.02
54	19,454	4,795	460	230	230	0.4	0.5	0.2	0.01	18,545	4,543	436	218	218	0.4	0.5	0.2	0.01	37,999	9,338	896	0.8	1.0	0.5	0.02
55	19,422	4,916	472	236	236	0.4	0.5	0.3	0.01	18,461	4,646	446	223	223	0.4	0.5	0.2	0.01	37,884	9,562	918	0.8	1.0	0.5	0.02
56	19,388	5,012	481	241	241	0.4	0.5	0.3	0.01	18,372	4,724	453	227	227	0.4	0.5	0.2	0.01	37,761	9,736	934	0.8	1.0	0.5	0.02
57	19,352	5,086	488	244	244	0.4	0.5	0.3	0.01	18,277	4,778	459	229	229	0.4	0.5	0.2	0.01	37,629	9,865	947	0.8	1.0	0.5	0.02
58	19,312	5,139	493	247	247	0.4	0.5	0.3	0.01	18,175	4,812	462	231	231	0.4	0.5	0.2	0.01	37,487	9,951	955	0.8	1.0	0.5	0.02
59	19,270	5,173	497	248	248	0.4	0.5	0.3	0.01	18,065	4,825	463	232	232	0.4	0.5	0.2	0.01	37,335	9,998	960	0.8	1.0	0.5	0.02
60	19,224	5,190	498	249	249	0.4	0.5	0.3	0.01	17,947	4,819	463	231	231	0.4	0.5	0.2	0.01	37,171	10,009	961	0.8	1.0	0.5	0.02
61	19,174	5,190	498	249	249	0.4	0.5	0.3	0.01	17,820	4,796	460	230	230	0.4	0.5	0.2	0.01	36,995	9,986	958	0.8	1.0	0.5	0.02
62	19,121	5,176	497	248	248	0.4	0.5	0.3	0.01	17,684	4,757	457	228	228	0.4	0.5	0.2	0.01	36,805	9,933	953	0.8	1.0	0.5	0.02
63	19,063	5,147	494	247	247	0.4	0.5	0.3	0.01	17,537	4,703	451	226	226	0.4	0.5	0.2	0.01	36,600	9,850	945	0.8	1.0	0.5	0.02
64	19,000	5,106	490	245	245	0.4	0.5	0.3	0.01	17,379	4,634	445	222	222	0.4	0.5	0.2	0.01	36,379	9,740	935	0.8	1.0	0.5	0.02
65	18,932	5,071	487	243	243	0.4	0.5	0.3	0.01	17,208	4,569	439	219	219	0.4	0.5	0.2	0.01	36,140	9,640	925	0.8	1.0	0.5	0.02
66	18,858	5,039	484	242	242	0.4	0.5	0.3	0.01	17,024	4,506	432	216	216	0.4	0.5	0.2	0.01	35,882	9,545	916	0.8	1.0	0.5	0.02
67	18,777	5,011	481	240	240	0.4	0.5	0.3	0.01	16,826	4,442	426	213	213	0.4	0.5	0.2	0.01	35,603	9,453	907	0.8	1.0	0.5	0.02
68	18,689	4,983	478	239	239	0.4	0.5	0.3	0.01	16,612	4,378	420	210	210	0.4	0.5	0.2	0.01	35,301	9,361	898	0.8	1.0	0.5	0.02
69	18,593	4,955	476	238	238	0.4	0.5	0.3	0.01	16,381	4,310	414	207	207	0.3	0.4	0.2	0.01	34,974	9,265	889	0.7	1.0	0.5	0.02
70	18,489	4,926	473	236	236	0.4	0.5	0.3	0.01	16,132	4,239	407	203	203	0.3	0.4	0.2	0.01	34,620	9,165	880	0.7	0.9	0.5	0.02
71	18,375	4,895	470	235	235	0.4	0.5	0.2	0.01	15,863	4,162	399	200	200	0.3	0.4	0.2	0.01	34,237	9,057	869	0.7	0.9	0.5	0.02
72	18,250	4,860	466	233	233	0.4	0.5	0.2	0.01	15,573	4,079	391	196	196	0.3	0.4	0.2	0.01	33,822	8,939	858	0.7	0.9	0.5	0.02
73	18,113	4,821	463	231	231	0.4	0.5	0.2	0.01	15,260	3,988	383	191	191	0.3	0.4	0.2	0.01	33,373	8,810	846	0.7	0.9	0.4	0.02
74	17,963	4,777	459	229	229	0.4	0.5	0.2	0.01	14,923	3,890	373	187	187	0.3	0.4	0.2	0.01	32,886	8,667	832	0.7	0.9	0.4	0.02
75	17,799	4,728	454	227	227	0.4	0.5	0.2	0.01	14,560	3,782	363	182	182	0.3	0.4	0.2	0.01	32,359	8,511	817	0.7	0.9	0.4	0.02
Total		***166,155***	***15,947***	***7,973***	***7,973***	***13.4***	***17.2***	***8.5***	***0.32***		***152,482***	***14,635***	***7,317***	***7,317***	***12.3***	***15.8***	***7.8***	***0.29***		***318,637***	***30,582***	***26***	***33***	***16***	***0.61***

- We assumed a utility loss equivalent to 2 days per colonoscopy performed (0.0055 QALYs per colonoscopy).[669]
- We assumed a utility loss equivalent to 2 days per minor bleeding event (0.0055 per bleeding event).[670]
- We assumed a utility loss equivalent to 2 weeks for non-lethal major complications (i.e., major bleed requiring hospitalization or perforation) associated with colonoscopy (0.0384 QALYs per major complication).[671]
- The colonoscopies and associated minor/major complications are associated with an estimated 208 QALYs lost while the 0.61 death attributable to colonoscopy is associated with 16.5 life years lost (see Table 15).

Table 15: Estimated QALYs and Life Years Lost Due to Colonoscopy Complications
Between the Ages of 45 and 79
In a British Columbia Birth Cohort of 40,000
With a Co-ordinated Screening Program

	Colonoscopy			Minor Complication			Major Comlication			Total QALYs Lost			Life Years Lost		
Age	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female	Male	Total
45	4.7	4.5	9.2	0.00	0.00	0.01	0.01	0.01	0.01	4.7	4.6	9.2	0.6	0.5	1.1
46	4.5	4.3	8.8	0.00	0.00	0.01	0.01	0.01	0.01	4.5	4.3	8.8	0.6	0.5	1.0
47	4.2	4.1	8.3	0.00	0.00	0.01	0.01	0.01	0.01	4.2	4.1	8.3	0.5	0.5	1.0
48	4.0	3.9	7.9	0.00	0.00	0.01	0.01	0.01	0.01	4.0	3.9	7.9	0.5	0.4	0.9
49	3.8	3.7	7.5	0.00	0.00	0.01	0.01	0.01	0.01	3.8	3.7	7.5	0.4	0.4	0.8
50	3.8	3.6	7.4	0.00	0.00	0.01	0.01	0.01	0.01	3.8	3.6	7.4	0.4	0.4	0.8
51	3.6	3.4	7.0	0.00	0.00	0.01	0.01	0.01	0.01	3.6	3.5	7.1	0.4	0.3	0.7
52	3.4	3.3	6.7	0.00	0.00	0.01	0.01	0.01	0.01	3.4	3.3	6.7	0.4	0.3	0.7
53	3.3	3.1	6.3	0.00	0.00	0.01	0.01	0.00	0.01	3.3	3.1	6.4	0.3	0.3	0.6
54	3.1	2.9	6.0	0.00	0.00	0.01	0.00	0.00	0.01	3.1	2.9	6.0	0.3	0.3	0.6
55	3.2	3.0	6.2	0.00	0.00	0.01	0.01	0.00	0.01	3.2	3.0	6.2	0.3	0.3	0.6
56	3.2	3.0	6.3	0.00	0.00	0.01	0.01	0.00	0.01	3.2	3.0	6.3	0.3	0.2	0.5
57	3.3	3.1	6.4	0.00	0.00	0.01	0.01	0.00	0.01	3.3	3.1	6.4	0.3	0.2	0.5
58	3.3	3.1	6.4	0.00	0.00	0.01	0.01	0.00	0.01	3.3	3.1	6.4	0.3	0.2	0.5
59	3.3	3.1	6.4	0.00	0.00	0.01	0.01	0.01	0.01	3.3	3.1	6.5	0.3	0.2	0.5
60	3.4	3.2	6.6	0.00	0.00	0.01	0.01	0.01	0.01	3.4	3.2	6.6	0.3	0.2	0.5
61	3.4	3.2	6.6	0.00	0.00	0.01	0.01	0.01	0.01	3.4	3.2	6.6	0.3	0.2	0.5
62	3.4	3.1	6.6	0.00	0.00	0.01	0.01	0.01	0.01	3.4	3.2	6.6	0.3	0.2	0.5
63	3.4	3.1	6.5	0.00	0.00	0.01	0.01	0.01	0.01	3.4	3.1	6.5	0.2	0.2	0.4
64	3.4	3.1	6.4	0.00	0.00	0.01	0.01	0.00	0.01	3.4	3.1	6.5	0.2	0.2	0.4
65	3.4	3.0	6.4	0.00	0.00	0.01	0.01	0.00	0.01	3.4	3.0	6.4	0.2	0.2	0.4
66	3.3	3.0	6.3	0.00	0.00	0.01	0.01	0.00	0.01	3.3	3.0	6.3	0.2	0.2	0.4
67	3.3	2.9	6.2	0.00	0.00	0.01	0.01	0.00	0.01	3.3	2.9	6.3	0.2	0.2	0.4
68	3.3	2.9	6.2	0.00	0.00	0.01	0.01	0.00	0.01	3.3	2.9	6.2	0.2	0.1	0.3
69	3.3	2.8	6.1	0.00	0.00	0.01	0.01	0.00	0.01	3.3	2.9	6.1	0.2	0.1	0.3
70	3.4	3.0	6.4	0.00	0.00	0.01	0.01	0.00	0.01	3.4	3.0	6.4	0.2	0.1	0.3
71	3.4	2.9	6.3	0.00	0.00	0.01	0.01	0.00	0.01	3.4	2.9	6.3	0.2	0.1	0.3
72	3.4	2.8	6.2	0.00	0.00	0.01	0.01	0.00	0.01	3.4	2.9	6.2	0.2	0.1	0.3
73	3.4	2.8	6.1	0.00	0.00	0.01	0.01	0.00	0.01	3.4	2.8	6.2	0.2	0.1	0.3
74	3.3	2.7	6.0	0.00	0.00	0.01	0.01	0.00	0.01	3.3	2.7	6.1	0.1	0.1	0.2
75	3.3	2.6	5.9	0.00	0.00	0.00	0.01	0.00	0.01	3.3	2.6	5.9	0.1	0.1	0.2
	108.5	**99.4**	**207.9**	**0.09**	**0.08**	**0.17**	**0.17**	**0.16**	**0.33**	**108.8**	**99.6**	**208.4**	**9.0**	**7.5**	**16.5**

[669] Goede S, Rabeneck L, van Ballegooijen M et al. Harms, benefits and costs of fecal immunochemical testing versus guaiac fecal occult blood testing for colorectal cancer screening. *PLOS One.* 2017; 12(3): e0172864.
[670] Knudsen A, Rutter C, Peterse E et al. *Colorectal Cancer Screening: An Updated Decision Analysis for the U.S. Preventive Services Task Force*. Agency for Healthcare Research and Quality. May, 2021.
[671] Goede S, Rabeneck L, van Ballegooijen M et al. Harms, benefits and costs of fecal immunochemical testing versus guaiac fecal occult blood testing for colorectal cancer screening. *PLOS One.* 2017; 12(3): e0172864.

Summary of CPB – Males and Females

- Other assumptions used in assessing CPB are detailed in the Reference Document.

Based on these assumptions, the CPB associated with screening for colorectal cancer in adults ages 45-75 in a British Columbia birth cohort of 40,000 is 3,617 QALYs (Table 16, row *am*). The CPB of 3,617 represents the gap between no coverage and the 'best in the world' screening coverage estimated at 77%.

Table 16: CPB of Screening and Treatment for Colorectal Cancer
Ages 45 - 75
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
a	Age to start screening	45	√
b	Age to stop screening	75	√
c	Years of 'protection' after stopping screening	4	Assumed
d	Life years lived between the ages of 45 and 79	1,240,816	Table 2
	Total Burden (QALYs) in Birth Cohort Without Screening		
e	Incidence of CRC per 100,000 life years	145	Table 2
	# of new CRC **cases** by Dukes' Stage		
f	A	262	Table 4
g	B	643	Table 4
h	C	505	Table 4
i	Distant	395	Table 4
j	Total new CRC case in birth cohort	1,804	Table 4
	# of CRC **deaths** by Dukes' Stage		
k	A	38	Table 8
l	B	161	Table 8
m	C	173	Table 8
n	Distant	340	Table 8
o	Total new CRC deaths in birth cohort	710	Table 8
p	Life years lost due to CRC deaths	12,950	Table 9
q	Life years lost per CRC death	18.2	= p / o
r	QALYs lost due to living with CRC	2,099	Table 9
s	***Total QALYs lost without screening***	**15,049**	= p + r
	Total Burden (QALYs) in Birth Cohort With Screening		
t	% of eligible cohort screened	77%	√
u	Incidence of CRC per 100,000 life years	121	=(z / d) * 100,000
	# of new CRC **cases** by Dukes' Stage		
v	A	379	Table 11
w	B	483	Table 11
x	C	385	Table 11
y	Distant	251	Table 11
z	Total new CRC case in birth cohort	1,499	Table 11
	# of CRC **deaths** by Dukes' Stage		
aa	A	54	Table 12
ab	B	121	Table 12
ac	C	132	Table 12
ad	Distant	216	Table 12
ae	Total new CRC deaths in birth cohort	523	Table 12
af	Life years lost due to CRC deaths	9,508	Table 13
ag	Life years lost per CRC death	18.2	= af / ae
ah	QALYs lost due to living with CRC	1,699	Table 13
	Harms Due to Colonoscopies		
ai	Life years lost due to colonoscopies	17	Table 15
aj	QALYs lost due to colonoscopies	208	Table 15
	Net QALYs Gained With Screening		
ak	Net life years gained	3,426	= p - af - ai
al	Net QALYs gained	191	= r - ah - aj
am	**Total QALYs gained (CPB)** - No screening to 77%	**3,617**	= ak + al
an	**Total QALYs gained (CPB)** - Screening rate improves from 50% to 77%	1,268	= (1-50/77) * am
ao	**Total QALYs gained (CPB)** - Screening rate improves from 35% to 77%	1,973	= (1-35/77) * am

√ = Estimates from the literature

Sensitivity Analysis – Males and Females

We also modified several major assumptions and recalculated the CPB as follows:

- Assume that the effectiveness of screening in reducing the incidence of CRC is reduced from 22% to 17%: CPB = 3,134
- Assume that the effectiveness of screening in reducing the incidence of CRC is increased from 22% to 26%: **CPB = 4,003**
- Reduced QoL impact. Use the lower limit of the disutility weights associated with the diagnosis and treatment (-0.288 to -0.193), remission (-0.049 to -0.031) and metastatic (-0.451 to -0.307) phases of living with CRC: CPB = 3,484
- Increased QoL impact. Use the upper limit of the disutility weights associated with the diagnosis and treatment (-0.288 to -0.399), remission (-0.049 to -0.072) and metastatic (-0.451 to -0.600) phases of living with CRC: CPB = 3,765
- Screening rate reduced from 77% to 50% (Table 16, row *t*): **CPB = 2,022**

Summary of CPB – Females Only

Based on these assumptions, the CPB associated with screening for colorectal cancer in females ages 45-75 in a British Columbia birth cohort of 40,000 is 1,583 QALYs (Table 17, row *am*). The CPB of 1,583 represents the gap between no coverage and the 'best in the world' screening coverage estimated at 77%.

Table 17: CPB of Screening and Treatment for Colorectal Cancer
Ages 45 - 75
Females in a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
a	Age to start screening	45	√
b	Age to stop screening	75	√
c	Years of 'protection' after stopping screening	4	Assumed
d	Life years lived between the ages of 45 and 79	642,278	Table 2
	Total Burden (QALYs) in Birth Cohort Without Screening		
e	Incidence of CRC per 100,000 life years	118	Table 2
	# of new CRC **cases** by Dukes' Stage		
f	A	110	Table 4
g	B	269	Table 4
h	C	211	Table 4
i	Distant	166	Table 4
j	Total new CRC case in birth cohort	756	Table 4
	# of CRC **deaths** by Dukes' Stage		
k	A	16	Table 8
l	B	67	Table 8
m	C	72	Table 8
n	Distant	142	Table 8
o	Total new CRC deaths in birth cohort	297	Table 8
p	Life years lost due to CRC deaths	5,773	Table 9
q	Life years lost per CRC death	19.4	= p / o
r	QALYs lost due to living with CRC	868	Table 9
s	***Total QALYs lost without screening***	**6,642**	= p + r
	Total Burden (QALYs) in Birth Cohort With Screening		
t	% of eligible cohort screened	77%	√
u	Incidence of CRC per 100,000 life years	98	=(z / d) * 100,000
	# of new CRC **cases** by Dukes' Stage		
v	A	159	Table 11
w	B	202	Table 11
x	C	161	Table 11
y	Distant	105	Table 11
z	Total new CRC case in birth cohort	628	Table 11
	# of CRC **deaths** by Dukes' Stage		
aa	A	23	Table 12
ab	B	50	Table 12
ac	C	55	Table 12
ad	Distant	90	Table 12
ae	Total new CRC deaths in birth cohort	219	Table 12
af	Life years lost due to CRC deaths	4,239	Table 13
ag	Life years lost per CRC death	19.4	= af / ae
ah	QALYs lost due to living with CRC	702	Table 13
	Harms Due to Colonoscopies		
ai	Life years lost due to colonoscopies	9	Table 15
aj	QALYs lost due to colonoscopies	109	Table 15
	Net QALYs Gained With Screening		
ak	Net life years gained	1,526	= p - af - ai
al	Net QALYs gained	57	= r - ah - aj
am	**Total QALYs gained (CPB) -** No screening to 77%	**1,583**	= ak + al
an	**Total QALYs gained (CPB) -** Screening rate improves from 50% to 77%	555	= (1-50/77) * am
ao	**Total QALYs gained (CPB) -** Screening rate improves from 35% to 77%	863	= (1-35/77) * am

√ = Estimates from the literature

Sensitivity Analysis – Females Only

We also modified several major assumptions and recalculated the CPB for females as follows:

- Assume that the effectiveness of screening in reducing the incidence of CRC is reduced from 22% to 17%: CPB = 1,370
- Assume that the effectiveness of screening in reducing the incidence of CRC is increased from 22% to 26%: **CPB = 1,753**
- Reduced QoL impact. Use the lower limit of the disutility weights associated with the diagnosis and treatment (-0.288 to -0.193), remission (-0.049 to -0.031) and metastatic (-0.451 to -0.307) phases of living with CRC: CPB = 1,528
- Increased QoL impact. Use the upper limit of the disutility weights associated with the diagnosis and treatment (-0.288 to -0.399), remission (-0.049 to -0.072) and metastatic (-0.451 to -0.600) phases of living with CRC: CPB = 1,644
- Screening rate reduced from 77% to 50% (Table 17, row *t*): **CPB = 883**

Summary of CPB – Males Only

Based on these assumptions, the CPB associated with screening for colorectal cancer in males ages 45-75 in a British Columbia birth cohort of 40,000 is 2,034 QALYs (Table 18, row *am*). The CPB of 2,034 represents the gap between no coverage and the 'best in the world' screening coverage estimated at 77%.

Table 18: CPB of Screening and Treatment for Colorectal Cancer
Ages 45 - 75
Males in a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
a	Age to start screening	45	√
b	Age to stop screening	75	√
c	Years of 'protection' after stopping screening	4	Assumed
d	Life years lived between the ages of 45 and 79	598,538	Table 2
	Total Burden (QALYs) in Birth Cohort Without Screening		
e	Incidence of CRC per 100,000 life years	175	Table 2
	# of new CRC **cases** by Dukes' Stage		
f	A	152	Table 4
g	B	373	Table 4
h	C	293	Table 4
i	Distant	230	Table 4
j	Total new CRC case in birth cohort	1,048	Table 4
	# of CRC **deaths** by Dukes' Stage		
k	A	22	Table 8
l	B	93	Table 8
m	C	100	Table 8
n	Distant	197	Table 8
o	Total new CRC deaths in birth cohort	413	Table 8
p	Life years lost due to CRC deaths	7,177	Table 9
q	Life years lost per CRC death	17.4	= p / o
r	QALYs lost due to living with CRC	1,230	Table 9
s	***Total QALYs lost without screening***	**8,407**	= p + r
	Total Burden (QALYs) in Birth Cohort With Screening		
t	% of eligible cohort screened	77%	√
u	Incidence of CRC per 100,000 life years	145	=(z / d) * 100,000
	# of new CRC **cases** by Dukes' Stage		
v	A	220	Table 11
w	B	281	Table 11
x	C	224	Table 11
y	Distant	146	Table 11
z	Total new CRC case in birth cohort	871	Table 11
	# of CRC **deaths** by Dukes' Stage		
aa	A	32	Table 12
ab	B	70	Table 12
ac	C	77	Table 12
ad	Distant	125	Table 12
ae	Total new CRC deaths in birth cohort	304	Table 12
af	Life years lost due to CRC deaths	5,269	Table 13
ag	Life years lost per CRC death	17.3	= af / ae
ah	QALYs lost due to living with CRC	997	Table 13
	Harms Due to Colonoscopies		
ai	Life years lost due to colonoscopies	7	Table 15
aj	QALYs lost due to colonoscopies	100	Table 15
	Net QALYs Gained With Screening		
ak	Net life years gained	1,900	= p - af - ai
al	Net QALYs gained	134	= r - ah - aj
am	**Total QALYs gained (CPB) -** No screening to 77%	**2,034**	= ak + al
an	**Total QALYs gained (CPB) -** Screening rate improves from 50% to 77%	713	= (1-50/77) * am
ao	**Total QALYs gained (CPB) -** Screening rate improves from 35% to 77%	1,109	= (1-35/77) * am

√ = Estimates from the literature

Sensitivity Analysis – Males Only

We also modified several major assumptions and recalculated the CPB for males as follows:

- Assume that the effectiveness of screening in reducing the incidence of CRC is reduced from 22% to 17%: CPB = 1,764
- Assume that the effectiveness of screening in reducing the incidence of CRC is increased from 22% to 26%: **CPB = 2,250**
- Reduced QoL impact. Use the lower limit of the disutility weights associated with the diagnosis and treatment (-0.288 to -0.193), remission (-0.049 to -0.031) and metastatic (-0.451 to -0.307) phases of living with CRC: CPB = 1,956
- Increased QoL impact. Use the upper limit of the disutility weights associated with the diagnosis and treatment (-0.288 to -0.399), remission (-0.049 to -0.072) and metastatic (-0.451 to -0.600) phases of living with CRC: CPB = 2,120
- Screening rate reduced from 77% to 50% (Table 18, row *t*): **CPB = 1,140**

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with screening for colorectal cancer in adults ages 45-75 in a British Columbia birth cohort of 40,000.

In estimating CE, we made the following assumptions:

Cost of Screening and Interventions

- Fixed screening program (ColonCancerCheck) costs in Ontario averaged $11.31 million (in 2013$ or $14.22 million in 2022$) per year. The fixed costs include costs for the screening registry, program infrastructure, communications and advertising, and sending activity reports to primary care physicians.[672]
- In 2010 and 2011, 29.8% of 2,612,382 eligible persons ages 50-74 completed an FOBT in the 2-year period through Ontario's ColonCancerCheck or an estimated 389,245 screens per year.[673] If we divide the annual fixed program cost by the number of annual screens we calculate an average fixed program cost of $36.53 per screen ($14.22 million / 389,245).
- Based on data from Ontario, the cost of the FIT kit and processing is $31.11 (in 2013$ or $39.11 in 2022$).[674]
- We have assumed that half of a physician office visit would be required to get a referral for a FIT kit. Results would be given to the patient at a second physician office visit. A negative result would require half of a physician office visit while a positive result and referral to colonoscopy would require an entire physician office visit.
- The cost of an office visit to a General Practitioner (GP) in BC is estimated at $35.97.

[672] Goede S, Rabeneck L, van Ballegooijen M et al. Harms, benefits and costs of fecal immunochemical testing versus guaiac fecal occult blood testing for colorectal cancer screening. *PLOS One.* 2017; 12(3): e0172864.
[673] Rabeneck L, Tinmouth J, Paszat L et al. Ontario's ColonCancerCheck: Results from Canada's first province-wide colorectal cancer screening program. *Cancer Epidemiology, Biomarkers & Prevention*. 2014; 23(3): 508 – 15.
[674] Goede S, Rabeneck L, van Ballegooijen M et al. Harms, benefits and costs of fecal immunochemical testing versus guaiac fecal occult blood testing for colorectal cancer screening. *PLOS One.* 2017; 12(3): e0172864.

- Based on data from Ontario, the cost of a colonoscopy (no polypectomy) is $872 (in 2013$ or $1,096 in 2022$).[675]
- Based on data from Ontario, the cost of a colonoscopy (with polypectomy) is $1,097 (in 2013$ or $1,379 in 2022$).[676]
- Based on a PPV of 50%, we have estimated that half of colonoscopies would be with and half without polypectomy.
- Patient time costs resulting from receiving, as well as travelling to and from, a service are valued based on the average hourly wage rate in BC in 2022 ($37.16 / hour). In the absence of specific data on the amount of time required, we assume two hours per service.
- Patient time costs are truncated at $278.70 per day (7.5 hours times $37.16). If, for example, we are valuing a patient's time costs while in hospital, each day would be assessed a value of $278.70 (rather than 24 hours times $37.16 or $891.84).
- We have assumed two days of patient time lost per colonoscopy, including the time for bowel preparation, the procedure and recovery time.[677]
- Over the lifetime of the BC birth cohort, total colorectal screening costs (excluding patient time costs) would be $79.69 million, consisting of $11.64 million in fixed program costs, $17.74 million in physician visit costs, $12.46 million for the cost of the FIT kit and processing and $37.84 million for colonoscopies (see Table 19).
- Over the lifetime of the BC birth cohort, patient time costs would be $53.70 million, consisting of $36.66 for time spent visiting their physician and $17.05 million for time spent for bowel preparation, the procedure and recovery time for colonoscopies (see Table 20).

[675] Goede S, Rabeneck L, van Ballegooijen M et al. Harms, benefits and costs of fecal immunochemical testing versus guaiac fecal occult blood testing for colorectal cancer screening. *PLOS One.* 2017; 12(3): e0172864.
[676] Goede S, Rabeneck L, van Ballegooijen M et al. Harms, benefits and costs of fecal immunochemical testing versus guaiac fecal occult blood testing for colorectal cancer screening. *PLOS One.* 2017; 12(3): e0172864.
[677] Jonas D, Russell L, Sandler R et al. Patient time requirements for screening colonoscopy. *American Journal of Gastroenterology.* 2007; 102(11), 2401 - 10.

Table 19: Estimated CRC Screening Costs

Between the Ages of 45 and 75

In a British Columbia Birth Cohort of 40,000

With a Co-ordinated Screening Program ($ in millions)

	Female									*Male*									*Total Population*				
		Colonoscopy			Fixed Program	Physician Visits		Cost of FIT Kit &	Cost of Colonos		Colonoscopy			Fixed Program	Physician Visits		Cost of FIT Kit &	Cost of Colonos	Fixed			Colonos	
Age	# of FIT	#	Pos	Neg	Costs	# of	$ of	Processing	copies	# of FIT	#	Pos	Neg	Costs	# of	$ of	Processing	copies	Program	Physician	FIT Kit	copies	Total
45	7,569	726	363	363	$0.28	11,717	$0.42	$0.30	$0.90	7,351	706	353	353	$0.27	11,380	$0.41	$0.29	$0.87	$0.55	$0.83	$0.58	$1.77	$3.73
46	7,199	691	345	345	$0.26	11,145	$0.40	$0.28	$0.86	6,980	670	335	335	$0.25	10,805	$0.39	$0.27	$0.83	$0.52	$0.79	$0.55	$1.68	$3.55
47	6,847	657	329	329	$0.25	10,599	$0.38	$0.27	$0.81	6,626	636	318	318	$0.24	10,257	$0.37	$0.26	$0.79	$0.49	$0.75	$0.53	$1.60	$3.37
48	6,511	625	312	312	$0.24	10,078	$0.36	$0.25	$0.77	6,287	603	302	302	$0.23	9,733	$0.35	$0.25	$0.75	$0.47	$0.71	$0.50	$1.52	$3.20
49	6,190	594	297	297	$0.23	9,582	$0.34	$0.24	$0.74	5,964	572	286	286	$0.22	9,232	$0.33	$0.23	$0.71	$0.44	$0.68	$0.48	$1.44	$3.04
50	5,884	565	282	282	$0.21	9,109	$0.33	$0.23	$0.70	5,655	543	271	271	$0.21	8,753	$0.31	$0.22	$0.67	$0.42	$0.64	$0.45	$1.37	$2.89
51	5,593	537	268	268	$0.20	8,657	$0.31	$0.22	$0.66	5,359	514	257	257	$0.20	8,295	$0.30	$0.21	$0.64	$0.40	$0.61	$0.43	$1.30	$2.74
52	5,314	510	255	255	$0.19	8,226	$0.30	$0.21	$0.63	5,075	487	244	244	$0.19	7,857	$0.28	$0.20	$0.60	$0.38	$0.58	$0.41	$1.23	$2.60
53	5,049	485	242	242	$0.18	7,815	$0.28	$0.20	$0.60	4,804	461	231	231	$0.18	7,436	$0.27	$0.19	$0.57	$0.36	$0.55	$0.39	$1.17	$2.46
54	4,795	460	230	230	$0.18	7,423	$0.27	$0.19	$0.57	4,543	436	218	218	$0.17	7,033	$0.25	$0.18	$0.54	$0.34	$0.52	$0.37	$1.11	$2.34
55	4,916	472	236	236	$0.18	7,610	$0.27	$0.19	$0.58	4,646	446	223	223	$0.17	7,192	$0.26	$0.18	$0.55	$0.35	$0.53	$0.37	$1.14	$2.39
56	5,012	481	241	241	$0.18	7,759	$0.28	$0.20	$0.60	4,724	453	227	227	$0.17	7,313	$0.26	$0.18	$0.56	$0.36	$0.54	$0.38	$1.16	$2.43
57	5,086	488	244	244	$0.19	7,874	$0.28	$0.20	$0.60	4,778	459	229	229	$0.17	7,397	$0.27	$0.19	$0.57	$0.36	$0.55	$0.39	$1.17	$2.47
58	5,139	493	247	247	$0.19	7,956	$0.29	$0.20	$0.61	4,812	462	231	231	$0.18	7,448	$0.27	$0.19	$0.57	$0.36	$0.55	$0.39	$1.18	$2.49
59	5,173	497	248	248	$0.19	8,009	$0.29	$0.20	$0.61	4,825	463	232	232	$0.18	7,468	$0.27	$0.19	$0.57	$0.37	$0.56	$0.39	$1.19	$2.50
60	5,190	498	249	249	$0.19	8,034	$0.29	$0.20	$0.62	4,819	463	231	231	$0.18	7,460	$0.27	$0.19	$0.57	$0.37	$0.56	$0.39	$1.19	$2.50
61	5,190	498	249	249	$0.19	8,034	$0.29	$0.20	$0.62	4,796	460	230	230	$0.18	7,424	$0.27	$0.19	$0.57	$0.36	$0.56	$0.39	$1.19	$2.50
62	5,176	497	248	248	$0.19	8,012	$0.29	$0.20	$0.61	4,757	457	228	228	$0.17	7,364	$0.26	$0.19	$0.56	$0.36	$0.55	$0.39	$1.18	$2.48
63	5,147	494	247	247	$0.19	7,968	$0.29	$0.20	$0.61	4,703	451	226	226	$0.17	7,280	$0.26	$0.18	$0.56	$0.36	$0.55	$0.39	$1.17	$2.46
64	5,106	490	245	245	$0.19	7,904	$0.28	$0.20	$0.61	4,634	445	222	222	$0.17	7,173	$0.26	$0.18	$0.55	$0.36	$0.54	$0.38	$1.16	$2.44
65	5,071	487	243	243	$0.19	7,849	$0.28	$0.20	$0.60	4,569	439	219	219	$0.17	7,073	$0.25	$0.18	$0.54	$0.35	$0.54	$0.38	$1.14	$2.41
66	5,039	484	242	242	$0.18	7,801	$0.28	$0.20	$0.60	4,506	432	216	216	$0.16	6,975	$0.25	$0.18	$0.54	$0.35	$0.53	$0.37	$1.13	$2.39
67	5,011	481	240	240	$0.18	7,756	$0.28	$0.20	$0.60	4,442	426	213	213	$0.16	6,877	$0.25	$0.17	$0.53	$0.35	$0.53	$0.37	$1.12	$2.36
68	4,983	478	239	239	$0.18	7,714	$0.28	$0.19	$0.59	4,378	420	210	210	$0.16	6,777	$0.24	$0.17	$0.52	$0.34	$0.52	$0.37	$1.11	$2.34
69	4,955	476	238	238	$0.18	7,671	$0.28	$0.19	$0.59	4,310	414	207	207	$0.16	6,672	$0.24	$0.17	$0.51	$0.34	$0.52	$0.36	$1.10	$2.32
70	4,926	473	236	236	$0.18	7,626	$0.27	$0.19	$0.59	4,239	407	203	203	$0.15	6,561	$0.24	$0.17	$0.50	$0.33	$0.51	$0.36	$1.09	$2.29
71	4,895	470	235	235	$0.18	7,577	$0.27	$0.19	$0.58	4,162	399	200	200	$0.15	6,443	$0.23	$0.16	$0.49	$0.33	$0.50	$0.35	$1.08	$2.27
72	4,860	466	233	233	$0.18	7,524	$0.27	$0.19	$0.58	4,079	391	196	196	$0.15	6,314	$0.23	$0.16	$0.48	$0.33	$0.50	$0.35	$1.06	$2.24
73	4,821	463	231	231	$0.18	7,463	$0.27	$0.19	$0.57	3,988	383	191	191	$0.15	6,174	$0.22	$0.16	$0.47	$0.32	$0.49	$0.34	$1.05	$2.20
74	4,777	459	229	229	$0.17	7,395	$0.27	$0.19	$0.57	3,890	373	187	187	$0.14	6,021	$0.22	$0.15	$0.46	$0.32	$0.48	$0.34	$1.03	$2.17
75	4,728	454	227	227	$0.17	7,319	$0.26	$0.18	$0.56	3,782	363	182	182	$0.14	5,855	$0.21	$0.15	$0.45	$0.31	$0.47	$0.33	$1.01	$2.13
Total	***166,155***	***15,947***	***7,973***	***7,973***	***$6.07***	***257,206***	***$9.25***	***$6.50***	***$19.73***	***152,482***	***14,635***	***7,317***	***7,317***	***$5.57***	***236,041***	***$8.49***	***$5.96***	***$18.11***	***$11.64***	***$17.74***	***$12.46***	***$37.84***	***$79.69***

Table 20: Estimated Patient Time Costs

Between the Ages of 45 and 75

In a British Columbia Birth Cohort of 40,000

With a Co-ordinated Screening Program ($ in millions)

	Female					*Male*					*Total Population*		
Age	**# of FIT**	**Colonoscopy #**	**Physician Visits # of**	**Physician Visits $ of**	**Cost of Colonoscopies**	**# of FIT**	**Colonoscopy #**	**Physician Visits # of**	**Physician Visits $ of**	**Cost of Colonoscopies**	**Physician Visits**	**Colonoscopies**	**Total**
45	7,569	726	11,717	$0.87	$0.40	7,351	706	11,380	$0.85	$0.39	$1.72	$0.80	$2.51
46	7,199	691	11,145	$0.83	$0.39	6,980	670	10,805	$0.80	$0.37	$1.63	$0.76	$2.39
47	6,847	657	10,599	$0.79	$0.37	6,626	636	10,257	$0.76	$0.35	$1.55	$0.72	$2.27
48	6,511	625	10,078	$0.75	$0.35	6,287	603	9,733	$0.72	$0.34	$1.47	$0.68	$2.16
49	6,190	594	9,582	$0.71	$0.33	5,964	572	9,232	$0.69	$0.32	$1.40	$0.65	$2.05
50	5,884	565	9,109	$0.68	$0.31	5,655	543	8,753	$0.65	$0.30	$1.33	$0.62	$1.94
51	5,593	537	8,657	$0.64	$0.30	5,359	514	8,295	$0.62	$0.29	$1.26	$0.59	$1.85
52	5,314	510	8,226	$0.61	$0.28	5,075	487	7,857	$0.58	$0.27	$1.20	$0.56	$1.75
53	5,049	485	7,815	$0.58	$0.27	4,804	461	7,436	$0.55	$0.26	$1.13	$0.53	$1.66
54	4,795	460	7,423	$0.55	$0.26	4,543	436	7,033	$0.52	$0.24	$1.07	$0.50	$1.57
55	4,916	472	7,610	$0.57	$0.26	4,646	446	7,192	$0.53	$0.25	$1.10	$0.51	$1.61
56	5,012	481	7,759	$0.58	$0.27	4,724	453	7,313	$0.54	$0.25	$1.12	$0.52	$1.64
57	5,086	488	7,874	$0.59	$0.27	4,778	459	7,397	$0.55	$0.26	$1.13	$0.53	$1.66
58	5,139	493	7,956	$0.59	$0.27	4,812	462	7,448	$0.55	$0.26	$1.14	$0.53	$1.68
59	5,173	497	8,009	$0.60	$0.28	4,825	463	7,468	$0.56	$0.26	$1.15	$0.53	$1.69
60	5,190	498	8,034	$0.60	$0.28	4,819	463	7,460	$0.55	$0.26	$1.15	$0.54	$1.69
61	5,190	498	8,034	$0.60	$0.28	4,796	460	7,424	$0.55	$0.26	$1.15	$0.53	$1.68
62	5,176	497	8,012	$0.60	$0.28	4,757	457	7,364	$0.55	$0.25	$1.14	$0.53	$1.67
63	5,147	494	7,968	$0.59	$0.28	4,703	451	7,280	$0.54	$0.25	$1.13	$0.53	$1.66
64	5,106	490	7,904	$0.59	$0.27	4,634	445	7,173	$0.53	$0.25	$1.12	$0.52	$1.64
65	5,071	487	7,849	$0.58	$0.27	4,569	439	7,073	$0.53	$0.24	$1.11	$0.52	$1.62
66	5,039	484	7,801	$0.58	$0.27	4,506	432	6,975	$0.52	$0.24	$1.10	$0.51	$1.61
67	5,011	481	7,756	$0.58	$0.27	4,442	426	6,877	$0.51	$0.24	$1.09	$0.51	$1.59
68	4,983	478	7,714	$0.57	$0.27	4,378	420	6,777	$0.50	$0.23	$1.08	$0.50	$1.58
69	4,955	476	7,671	$0.57	$0.27	4,310	414	6,672	$0.50	$0.23	$1.07	$0.50	$1.56
70	4,926	473	7,626	$0.57	$0.26	4,239	407	6,561	$0.49	$0.23	$1.05	$0.49	$1.54
71	4,895	470	7,577	$0.56	$0.26	4,162	399	6,443	$0.48	$0.22	$1.04	$0.48	$1.53
72	4,860	466	7,524	$0.56	$0.26	4,079	391	6,314	$0.47	$0.22	$1.03	$0.48	$1.51
73	4,821	463	7,463	$0.55	$0.26	3,988	383	6,174	$0.46	$0.21	$1.01	$0.47	$1.48
74	4,777	459	7,395	$0.55	$0.26	3,890	373	6,021	$0.45	$0.21	$1.00	$0.46	$1.46
75	4,728	454	7,319	$0.54	$0.25	3,782	363	5,855	$0.44	$0.20	$0.98	$0.46	$1.43
Total	***166,155***	***15,947***	***257,206***	***$19.12***	***$8.89***	***152,482***	***14,635***	***236,041***	***$17.54***	***$8.16***	***$36.66***	***$17.05***	***$53.70***

Cost of Harms

- Based on data from Ontario, the cost of a bleeding complication following a colonoscopy is $3,521 (in 2013$ or $4,426 in 2022$).[678]
- Based on data from Ontario, the cost of a perforation complication following a colonoscopy is $34,412 (in 2013$ or $43,261 in 2022$).[679]
- Over the lifetime of the BC birth cohort, the healthcare costs associated with treating bleeding and perforations resulting from colonoscopies is estimated at $961,063 (see Table 21).

Table 21: Cost of Complications Due to Colonoscopy
Between the Ages of 45 and 75
In a British Columbia Birth Cohort of 40,000
With a Co-ordinated Screening Program

	Female				*Male*				*Total Population*		
	Bleeding		**Perforations**		**Bleeding**		**Perforations**		**Cost for Treating**		
Age	**#**	$	#	$	**#**	$	#	$	Bleeds	Perforations	Total
45	1.4	$6,174	0.4	$16,657	1.4	$5,996	0.4	$16,177	$12,169	$32,834	$45,004
46	1.3	$5,872	0.4	$15,843	1.3	$5,693	0.4	$15,360	$11,565	$31,203	$42,768
47	1.3	$5,584	0.3	$15,067	1.2	$5,404	0.3	$14,581	$10,988	$29,648	$40,636
48	1.2	$5,310	0.3	$14,327	1.2	$5,128	0.3	$13,836	$10,438	$28,163	$38,601
49	1.1	$5,049	0.3	$13,622	1.1	$4,864	0.3	$13,124	$9,913	$26,746	$36,658
50	1.1	$4,799	0.3	$12,949	1.0	$4,612	0.3	$12,444	$9,411	$25,392	$34,803
51	1.0	$4,561	0.3	$12,307	1.0	$4,371	0.3	$11,792	$8,932	$24,099	$33,031
52	1.0	$4,334	0.3	$11,694	0.9	$4,139	0.3	$11,169	$8,474	$22,863	$31,337
53	0.9	$4,118	0.3	$11,110	0.9	$3,918	0.2	$10,571	$8,036	$21,681	$29,717
54	0.9	$3,911	0.2	$10,552	0.8	$3,706	0.2	$9,998	$7,616	$20,550	$28,166
55	0.9	$4,009	0.3	$10,818	0.9	$3,789	0.2	$10,224	$7,799	$21,042	$28,841
56	0.9	$4,088	0.3	$11,030	0.9	$3,853	0.2	$10,395	$7,941	$21,425	$29,366
57	0.9	$4,148	0.3	$11,193	0.9	$3,897	0.2	$10,515	$8,046	$21,708	$29,754
58	0.9	$4,192	0.3	$11,310	0.9	$3,924	0.2	$10,588	$8,116	$21,898	$30,014
59	1.0	$4,219	0.3	$11,385	0.9	$3,935	0.2	$10,617	$8,154	$22,001	$30,156
60	1.0	$4,233	0.3	$11,421	0.9	$3,930	0.2	$10,604	$8,163	$22,025	$30,189
61	1.0	$4,233	0.3	$11,422	0.9	$3,912	0.2	$10,554	$8,145	$21,976	$30,120
62	1.0	$4,221	0.3	$11,389	0.9	$3,880	0.2	$10,468	$8,101	$21,857	$29,958
63	0.9	$4,198	0.3	$11,327	0.9	$3,835	0.2	$10,348	$8,033	$21,675	$29,709
64	0.9	$4,165	0.3	$11,236	0.9	$3,780	0.2	$10,198	$7,944	$21,434	$29,378
65	0.9	$4,136	0.3	$11,159	0.8	$3,726	0.2	$10,054	$7,862	$21,213	$29,075
66	0.9	$4,110	0.3	$11,090	0.8	$3,675	0.2	$9,915	$7,785	$21,004	$28,789
67	0.9	$4,087	0.3	$11,026	0.8	$3,623	0.2	$9,776	$7,710	$20,802	$28,512
68	0.9	$4,064	0.3	$10,965	0.8	$3,570	0.2	$9,633	$7,634	$20,599	$28,233
69	0.9	$4,041	0.3	$10,904	0.8	$3,515	0.2	$9,485	$7,557	$20,389	$27,946
70	0.9	$4,018	0.3	$10,840	0.8	$3,457	0.2	$9,327	$7,475	$20,168	$27,643
71	0.9	$3,992	0.2	$10,772	0.8	$3,394	0.2	$9,159	$7,387	$19,930	$27,317
72	0.9	$3,964	0.2	$10,695	0.8	$3,327	0.2	$8,976	$7,291	$19,671	$26,962
73	0.9	$3,932	0.2	$10,610	0.7	$3,253	0.2	$8,777	$7,185	$19,386	$26,571
74	0.9	$3,896	0.2	$10,513	0.7	$3,172	0.2	$8,559	$7,069	$19,072	$26,141
75	0.9	$3,856	0.2	$10,405	0.7	$3,085	0.2	$8,324	$6,941	$18,728	$25,670
Total	**30.6**	**$135,515**	**8.5**	**$365,636**	**28.1**	**$124,364**	**7.8**	**$335,548**	**$259,879**	**$701,183**	**$961,063**

[678] Goede S, Rabeneck L, van Ballegooijen M et al. Harms, benefits and costs of fecal immunochemical testing versus guaiac fecal occult blood testing for colorectal cancer screening. *PLOS One.* 2017; 12(3): e0172864.
[679] Ibid.

Costs Avoided Due to a Reduction in CRC

- Based on data from Ontario, the estimated net healthcare costs associated with a CRC by sex and phase are as follows:[680]
    - Females
        - Initial 6 months - $24,765 (in 2009$, $34,039 in 2022$)
        - Continuing care (annual) - $5,349 ($7,352)
        - Terminal care (12 months) - $31,120 ($42,774)
    - Males
        - Initial 6 months - $25,138 ($34,552)
        - Continuing care (annual) - $5,446 ($7,486)
        - Terminal care (12 months) - $32,408 ($44,545)
- Based on data from Ontario, *first year* healthcare costs associated with a CRC survivor are $47,823 (in 2017$ or $65,733 in 2022$). The mean costs for females / males in 2022$ are $62,177 and $68,220, respectively. The costs by stage in 2022$ are $34,562 for Stage I, $56,956 for Stage II, $87,106 for Stage III and $114,276 for Stage IV.[681]
- Based on the data in the two previous bullet points, we assumed no difference in treatment costs between males and females.
- Based on data from Ontario, the estimated *first year* healthcare costs associated with a CRC survivor by stage was as follows:[682]
    - Stage I - $28,981 (in 2013 $, $36,434 in 2022$)
    - Stage II - $43,348 ($54,495)
    - Stage III - $62,259 ($78,270)
    - Stage IV – $83,440 ($104,897)
- To calculate first year healthcare costs avoided due to a lower number of new CRCs associated with a screening program, we determined the number of new CRCs avoided (Table 4 minus Table 11) by sex and stage and multiplied this by the first-year healthcare costs noted above. In doing so, we excluded new CRCs that died within the year following their diagnosis. The costs associated with these early deaths are included on Table 24. The estimated 209 new CRC cases avoided (306 new CRCs minus 97 that died in Year 1) are associated with costs avoided of $19.43 million during the first year following diagnosis (see Table 22).

[680] de Oliveira C, Pataky R, Bremner K et al. Phase-specific and lifetime costs of cáncer care in Ontario, Canada. *BMC Cancer*. 2016; 16: 809.
[681] Paszat L, Sutradhar R, Luo J et al. Overall health care cost during the year following diagnosis of colorectal cancer stratified by history of colorectal evaluative procedures. *Journal of the Canadian Association of Gastroenterology*. 2021. 4(6): 274-83.
[682] Goede S, Rabeneck L, van Ballegooijen M et al. Harms, benefits and costs of fecal immunochemical testing versus guaiac fecal occult blood testing for colorectal cancer screening. *PLOS One*. 2017; 12(3): e0172864.

Table 22: Estimated New CRCs and Costs Avoided by Dukes' Stage

Between the Ages of 45 and 79

In a British Columbia Birth Cohort of 40,000

With a Co-ordinated Screening Program ($ In Millions)

	Females						*Males*						*Total Population*					
	Dukes' Stage				**Total Avoided**		**Dukes' Stage**				**Total Avoided**		**Dukes' Stage**				**Total Avoided**	
Age	A	B	C	Distant	New CRC	Costs	A	B	C	Distant	New CRC	Costs	A	B	C	Distant	New CRC	Costs
45	-0.2	0.3	0.2	0.2	0.5	$0.04	-0.5	0.7	0.5	0.4	1.1	$0.10	-0.7	1.0	0.7	0.6	1.6	$0.15
46	-0.2	0.3	0.2	0.2	0.5	$0.04	-0.5	0.7	0.5	0.4	1.1	$0.10	-0.7	1.0	0.7	0.6	1.6	$0.15
47	-0.2	0.3	0.2	0.2	0.5	$0.04	-0.5	0.7	0.5	0.4	1.1	$0.10	-0.7	1.0	0.7	0.6	1.6	$0.15
48	-0.2	0.3	0.2	0.2	0.5	$0.04	-0.5	0.7	0.5	0.4	1.1	$0.10	-0.7	1.0	0.7	0.6	1.6	$0.15
49	-0.2	0.3	0.2	0.2	0.5	$0.04	-0.5	0.7	0.5	0.4	1.1	$0.10	-0.7	1.0	0.7	0.6	1.6	$0.15
50	-0.6	0.8	0.6	0.5	1.3	$0.12	-0.7	0.9	0.7	0.5	1.4	$0.13	-1.3	1.7	1.3	1.0	2.7	$0.25
51	-0.6	0.8	0.6	0.5	1.3	$0.12	-0.7	0.9	0.7	0.5	1.4	$0.13	-1.3	1.7	1.3	1.0	2.6	$0.25
52	-0.6	0.8	0.6	0.5	1.3	$0.12	-0.7	0.9	0.7	0.5	1.4	$0.13	-1.3	1.7	1.3	1.0	2.6	$0.25
53	-0.6	0.8	0.6	0.5	1.3	$0.12	-0.7	0.9	0.7	0.5	1.4	$0.13	-1.3	1.7	1.3	1.0	2.6	$0.24
54	-0.6	0.8	0.6	0.5	1.2	$0.12	-0.7	0.9	0.7	0.5	1.4	$0.13	-1.3	1.7	1.3	0.9	2.6	$0.24
55	-0.8	1.0	0.7	0.6	1.5	$0.14	-1.2	1.6	1.2	0.9	2.5	$0.23	-2.0	2.6	1.9	1.5	4.0	$0.38
56	-0.8	1.0	0.7	0.6	1.5	$0.14	-1.2	1.6	1.2	0.9	2.5	$0.23	-2.0	2.6	1.9	1.5	4.0	$0.37
57	-0.8	1.0	0.7	0.6	1.5	$0.14	-1.2	1.6	1.2	0.9	2.5	$0.23	-2.0	2.6	1.9	1.4	4.0	$0.37
58	-0.7	1.0	0.7	0.5	1.5	$0.14	-1.2	1.6	1.2	0.9	2.5	$0.23	-2.0	2.6	1.9	1.4	4.0	$0.37
59	-0.7	1.0	0.7	0.5	1.5	$0.14	-1.2	1.6	1.2	0.9	2.4	$0.23	-2.0	2.6	1.9	1.4	4.0	$0.37
60	-1.2	1.6	1.2	0.9	2.5	$0.23	-2.0	2.6	1.9	1.4	4.0	$0.37	-3.2	4.2	3.1	2.4	6.5	$0.60
61	-1.2	1.6	1.2	0.9	2.5	$0.23	-2.0	2.6	1.9	1.4	4.0	$0.37	-3.2	4.2	3.1	2.3	6.5	$0.60
62	-1.2	1.6	1.2	0.9	2.5	$0.23	-1.9	2.6	1.9	1.4	3.9	$0.37	-3.2	4.2	3.1	2.3	6.4	$0.60
63	-1.2	1.6	1.2	0.9	2.5	$0.23	-1.9	2.5	1.9	1.4	3.9	$0.36	-3.1	4.1	3.1	2.3	6.4	$0.59
64	-1.2	1.6	1.2	0.9	2.5	$0.23	-1.9	2.5	1.9	1.4	3.9	$0.36	-3.1	4.1	3.0	2.3	6.3	$0.59
65	-1.7	2.2	1.6	1.2	3.4	$0.31	-2.3	3.0	2.2	1.7	4.6	$0.43	-3.9	5.2	3.8	2.9	7.9	$0.74
66	-1.7	2.2	1.6	1.2	3.4	$0.31	-2.2	2.9	2.2	1.6	4.5	$0.42	-3.9	5.1	3.8	2.9	7.9	$0.73
67	-1.6	2.2	1.6	1.2	3.3	$0.31	-2.2	2.9	2.1	1.6	4.5	$0.42	-3.9	5.1	3.8	2.8	7.8	$0.73
68	-1.6	2.1	1.6	1.2	3.3	$0.31	-2.2	2.9	2.1	1.6	4.4	$0.41	-3.8	5.0	3.7	2.8	7.7	$0.72
69	-1.6	2.1	1.6	1.2	3.3	$0.31	-2.1	2.8	2.1	1.6	4.3	$0.40	-3.8	5.0	3.7	2.8	7.6	$0.71
70	-2.3	3.0	2.1	1.1	3.9	$0.36	-3.3	4.2	3.0	1.6	5.5	$0.51	-5.6	7.2	5.1	2.7	9.4	$0.87
71	-2.3	2.9	2.1	1.1	3.8	$0.36	-3.2	4.1	2.9	1.5	5.4	$0.50	-5.5	7.1	5.0	2.6	9.2	$0.85
72	-2.3	2.9	2.1	1.1	3.8	$0.35	-3.1	4.0	2.9	1.5	5.3	$0.49	-5.4	6.9	5.0	2.6	9.1	$0.84
73	-2.2	2.9	2.1	1.1	3.8	$0.35	-3.1	4.0	2.8	1.5	5.2	$0.48	-5.3	6.8	4.9	2.5	8.9	$0.83
74	-2.2	2.8	2.0	1.1	3.7	$0.34	-3.0	3.9	2.8	1.4	5.1	$0.47	-5.2	6.7	4.8	2.5	8.8	$0.81
75	-2.9	3.7	2.6	1.4	4.8	$0.44	-3.7	4.7	3.4	1.7	6.1	$0.57	-6.5	8.4	6.0	3.1	10.9	$1.01
76	-2.8	3.6	2.6	1.3	4.7	$0.44	-3.6	4.6	3.3	1.7	6.0	$0.55	-6.4	8.2	5.8	3.0	10.7	$0.99
77	-2.7	3.5	2.5	1.3	4.6	$0.43	-3.5	4.4	3.2	1.6	5.8	$0.54	-6.2	8.0	5.7	3.0	10.4	$0.96
78	-2.7	3.5	2.5	1.3	4.5	$0.42	-3.3	4.3	3.1	1.6	5.6	$0.52	-6.0	7.7	5.5	2.9	10.1	$0.94
79	-2.6	3.4	2.4	1.3	4.4	$0.41	-3.2	4.1	3.0	1.5	5.4	$0.50	-5.8	7.5	5.4	2.8	9.8	$0.91
Total	**-47.4**	**61.5**	**44.7**	**28.4**	**87.3**	**$8.11**	**-65.7**	**85.5**	**62.2**	**40.0**	**121.9**	**$11.33**	**-113.1**	**147.0**	**106.9**	**68.4**	**209.2**	**$19.43**

- Based on data from Ontario, the *ongoing annual* healthcare costs associated with a CRC survivor by stage was as follows:[683]
    - Stage I - $7,442 (in 2013 $, $9,356 in 2022$)
    - Stage II - $10,435 ($13,118)
    - Stage III - $13,344 ($16,776)
    - Stage IV – $42,551 ($53,493)
- To calculate ongoing healthcare costs avoided due to a lower number of new CRCs and deaths associated with a screening program, we determined the number of years of survivors avoided by sex and stage and multiplied this by the ongoing annual healthcare costs noted above. The reduction in the number of years living with CRC (survivors) are associated with costs avoided of $43.10 million (see Table 23).

Table 23: Estimated Cost of Living with CRC Avoided by Dukes' Stage
Between the Ages of 45 and 79
In a British Columbia Birth Cohort of 40,000
With a Co-ordinated Screening Program ($ In Millions)

	Females						*Males*						*Total Population*					
	Dukes' Stage				Total Avoided		Dukes' Stage				Total Avoided		Dukes' Stage				Total Avoided	
Age	A	B	C	Distant	Survivors	Costs	A	B	C	Distant	Survivors	Costs	A	B	C	Distant	Survivors	Costs
45	-0.2	0.3	0.2	0.2	0.5	$0.02	-0.5	0.7	0.5	0.4	1.1	$0.04	-0.7	1.0	0.7	0.6	1.6	$0.05
46	-0.4	0.6	0.4	0.3	0.9	$0.03	-1.0	1.3	1.0	0.7	2.0	$0.06	-1.5	1.9	1.4	1.1	2.9	$0.09
47	-0.6	0.8	0.6	0.4	1.2	$0.04	-1.5	2.0	1.4	0.9	2.8	$0.09	-2.2	2.8	2.0	1.3	4.0	$0.12
48	-0.8	1.1	0.8	0.5	1.5	$0.04	-2.0	2.6	1.8	1.1	3.5	$0.10	-2.8	3.6	2.6	1.6	5.0	$0.15
49	-1.0	1.3	0.9	0.5	1.7	$0.05	-2.4	3.1	2.2	1.2	4.1	$0.12	-3.5	4.4	3.1	1.7	5.8	$0.17
50	-1.6	2.1	1.5	0.8	2.8	$0.08	-3.0	3.9	2.7	1.4	5.0	$0.14	-4.7	5.9	4.2	2.3	7.7	$0.23
51	-2.2	2.8	2.0	1.1	3.7	$0.11	-3.7	4.6	3.2	1.6	5.8	$0.17	-5.9	7.4	5.2	2.7	9.5	$0.27
52	-2.8	3.5	2.5	1.3	4.5	$0.13	-4.3	5.4	3.7	1.7	6.5	$0.18	-7.0	8.9	6.2	3.0	11.0	$0.31
53	-3.3	4.2	2.9	1.4	5.2	$0.15	-4.9	6.1	4.2	1.8	7.3	$0.20	-8.2	10.3	7.2	3.2	12.5	$0.35
54	-3.9	4.8	3.4	1.5	5.8	$0.16	-5.5	6.8	4.7	2.0	8.0	$0.22	-9.3	11.6	8.1	3.5	13.8	$0.39
55	-4.5	5.7	3.9	1.7	6.8	$0.19	-6.6	8.2	5.7	2.5	9.8	$0.28	-11.1	13.9	9.7	4.2	16.6	$0.47
56	-5.2	6.5	4.5	1.9	7.7	$0.21	-7.7	9.6	6.7	2.9	11.5	$0.32	-12.9	16.1	11.2	4.8	19.2	$0.54
57	-5.9	7.3	5.0	2.1	8.5	$0.24	-8.8	11.0	7.6	3.2	13.0	$0.36	-14.7	18.2	12.7	5.3	21.5	$0.60
58	-6.5	8.1	5.6	2.2	9.3	$0.26	-9.9	12.3	8.5	3.5	14.4	$0.40	-16.4	20.3	14.1	5.7	23.7	$0.66
59	-7.2	8.8	6.1	2.4	10.1	$0.28	-11.0	13.5	9.3	3.7	15.6	$0.43	-18.1	22.4	15.5	6.1	25.8	$0.71
60	-8.3	10.3	7.1	2.9	11.9	$0.33	-12.8	15.8	10.9	4.5	18.5	$0.51	-21.1	26.0	18.0	7.4	30.4	$0.84
61	-9.4	11.7	8.1	3.3	13.6	$0.37	-14.5	18.0	12.5	5.1	21.0	$0.58	-24.0	29.6	20.5	8.4	34.6	$0.96
62	-10.6	13.0	9.0	3.6	15.0	$0.41	-16.3	20.1	13.9	5.6	23.3	$0.64	-26.8	33.1	22.9	9.1	38.3	$1.06
63	-11.6	14.3	9.9	3.8	16.4	$0.45	-18.0	22.1	15.3	6.0	25.4	$0.70	-29.6	36.4	25.2	9.8	41.8	$1.15
64	-12.7	15.6	10.7	4.1	17.7	$0.48	-19.6	24.1	16.6	6.3	27.4	$0.75	-32.3	39.7	27.4	10.4	45.1	$1.23
65	-14.2	17.4	12.0	4.6	19.9	$0.54	-21.6	26.6	18.3	6.9	30.2	$0.82	-35.8	44.0	30.3	11.5	50.1	$1.37
66	-15.7	19.3	13.3	5.1	21.9	$0.60	-23.6	28.9	19.9	7.5	32.7	$0.89	-39.3	48.2	33.2	12.5	54.7	$1.49
67	-17.1	21.0	14.5	5.4	23.8	$0.65	-25.5	31.3	21.5	7.9	35.2	$0.96	-42.7	52.3	36.0	13.3	59.0	$1.60
68	-18.6	22.8	15.7	5.8	25.6	$0.70	-27.4	33.6	23.1	8.3	37.5	$1.02	-46.0	56.3	38.7	14.1	63.1	$1.71
69	-20.0	24.4	16.8	6.1	27.3	$0.74	-29.3	35.8	24.6	8.7	39.7	$1.07	-49.3	60.2	41.4	14.8	67.0	$1.81
70	-22.1	27.0	18.5	6.3	29.6	$0.79	-32.3	39.4	27.0	9.1	43.1	$1.15	-54.4	66.3	45.4	15.4	72.8	$1.95
71	-24.2	29.4	20.0	6.5	31.7	$0.84	-35.2	42.8	29.1	9.4	46.1	$1.22	-59.3	72.2	49.2	15.8	77.9	$2.06
72	-26.2	31.7	21.5	6.6	33.6	$0.88	-38.0	46.0	31.1	9.5	48.7	$1.28	-64.1	77.8	52.6	16.1	82.4	$2.17
73	-28.1	34.0	22.8	6.7	35.5	$0.93	-40.7	49.2	33.0	9.7	51.3	$1.34	-68.8	83.2	55.9	16.5	86.7	$2.27
74	-30.0	36.2	24.2	6.9	37.3	$0.97	-43.3	52.1	34.9	10.0	53.7	$1.40	-73.3	88.3	59.0	16.9	90.9	$2.37
75	-32.6	39.2	26.1	7.4	40.2	$1.05	-46.5	55.9	37.3	10.5	57.2	$1.49	-79.2	95.2	63.4	18.0	97.4	$2.53
76	-35.1	42.1	28.0	7.8	42.8	$1.11	-49.7	59.6	39.6	11.0	60.4	$1.57	-84.8	101.7	67.5	18.8	103.2	$2.68
77	-37.5	44.9	29.7	8.1	45.2	$1.17	-52.7	63.1	41.7	11.3	63.3	$1.64	-90.2	108.0	71.4	19.3	108.5	$2.81
78	-39.9	47.6	31.4	8.3	47.4	$1.22	-55.6	66.4	43.7	11.5	66.0	$1.70	-95.5	114.0	75.1	19.8	113.4	$2.92
79	-42.2	50.2	32.9	8.5	49.5	$1.27	-58.4	69.5	45.6	11.7	68.5	$1.76	-100.5	119.8	78.5	20.3	118.0	$3.03
Total						**$17.49**						**$25.61**						**$43.10**

[683] Goede S, Rabeneck L, van Ballegooijen M et al. Harms, benefits and costs of fecal immunochemical testing versus guaiac fecal occult blood testing for colorectal cancer screening. *PLOS One.* 2017; 12(3): e0172864.

- Based on data from Ontario, the *final year* healthcare costs associated with a death due to CRC by stage was as follows:[684]
  - Stage I - $302,484 (in 2013 $, $380,271 in 2022$)
  - Stage II - $202,540 ($254,625)
  - Stage III - $134,354 ($168,905)
  - Stage IV - $117,128 ($147,249)
- To calculate ongoing healthcare costs avoided due to a lower number of CRC deaths associated with a screening program, we determined the number of CRC deaths avoided by sex and stage and multiplied this by the final year healthcare costs noted above. The reduction in the number of deaths (711 with no screening program [Table 8] minus 523 with a coordinated screening program [Table 12], or a reduction of 188 deaths) are associated with costs avoided of $26.38 million (see Table 24).

Table 24: Estimated CRC Deaths and Costs Avoided by Dukes' Stage
Between the Ages of 45 and 79
In a British Columbia Birth Cohort of 40,000
With a Co-ordinated Screening Program ($ in Millions)

	Females						*Males*						*Total Population*					
	Dukes' Stage				Total Avoided		Dukes' Stage				Total Avoided		Dukes' Stage				Total Avoided	
Age	A	B	C	Distant	CRC Deaths	Costs	A	B	C	Distant	CRC Deaths	Costs	A	B	C	Distant	CRC Deaths	Costs
45	0.0	0.0	0.0	0.1	0.1	$0.02	0.0	0.0	0.0	0.2	0.3	$0.04	0.0	0.0	0.0	0.3	0.4	$0.05
46	0.0	0.0	0.0	0.1	0.2	$0.03	0.0	0.1	0.1	0.3	0.4	$0.06	0.0	0.1	0.1	0.5	0.6	$0.08
47	0.0	0.0	0.0	0.2	0.2	$0.03	0.0	0.1	0.1	0.4	0.6	$0.08	0.0	0.1	0.1	0.6	0.8	$0.12
48	0.0	0.1	0.1	0.2	0.3	$0.04	-0.1	0.1	0.1	0.5	0.7	$0.09	-0.1	0.2	0.2	0.7	1.0	$0.13
49	0.0	0.1	0.1	0.2	0.3	$0.05	-0.1	0.2	0.2	0.5	0.8	$0.11	-0.1	0.2	0.2	0.7	1.1	$0.15
50	0.0	0.1	0.1	0.5	0.6	$0.08	-0.1	0.2	0.2	0.7	0.9	$0.13	-0.1	0.3	0.3	1.1	1.5	$0.22
51	-0.1	0.1	0.1	0.5	0.7	$0.10	-0.1	0.2	0.2	0.7	1.0	$0.14	-0.1	0.3	0.3	1.2	1.7	$0.24
52	-0.1	0.2	0.2	0.6	0.9	$0.12	-0.1	0.2	0.2	0.7	1.0	$0.15	-0.2	0.4	0.4	1.3	1.9	$0.27
53	-0.1	0.2	0.2	0.6	0.9	$0.13	-0.1	0.2	0.2	0.7	1.1	$0.15	-0.2	0.4	0.4	1.3	2.0	$0.28
54	-0.1	0.2	0.2	0.7	1.0	$0.14	-0.1	0.2	0.2	0.7	1.1	$0.15	-0.2	0.4	0.4	1.4	2.1	$0.29
55	-0.1	0.2	0.2	0.7	1.1	$0.15	-0.1	0.3	0.3	1.0	1.4	$0.20	-0.2	0.5	0.5	1.7	2.5	$0.35
56	-0.1	0.2	0.2	0.8	1.1	$0.15	-0.1	0.3	0.3	1.1	1.6	$0.22	-0.2	0.5	0.5	1.9	2.7	$0.38
57	-0.1	0.2	0.2	0.8	1.1	$0.16	-0.1	0.3	0.3	1.2	1.8	$0.25	-0.2	0.6	0.6	2.0	2.9	$0.41
58	-0.1	0.2	0.2	0.8	1.2	$0.16	-0.2	0.4	0.4	1.3	1.8	$0.26	-0.3	0.6	0.6	2.0	3.0	$0.42
59	-0.1	0.3	0.2	0.8	1.2	$0.17	-0.2	0.4	0.4	1.3	1.9	$0.27	-0.3	0.7	0.7	2.1	3.1	$0.44
60	-0.1	0.3	0.3	1.0	1.5	$0.21	-0.2	0.5	0.4	1.7	2.4	$0.34	-0.3	0.8	0.7	2.7	3.9	$0.54
61	-0.1	0.3	0.3	1.1	1.6	$0.23	-0.2	0.5	0.5	1.8	2.6	$0.37	-0.3	0.8	0.8	3.0	4.3	$0.60
62	-0.1	0.4	0.3	1.2	1.8	$0.25	-0.2	0.6	0.6	2.0	2.8	$0.40	-0.4	0.9	0.9	3.2	4.6	$0.65
63	-0.2	0.4	0.4	1.3	1.9	$0.26	-0.3	0.6	0.6	2.0	2.9	$0.41	-0.4	1.0	1.0	3.3	4.8	$0.67
64	-0.2	0.4	0.4	1.3	1.9	$0.27	-0.3	0.7	0.6	2.0	3.0	$0.43	-0.5	1.1	1.0	3.3	5.0	$0.70
65	-0.2	0.4	0.4	1.5	2.2	$0.31	-0.3	0.7	0.7	2.2	3.2	$0.46	-0.5	1.1	1.1	3.7	5.5	$0.77
66	-0.2	0.5	0.5	1.6	2.3	$0.33	-0.3	0.7	0.7	2.3	3.3	$0.47	-0.5	1.2	1.1	3.9	5.7	$0.80
67	-0.2	0.5	0.5	1.7	2.5	$0.35	-0.3	0.7	0.7	2.3	3.4	$0.48	-0.5	1.2	1.2	4.0	5.9	$0.83
68	-0.2	0.5	0.5	1.7	2.5	$0.35	-0.3	0.7	0.7	2.3	3.4	$0.48	-0.5	1.3	1.2	4.0	6.0	$0.84
69	-0.2	0.6	0.5	1.7	2.6	$0.36	-0.3	0.7	0.7	2.3	3.5	$0.48	-0.6	1.3	1.3	4.0	6.0	$0.85
70	-0.3	0.8	0.8	2.8	4.1	$0.57	-0.5	1.1	1.1	3.9	5.6	$0.78	-0.8	1.9	1.9	6.6	9.7	$1.35
71	-0.4	0.9	0.9	2.8	4.2	$0.59	-0.5	1.2	1.3	3.9	5.8	$0.82	-0.9	2.1	2.2	6.7	10.0	$1.41
72	-0.4	0.9	1.0	2.8	4.4	$0.62	-0.5	1.3	1.4	3.9	6.0	$0.85	-0.9	2.2	2.4	6.7	10.4	$1.47
73	-0.4	1.0	1.0	2.7	4.3	$0.61	-0.6	1.3	1.4	3.8	6.0	$0.84	-1.0	2.3	2.4	6.5	10.3	$1.45
74	-0.4	1.0	1.0	2.7	4.3	$0.60	-0.6	1.4	1.4	3.7	5.9	$0.83	-1.0	2.4	2.5	6.4	10.2	$1.43
75	-0.5	1.1	1.1	3.2	5.0	$0.70	-0.6	1.4	1.5	4.2	6.5	$0.92	-1.1	2.5	2.6	7.4	11.5	$1.62
76	-0.5	1.1	1.2	3.3	5.1	$0.72	-0.6	1.5	1.5	4.2	6.6	$0.93	-1.1	2.6	2.7	7.4	11.7	$1.64
77	-0.5	1.1	1.2	3.3	5.2	$0.73	-0.6	1.5	1.6	4.2	6.6	$0.93	-1.1	2.6	2.8	7.5	11.8	$1.67
78	-0.5	1.2	1.2	3.3	5.2	$0.73	-0.6	1.5	1.6	4.1	6.5	$0.92	-1.1	2.7	2.8	7.3	11.7	$1.65
79	-0.5	1.2	1.2	3.2	5.1	$0.72	-0.6	1.5	1.6	4.0	6.4	$0.90	-1.1	2.7	2.8	7.2	11.5	$1.62
Total	**-7.0**	**16.7**	**17.1**	**51.8**	**78.6**	**$11.05**	**-9.8**	**23.2**	**23.7**	**71.9**	**109.0**	**$15.33**	**-16.9**	**39.9**	**40.9**	**123.8**	**187.6**	**$26.38**

[684] Goede S, Rabeneck L, van Ballegooijen M et al. Harms, benefits and costs of fecal immunochemical testing versus guaiac fecal occult blood testing for colorectal cancer screening. *PLOS One.* 2017; 12(3): e0172864.

- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the CE associated with screening for colorectal cancer in adults ages 45-75 in a British Columbia birth cohort of 40,000 is $18,064 (Table 25, row *v*).

Table 25: CE of Screening and Treatment for Colorectal Cancer
Ages 45 - 75
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
	Cost of Screening Program		
a	Fixed program costs (in millions)	$11.64	Table 19
b	Physician visit costs (in millions)	$17.74	Table 19
c	Cost of FIT kit & processing (in millions)	$12.46	Table 19
d	Cost of colonoscopies (in millions)	$37.84	Table 19
e	**Subtotal Program Costs (in millions)**	**$79.69**	= a + b + c + d
f	Patient time costs for physician visits (in millions)	$36.66	Table 20
g	Patient time costs for colonoscopies (in millions)	$17.05	Table 20
h	**Subtotal Patient Time Costs (in millions)**	**$53.70**	=f+g
i	Cost of complications due to colonoscopy - Bleeding (in millions)	$0.26	Table 21
j	Cost of complications due to colonoscopy - Perforations (in millions)	$0.70	Table 21
k	**Subtotal Cost of Harms (in millions)**	**$0.96**	= i + j
l	**Total Cost of Screening Program**	**$134.35**	= e + h + k
	Treatment Costs Avoided with a Screening Program		
m	Cost of treating new CRCs avoided (in millions)	$19.43	Table 22
n	Cost of treating those living with CRC avoided (in millions)	$43.10	Table 23
o	Cost of treating those who die due to CRC avoided (in millions)	$26.38	Table 24
p	**Total Treatment Costs Avoided**	**$88.92**	= m + n + o
	CE per QALY Gained		
q	Net cost of screening and treatment (in millions)	$45.44	= l - p
r	Total QALYs gained	3,617	Table 16
s	CE ($/QALY gained)	$12,562	=(q/r)*1,000,000
t	Net cost of screening and treatment (in millions, 1.5% discount)	$47.50	Calculated
u	Total QALYs gained, 1.5% Discount	2,629	Calculated
v	**CE ($/QALY gained), 1.5% Discount**	$18,064	=(t/u)*1,000,000

v = Estimates from the literature

Sensitivity Analysis – Males and Females

We also modified several major assumptions and recalculated the CE as follows:

- Assume that the effectiveness of screening in reducing the incidence of CRC is reduced from 22% to 17%: **CE = $25,839**
- Assume that the effectiveness of screening in reducing the incidence of CRC is increased from 22% to 26%: **CE = $13,194**
- Reduced QoL impact. Use the lower limit of the disutility weights associated with the diagnosis and treatment (-0.288 to -0.193), remission (-0.049 to -0.031) and metastatic (-0.451 to -0.307) phases of living with CRC: CE = $18,727
- Increased QoL impact. Use the upper limit of the disutility weights associated with the diagnosis and treatment (-0.288 to -0.399), remission (-0.049 to -0.072) and metastatic (-0.451 to -0.600) phases of living with CRC: CE = $17,380
- Screening rate reduced from 77% to 50% (Table 16, row *t*): CE = $21,974

Summary of CE – Females Only

Based on these assumptions, the CE associated with screening for colorectal cancer in females ages 45-75 in a British Columbia birth cohort of 40,000 is $27,633 (Table 26, row *v*).

Table 26: CE of Screening and Treatment for Colorectal Cancer
Females Ages 45 - 75
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
	Cost of Screening Program		
a	Fixed program costs (in millions)	$6.07	Table 19
b	Physician visit costs (in millions)	$9.25	Table 19
c	Cost of FIT kit & processing (in millions)	$6.50	Table 19
d	Cost of colonoscopies (in millions)	$19.73	Table 19
e	**Subtotal Program Costs (in millions)**	**$41.55**	= a + b + c + d
f	Patient time costs for physician visits (in millions)	$19.12	Table 20
g	Patient time costs for colonoscopies (in millions)	$8.89	Table 20
h	**Subtotal Patient Time Costs (in millions)**	**$28.00**	=f+g
i	Cost of complications due to colonoscopy - Bleeding (in millions)	$0.14	Table 21
j	Cost of complications due to colonoscopy - Perforations (in millions)	$0.37	Table 21
k	**Subtotal Cost of Harms (in millions)**	**$0.50**	= i + j
l	**Total Cost of Screening Program**	**$70.06**	= e + h + k
	Treatment Costs Avoided with a Screening Program		
m	Cost of treating new CRCs avoided (in millions)	$8.11	Table 22
n	Cost of treating those living with CRC avoided (in millions)	$17.49	Table 23
o	Cost of treating those who die due to CRC avoided (in millions)	$11.05	Table 24
p	**Total Treatment Costs Avoided**	**$36.65**	= m + n + o
	CE per QALY Gained		
q	Net cost of screening and treatment (in millions)	$33.41	= l - p
r	Total QALYs gained	1,583	Table 17
s	CE ($/QALY gained)	$21,105	=(q/r)*1,000,000
t	Net cost of screening and treatment (in millions, 1.5% discount)	$31.56	Calculated
u	Total QALYs gained, 1.5% Discount	1,142	Calculated
v	**CE ($/QALY gained), 1.5% Discount**	$27,633	=(t/u)*1,000,000

Sensitivity Analysis – Females Only

We also modified several major assumptions and recalculated the CE for females follows:

- Assume that the effectiveness of screening in reducing the incidence of CRC is reduced from 22% to 17%: **CE = $36,657**
- Assume that the effectiveness of screening in reducing the incidence of CRC is increased from 22% to 26%: **CE = $21,994**
- Reduced QoL impact. Use the lower limit of the disutility weights associated with the diagnosis and treatment (-0.288 to -0.193), remission (-0.049 to -0.031) and metastatic (-0.451 to -0.307) phases of living with CRC: CE = $28,598
- Increased QoL impact. Use the upper limit of the disutility weights associated with the diagnosis and treatment (-0.288 to -0.399), remission (-0.049 to -0.072) and metastatic (-0.451 to -0.600) phases of living with CRC: CE = $26,636
- Screening rate reduced from 77% to 50% (Table 17, row *t*): CE = $33,178

Summary of CE – Males Only

Based on these assumptions, the CE associated with screening for colorectal cancer in males ages 45-75 in a British Columbia birth cohort of 40,000 is $10,717 (Table 27, row *v*).

Table 27: CE of Screening and Treatment for Colorectal Cancer
Males Ages 45 - 75
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
	Cost of Screening Program		
a	Fixed program costs (in millions)	$5.57	Table 19
b	Physician visit costs (in millions)	$8.49	Table 19
c	Cost of FIT kit & processing (in millions)	$5.96	Table 19
d	Cost of colonoscopies (in millions)	$18.11	Table 19
e	**Subtotal Program Costs (in millions)**	**$38.13**	= a + b + c + d
f	Patient time costs for physician visits (in millions)	$17.54	Table 20
g	Patient time costs for colonoscopies (in millions)	$8.16	Table 20
h	**Subtotal Patient Time Costs (in millions)**	**$25.70**	=f+g
i	Cost of complications due to colonoscopy - Bleeding (in millions)	$0.12	Table 21
j	Cost of complications due to colonoscopy - Perforations (in millions)	$0.34	Table 21
k	**Subtotal Cost of Harms (in millions)**	**$0.46**	= i + j
l	**Total Cost of Screening Program**	**$64.29**	= e + h + k
	Treatment Costs Avoided with a Screening Program		
m	Cost of treating new CRCs avoided (in millions)	$11.33	Table 22
n	Cost of treating those living with CRC avoided (in millions)	$25.61	Table 23
o	Cost of treating those who die due to CRC avoided (in millions)	$15.33	Table 24
p	**Total Treatment Costs Avoided**	**$52.27**	= m + n + o
	CE per QALY Gained		
q	Net cost of screening and treatment (in millions)	$12.03	= l - p
r	Total QALYs gained	2,034	Table 18
s	CE ($/QALY gained)	$5,913	=(q/r)*1,000,000
t	Net cost of screening and treatment (in millions, 1.5% discount)	$15.94	Calculated
u	Total QALYs gained, 1.5% Discount	1,487	Calculated
v	**CE ($/QALY gained), 1.5% Discount**	$10,717	=(t/u)*1,000,000

Sensitivity Analysis – Males Only

We also modified several major assumptions and recalculated the CE in males as follows:

- Assume that the effectiveness of screening in reducing the incidence of CRC is reduced from 22% to 17%: **CE = $17,553**
- Assume that the effectiveness of screening in reducing the incidence of CRC is increased from 22% to 26%: **CE = $6,427**
- Reduced QoL impact. Use the lower limit of the disutility weights associated with the diagnosis and treatment (-0.288 to -0.193), remission (-0.049 to -0.031) and metastatic (-0.451 to -0.307) phases of living with CRC: CE = $11,125
- Increased QoL impact. Use the upper limit of the disutility weights associated with the diagnosis and treatment (-0.288 to -0.399), remission (-0.049 to -0.072) and metastatic (-0.451 to -0.600) phases of living with CRC: CE = $10,297
- Screening rate reduced from 77% to 50% (Table 18, row *t*): CE = $13,417.

Summary – Males and Females

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening for colorectal cancer in adults ages 45-75 in a British Columbia birth cohort of 40,000 is estimated to be 2,629 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $18,064 per QALY (see Table 28).

Table 28: Screening and Treatment for Colorectal Cancer
Ages 45-75
in a BC Birth Cohort of 40,000
Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
	Assume No Current Service		
1.5% Discount Rate	**2,629**	1,465	2,910
3% Discount Rate	1,952	1,083	2,161
0% Discount Rate	3,617	2,022	4,003
	Assume 50% Current Service		
1.5% Discount Rate	922	514	1,020
3% Discount Rate	684	380	758
0% Discount Rate	1,268	709	1,403
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$18,064**	$13,194	$25,839
3% Discount Rate	$24,148	$18,805	$32,680
0% Discount Rate	$12,562	$8,109	$19,672
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$1,295	Cost Saving	$6,488
3% Discount Rate	$5,227	$1,709	$10,843
0% Discount Rate	Cost Saving	Cost Saving	$2,538

Summary – Females Only

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening for colorectal cancer in females ages 45-75 in a British Columbia birth cohort of 40,000 is estimated to be 1,142 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $27,633 per QALY (see Table 29).

Table 29: Screening and Treatment for Colorectal Cancer
Females Ages 45-75
in a BC Birth Cohort of 40,000
Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
	Assume No Current Service		
1.5% Discount Rate	**1,142**	634	1,265
3% Discount Rate	841	465	932
0% Discount Rate	1,583	883	1,753
	Assume 50% Current Service		
1.5% Discount Rate	400	222	444
3% Discount Rate	295	163	327
0% Discount Rate	555	310	615
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$27,633**	$21,994	$36,657
3% Discount Rate	$34,965	$28,701	$44,995
0% Discount Rate	$21,105	$16,008	$29,258
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$7,564	$3,876	$13,466
3% Discount Rate	$12,196	$8,151	$18,673
0% Discount Rate	$3,415	$34	$8,822

Summary – Males Only

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening for colorectal cancer in males ages 45-75 in a British Columbia birth cohort of 40,000 is estimated to be 1,487 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $10,717 per QALY (see Table 30).

Table 30: Screening and Treatment for Colorectal Cancer
Males Ages 45-75
in a BC Birth Cohort of 40,000
Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume No Current Service			
1.5% Discount Rate	**1,487**	830	1,645
3% Discount Rate	1,112	618	1,229
0% Discount Rate	2,034	1,140	2,250
Assume 50% Current Service			
1.5% Discount Rate	521	291	577
3% Discount Rate	390	217	431
0% Discount Rate	713	400	789
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$10,717**	$6,427	$17,553
3% Discount Rate	$15,966	$11,304	$23,392
0% Discount Rate	$5,913	$1,954	$12,226
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	Cost Saving	Cost Saving	$1,144
3% Discount Rate	Cost Saving	Cost Saving	$4,939
0% Discount Rate	Cost Saving	Cost Saving	Cost Saving

Screening for Lung Cancer

Canadian Task Force on Preventive Health Care (2016)

> *We recommend screening for lung cancer among adults 55 to 74 years of age with at least a 30 pack-year smoking history, who smoke or quit smoking less than 15 years ago, with low-dose computed tomography (CT) every year up to three consecutive years. Screening should only be done in health care settings with access to expertise in early diagnosis and treatment of lung cancer. (Weak recommendation, low-quality evidence.)*
>
> *We recommend not screening all other adults, regardless of age, smoking history or other risk factors, for lung cancer with low-dose CT. (Strong recommendation, very low quality evidence.)*
>
> *We recommend that chest radiography, with or without sputum cytology, not be used to screen for lung cancer. (Strong recommendation, low-quality evidence.)* [685]

United States Preventive Services Task Force Recommendations (2014)

> *The USPSTF recommends annual screening for lung cancer with low-dose computed tomography in adults aged 55 to 80 years who have a 30 pack-year smoking history and currently smoke or have quit within the past 15 years. Screening should be discontinued once a person has not smoked for 15 years or develops a health problem that substantially limits life expectancy or the ability or willingness to have curative lung surgery. (Grade B recommendation)* [686]

The relevant BC population includes all adults aged 55 to 74 years who have a 30 pack-year smoking history and currently smoke or have quit within the past 15 years. To estimate the relevant BC population, we used data from the 2012 Canadian Community Health Survey (CCHS) to determine the proportion of the population by age group who were current daily smokers, former daily (now occasional) smokers and former daily (now non-) smokers (variable SMKDSTY, type of smoker).[687] This information was combined with data on the number of years smoked (variable SMKDYCS), years since stopped smoking daily (variable SMK_G09C), number of cigarettes smoked/day for daily smokers (variable SMK_204) and number of cigarettes smoked/day for former daily smokers (variable SMK_208) to calculate the proportion of smokers or former smokers who meet the criteria of a 30 pack-year smoking history and currently smoke or have quit within the past 15 years.

The data suggest that approximately 90,900 individuals between the ages of 55 to 74 meet the criteria for lung cancer screening in BC, or 8.7% of this population (see Table 1).

[685] Canadian Task Force on Preventive Health Care. Recommendations on screening for lung cancer. *Canadian Medical Association Journal*. 2016: 1-8.
[686] Moyer VA. Screening for lung cancer: US Preventive Services Task Force recommendation statement. *Annals of Internal Medicine*. 2014; 160(5): 330-8.
[687] Statistics Canada. Canadian Community Health Survey (CCHS), 2012 Public Use Microdata file (Catalogue number 82M0013X2013001). 2013: All computations, use and interpretation of these data are entirely that of H. Krueger & Associates Inc.

Table 1: Proportion of Population Eligible for Lung Cancer (LC) Screening
British Columbia, 2013
by Age Group, Based on CCHS Data 2012

	Age Group (years)				
	55 to 59	60 to 64	65 to 69	70 to 74	**55 to 74**
BC Population 2013	335,332	293,907	244,139	175,627	**1,049,005**
Current Daily Smokers					
Proportion of the Population in BC who are CD Smokers	14.44%	10.04%	6.84%	5.78%	
Proportion of CD Smokers who Meet Criteria	48.64%	48.96%	54.80%	48.34%	
Number of CD Smokers Eligible for LC Screening	23,560	14,452	9,154	4,910	**52,076**
Former Daily (Now Occasional) Smokers					
Proportion of the Population in BC who are FD(NO) Smokers	0.43%	0.33%	0.38%	0.00%	
Proportion of FD(NO) Smokers who Meet Criteria	53.10%	89.86%	18.40%	0.00%	
Number of FD(NO) Smokers Eligible for LC Screening	760	859	172	0	**1,791**
Former Daily (Now Non-) Smokers					
Proportion of the Population in BC who are FD(NN) Smokers	6.44%	5.00%	6.00%	3.57%	
Proportion of FD(NN) Smokers who Meet Criteria	50.9%	67.7%	81.5%	66.0%	
Number of FD(NN) Smokers Eligible for LC Screening	11,002	9,957	11,939	4,140	**37,038**
BC Population Eligible for LC Screening, by Age Group	**35,323**	**25,268**	**21,264**	**9,050**	**90,905**
Proportion of the BC Population Eligible for LC Screening, by Age Group	**10.5%**	**8.6%**	**8.7%**	**5.2%**	**8.7%**

CD=current daily; FD(NO) = former (now occasional); FD(NN) = former daily (now non-)

Note that this estimate is lower than the Canadian average based on the Cancer Risk Management Model (CRMM). In a cost-effectiveness analysis using the CRMM, Goffin and colleagues estimated that 32% of 55-59 year-olds would be eligible for screening, decreasing to 30% for 60-64, 23% for 65-69 and 15% for 70-74.[688]

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with screening for lung cancer in adults aged 55 to 74 years who have a 30 pack-year smoking history and currently smoke or have quit within the past 15 years, in a BC birth cohort of 40,000.

In modelling CPB, we made the following assumptions:

- Based on BC life tables for 2018 to 2020, a total of 10,459 deaths would be expected between the ages of 55-79 in a BC birth cohort of 40,000 (see Table 2). Routine screening occurs to age 74, but we have assumed the protective effect of routine screening continues to age 79.
- Based on BC vital statistics data, there were 5,324 deaths between the ages of 45 and 64 in BC in 2015, with 479 (9.00%) of these deaths due to lung cancer (ICD-10 codes C34). There were also 9,636 deaths between the ages of 65 and 79 that year, with

[688] Goffin JR, Flanagan WM, Miller AB et al. Cost-effectiveness of lung cancer screening in Canada. *JAMA Oncology*. 2015; 1(6): 807-13.

1,187 (12.32%) of these deaths due to lung cancer.[689] This suggests that 1,222 of the 10,459 (11.69%) of the deaths in the BC birth cohort between the ages of 55 and 79 would be due to lung cancer (see Table 2).

Table 2: Mortality Due to Lung Cancer Between the Ages of 55 and 79
in a British Columbia Birth Cohort of 40,000

Age Group	*Life Years Lived in Birth Cohort* Males	Females	Total	*Deaths in Birth Cohort*	Deaths due to Lung Cancer %	#	*Life Years Lost* Per Death	Total
55-59	91,094	95,436	186,530	807	9.00%	73	28.4	2,060
60-64	87,997	93,628	181,625	1,185	9.00%	107	24.0	2,563
65-69	83,512	90,843	174,356	1,774	12.32%	219	19.9	4,346
70-74	76,965	86,461	163,426	2,679	12.32%	330	16.0	5,273
75-79	67,475	79,488	146,963	4,014	12.32%	495	12.4	6,127
				10,459	**11.69%**	**1,222**	**16.7**	**20,368**

- In the National Lung Cancer Screening Trial (NLST), 53,454 persons at high risk of lung cancer were randomly assigned to undergo three annual screenings (see Table 4, row *j*) with low-dose computed tomography (LDCT group) or single-view posteroanterior chest radiography (X-ray group). Mortality from lung cancer was reduced by 19.6% (RR of 0.804, 95% CI of 0.700 to 0.923) in the CT group (see Table 4, row *w*) compared to the X-ray group. Mortality from any cause was reduced by 6.1% (RR of 0.939, 95% CI of 0.884 to 0.998). Based on a nodule cut-off size of 4mm (to be identified as a positive screen), 24.2% of all screens in the CT group were positive (see Table 4, row *m*). Of these positive screens, 96.4% were false positives (see Table 4, row *o*).[690]
- Three smaller, low quality RCTs have found no significant reduction in either lung cancer or all-cause mortality associated with screening with LDCT versus usual care (RR of 1.42, 95% CI of 0.91 to 2.22).[691]
- Compared with usual care, screening with LDCT detects lung cancers at an earlier stage. With LDCT, 66% of lung cancers at detected at Stage I or II, versus 40% with usual care (see Table 3).[692,693]

[689] British Columbia Vital Statistics Agency. *Selected Vital Statistics and Health Status Indicators: One Hundred and Forty-Fourth Annual Report.* Apendix 2. 2015. British Columbia Ministry of Health. Available at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2015/pdf/annual-report-2015.pdf. Accessed March 2017.
[690] National Lung Screening Trial Research Team. Reduced lung-cancer mortality with low-dose computed tomographic screening. *New England Journal of Medicine*. 2011; 365(5): 395-409.
[691] Canadian Task Force on Preventive Health Care. *Screening for Lung Cancer: Systematic Review and Meta-analysis*. 2015. Available at http://canadiantaskforce.ca/files/lung-cancer-screening-systematic-reviewfinal-2.pdf. Accessed March 2016.
[692] Ibid.
[693] Field J, Duffy S, Baldwin D et al. UK Lung Cancer RCT Pilot Screening Trial: baseline findings from the screening arm provide evidence for the potential implementation of lung cancer screening. *Thorax*. 2016; 71: 161-70.

Table 3: Stage of Lung Cancers: Screening with LDCT vs. Usual Care

	Usual Care Group		LDCT Group	
Stage	#	%	#	%
I or II	21	40.4%	83	65.9%
III or IV	31	59.6%	43	34.1%
Total	**52**	**100.0%**	**126**	**100.0%**

Source: Canadian Task Force on Preventive Health Care. Screening for Lung Cancer: Systematic Review and Meta-analysis. 2015.

- To date, the uptake of lung cancer screening has been less than optimal, with just 6.0% of the eligible US population being screened in 2015 (see *Reference Document* for more details).[694] For modelling purposes we have assumed that screening rates of 60% (see Table 4, row *k*) would eventually be achieved, with sensitivity analysis using a range from 50-70%. The 60% is approximately half-way between current screening rates in BC for breast cancer (52%) and cervical cancer (69%) (see *Reference Document*).
- Screening with LDCT is also associated with a number of harms, including deaths following invasive follow-up testing, over diagnosis, major complications, false positive results and invasive procedures as a consequence of the false positive results.[695]
- **Death from follow-up testing** refers to "mortality that is the direct consequence of an invasive follow-up procedure (e.g., video-assisted thoracoscopic surgery, fine-needle aspiration biopsy or fine-needle aspiration cytology, thoracotomy, bronchoscopy, mediastinoscopy, surgical resection) initiated as a result of screening."[696] Based upon a review of seven studies, the CTFPHC found that 20 of 1,502 (1.33%) patients died as a result of follow-up testing after screening with LDCT (see Table 4, row *s*).
- "**Over diagnosis** refers to the detection of a lung cancer that will not otherwise cause symptoms throughout the person's lifetime or result in death."[697] Based upon a review of four studies, the CTFPHC found an over diagnosis rate of between 11.0% and 25.8%. The rate in the NLST was 11.0% (95% CI of 3.2% to 18.2%).
- **Major complications** are defined as "requiring hospitalization or medical intervention (e.g., hemothorax and pneumothorax requiring tube placement, lung collapse, severe pain, cardiac arrhythmias and thromboembolic complications) that are the direct result of an invasive procedure (e.g., video-assisted thoracoscopic surgery, fine-needle aspiration biopsy or fine-needle aspiration cytology, thoracotomy, bronchoscopy, mediastinoscopy, surgical resection)

[694] Huo J, Shen C, Volk R et al. Use of CT and chest radiography for lung cancer screening before and after publication of screening guidelines: intended and unintended uptake. *Journal of American Medical Association Internal Medicine*. 2017; 177(3): 439-41.
[695] Canadian Task Force on Preventive Health Care. *Screening for Lung Cancer: Systematic Review and Meta-analysis*. 2015. Available at http://canadiantaskforce.ca/files/lung-cancer-screening-systematic-reviewfinal-2.pdf. Accessed March 2016.
[696] Ibid.
[697] Ibid.

initiated as a result of screening."[698] Based upon a review of four studies, the CTFPHC found that 92 of 1,336 (1.33%) patients had major complications as a result of follow-up testing after screening with LDCT.

- "A **false positive** refers to a screening test result that indicates the presence of lung cancer, when in fact no lung malignancy exists."[699] Based upon a review of seven studies, the CTFPHC found that 8,290 of 42,774 (19.4%) individuals who underwent screening with LDCT received at least one false positive result.
- Minor (e.g., fine-needle aspiration biopsy or fine-needle aspiration cytology, thoracic or lymph node biopsy, bronchoscopy) and major (e.g., video-assisted thoracoscopic surgery, thoracotomy, surgical resection) **invasive procedures initiated as a result of false positive screening tests**. Based on a review of seven studies, the CTFPHC found that 0.72% (95% CI of 0.33% to 1.11%) of individuals with benign conditions underwent minor invasive procedures. Based on a further review of 17 studies, the CTFPHC found that 0.50% (95% CI of 0.37% to 0.63%) of individuals with benign conditions underwent major invasive procedures. [700]
- We have assumed a disutility of 0.05 associated with a false positive screen (see Table 4, row *q*).[701,702]
- Note that the NLTS (which the CTFPHC and our model follow) used a nodule cut-off size of 4mm (to be identified as a positive screen). Significant analysis has since been completed to assess the pros and cons of moving to a larger nodule cut-off size as well as developing more advanced algorithms to fine-tune screening frequency.
- Gierada and colleagues re-examined the NLST results based on results associated with different size nodules.[703] Moving the nodule cut-off size from 4mm to 5mm resulted in a 1.0% increase in missed or delayed lung cancer diagnosis but a 15.8% reduction in false positive results. With a cut-off of 8mm, there would have been a 10.5% increase in missed or delayed lung cancer diagnosis but a 65.8% reduction in false positive results.
- Henschke et al. tested the effect of moving the nodule cut-off size to between 6mm and 9mm on false positive results and potential delays in detecting lung cancers.[704] When alternative cut-offs of 6, 7, 8 and 9mm were used, the overall proportion of positive results declined to 10.2%, 7.1%, 5.1% and 4.8%. The use of these alternative cut-offs would have reduced the work-up load by 36%, 56%, 68% and 75% respectively. Concomitantly, a lung cancer diagnosis would have been delayed by at most 9 months in 0%, 5.0%, 5.9%, and 6.7% of cases of cancer.

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[698] Ibid.

[699] Ibid.

[700] Canadian Task Force on Preventive Health Care. *Screening for Lung Cancer: Systematic Review and Meta-analysis*. 2015. Available at http://canadiantaskforce.ca/files/lung-cancer-screening-systematic-reviewfinal-2.pdf. Accessed March 2016.

[701] Black WC, Gareen IF, Soneji SS et al. Cost-effectiveness of CT screening in the National Lung Screening Trial. *New England Journal of Medicine*. 2014; 371(19): 1793-802.

[702] Gareen IF, Duan F, Greco EM, et al. Impact of lung cancer screening results on participant health-related quality of life and state anxiety in the National Lung Screening Trial. *Cancer*. 2014; November 1: 3401-09.

[703] Gierada DS, Pinsky P, Nath H et al. Projected outcomes using different nodule sizes to define a positive CT lung cancer screening examination. *Journal of the National Cancer Institute*. 2014; 106(11): dju284.

[704] Henschke CI, Yip R, Yankelevitz DF et al. Definition of a positive test result in computed tomography screening for lung cancer: a cohort study. *Annals of Internal Medicine*. 2013; 158(4): 246-52.

- The Pan-Canadian Early Detection of Lung Cancer Study (PAN-CAN) developed a more sophisticated approach to ascertaining the probability of lung cancer in pulmonary nodules detected on first screening CT, based on a combination of nodule size, age, sex, family history of lung cancer, emphysema location, type and count of the nodule and spiculation.[705] Based on this approach, 80% of first screens placed patients in Category I (<1.5% lung cancer risk over the next 5.5 years), 12% in Category II (1.5% - <6% risk), 6% in Category 3 (6% - <30% risk) and 2% in Category IV (≥ 30% risk).[706]
- The PAN-CAN lung cancer risk model has been validated in at least two studies.[707,708] The results suggest that nodule size is still the most important predictor of lung cancer risk, with nodule spiculation, age and family history of lung cancer also being important predictive variables.
- The developers of the PAN-CAN lung cancer risk model suggest that patients in Category I require biennial screening, those in Category II require annual screening, those in Category III require rescreening in three months with annual screening thereafter if no growth in nodule size and those in Category IV should be referred for a definitive diagnosis.[709]
- A recent retrospective analysis of the NLST data suggests that annual screening might not be needed in individuals who have no abnormality identified on their initial screen and that a screening interval of at least two years could be considered on these individuals.[710,711]

Based on the above assumptions drawn from the NLST and the CTFPHC, the CPB is 2,060 quality-adjusted life years saved (see Table 4, row *z*). The CPB of 2,060 represents the gap between the existing coverage (no coverage) and 60%.

[705] McWilliams A, Tammemagi MC, Mayo JR et al. Probability of cancer in pulmonary nodules detected on first screening CT. *New England Journal of Medicine*. 2013; 369(10): 910-9.
[706] Tammemagi MC and Lam S. Screening for lung cancer using low dose computed tomography. *BMJ* 2014; 348: g2253-63.
[707] Winkler Wille MM, van Riel SJ, Saghir Z et al. Predictive Accuracy of the PanCan Lung Cancer Risk Prediction Model-External Validation based on CT from the Danish Lung Cancer Screening Trial. *European Radiology*. 2015; 25(10): 3093-9.
[708] Al-Ameri A, Malhotra P, Thygesen H et al. Risk of malignancy in pulmonary nodules: a validation study of four prediction models. *Lung Cancer*. 2015; 89(1): 27-30.
[709] Tammemagi MC and Lam S. Screening for lung cancer using low dose computed tomography. *BMJ* 2014; 348: g2253-63.
[710] Patz EF, Greco E, Gatsonis C et al. Lung cancer incidence and mortality in National Lung Screening Trial participants who underwent low-dose CT prevalence screening: a retrospective cohort analysis of a randomised, multicentre, diagnostic screening trial. *The Lancet Oncology*. 2016: Published online March 18, 2016.
[711] Field JK and Duffy SW. Lung cancer CT screening: is annual screening necessary? *The Lancet Oncology*. 2016: Published online March 18, 2016.

Table 4. Calculation of Clinically Preventable Burden (CPB) Estimate for Lung Cancer Screening in a Birth Cohort of 40,000			
Row Label	**Variable**	**Base Case**	**Data Source**
a	Age 55-59: # of individuals alive in cohort	37,306	Table 2
b	Age 55-59: % of individuals eligible for screening	10.5%	Table 1
c	Age 60-64: # of individuals alive in cohort	36,325	Table 2
d	Age 60-64: % of individuals eligible for screening	8.6%	Table 1
e	Age 65-69: # of individuals alive in cohort	34,871	Table 2
f	Age 65-69: % of individuals eligible for screening	8.7%	Table 1
g	Age 70-74: # of individuals alive in cohort	32,685	Table 2
h	Age 70-74: % of individuals eligible for screening	5.2%	Table 1
i	# of individuals eligible for screening	2,944	= ((a * b)+ (c * d) + (e * f) + (g * h))/4
j	Average # of screens per eligible individual	3	√
k	Adherence with offers to receive screening	60.0%	√
l	Total # of screens in cohort	5,298	= i * j * k
m	Proportion of screens positive	24.2%	√
n	# of positive screens	1,282	= l * m
o	Proportion of screens false positive	96.4%	√
p	# of false positive screens	1,236	= n * o
q	QALYs lost per false positive test	0.05	√
r	QALYs lost due to false positive test	62	= p * q
s	Rate of death due to follow-up testing after screening	1.33%	√
t	'Unnecessary' deaths due to follow-up testing after screening	16	= p * s
u	Lung cancer deaths ages 55-79	1,222	Table 2
v	Remaining life expectancy at death from lung cancer (in years)	16.66	Table 2
w	Effectiveness of screening in reducing LC deaths	19.6%	√
x	LC deaths avoided due to LC screening	144	= u * w * k
y	Net deaths avoided due to LC screening	127	= x - t
z	Potential QALYs saved (CPB) - Utilization increasing from 0% to 60%	2,060	= (y * v)- r

√ = Estimates from the literature

We also modified a number of major assumptions and recalculated the CPB as follows:

- Assume the estimated effectiveness of lung cancer screening in reducing deaths due to lung cancers is reduced from 19.6% to 7.7% (Table 4, row *w*): **CPB = 605**.
- Assume the estimated effectiveness of lung cancer screening in reducing deaths due to lung cancers is increased from 19.6% to 30.0% (Table 4, row *w*): **CPB = 3,331**.
- Assume the adherence rate is reduced from 60% to 50% (Table 4, row *k*): CPB = 1,716.
- Assume the adherence rate is increased from 60% to 70% (Table 4, row *k*): CPB = 2,403.

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with screening for lung cancer in adults aged 55 to 74 years who have a 30 pack-year smoking history and currently smoke or have quit within the past 15 years, in a BC birth cohort of 40,000.

In modelling CE, we made the following assumptions:

- **Assessment of patient risk** – There are an expected 37,306 individuals in a BC birth cohort of 40,000 who are expected to survive to age 55 (see Table 2). Each of the 37,306 survivors would undergo a one-time screen by their primary care practitioner to determine if they were eligible for lung cancer screening. We assumed that 85% of individuals would agree to this screening and varied this in the sensitivity analysis from 75% to 95% (see Table 6, row *c*).
- **Costs of screening** - We assumed an annual LDCT screening exam would cost $193 (2013 CAD or $222 in 2022 CAD) (see Table 6, row *i*).[712]
- **Physician visits** - LDCT screening results in an additional 14 physician visits per 100 persons screened (see Table 6, row *j*).[713]
- Positive findings on the screening CT result in the **ensuing follow-up procedures** (Table 5 rows *c* to *k*):[714]
    - Follow-up chest CT – 49.8%
    - Follow-up chest radiograph – 14.4%
    - Follow-up PET/CT scan – 8.3%
    - Percutaneous biopsy – 1.8%
    - Bronchoscopy without biopsy – 1.8%
    - Bronchoscopy with biopsy – 1.8%
    - Mediastinoscopy – 0.7%
    - Thoracoscopy – 1.3%
    - Thoracotomy – 2.9%

    By including all ensuing procedures following a positive screening CT result, we also include those procedures attributable to all identified harms, including deaths following invasive follow-up testing, over diagnosis, major complications, false positive results and invasive procedures as a consequence of the false positive results.
- The **unit cost** of the ensuing follow-up procedures is as follows (Table 5, rows *u* to *ac*):[715]
    - Follow-up chest radiograph – $65 in 2013 CAD ($75 in 2022 CAD)
    - Follow-up chest CT – $160 ($184)
    - Follow-up PET/CT scan – $1,361 ($1,563)
    - Percutaneous biopsy – CT-guided = $1,054 ($1,211), US-guided = $664 ($763)
    - Bronchoscopy without biopsy – $747 ($858)
    - Bronchoscopy with biopsy – $782 ($898)
    - Mediastinoscopy – $950 ($1,091)

[712] Cressman S, Lam S, Tammemagi MC et al. Resource Utilization and Costs during the Initial Years of Lung Cancer Screening with Computed Tomography in Canada. *Journal of Thoracic Oncology*. 2014; 9(10): 1449-58.
[713] Ibid.
[714] Goulart BH, Bensink ME, Mummy DG et al. Lung cancer screening with low-dose computed tomography: costs, national expenditures, and cost-effectiveness. *Journal of the National Comprehensive Cancer Network*. 2012; 10(2): 267-75.
[715] Cressman S, Lam S, Tammemagi MC et al. Resource Utilization and Costs during the Initial Years of Lung Cancer Screening with Computed Tomography in Canada. *Journal of Thoracic Oncology*. 2014; 9(10): 1449-58. See Supplementary Table S1 *Unit Costs*.

- Thoracoscopy – $16,361 ($18,795)
- Thoracotomy – $18,186 ($20,891)

- **Patient time and travel costs for follow-up procedures** – We assumed 2 hours of patient time for a follow-up chest radiograph or chest CT, and 7.5 hours of patient time for a PET/CT scan, percutaneous biopsy or bronchoscopy. For a mediastinoscopy or a thoracoscopy we assumed a hospital stay of 3 days plus 4 weeks recovery (see Table 5, rows *ae* to *am*).

Table 5. Calculation of Costs Associated with Follow-up Procedures

Row Label	Variable	Base Case	Data Source
a	Number of positive screens	1,282	Table 4, row n
b	Number of false positive screens	1,236	Table 4, row p
	Proportion of positive screens undergoing investigation		
c	Follow-up chest radiograph	14.4%	√
d	Follow-up chest CT	49.8%	√
e	Follow-up PET/CT scan	8.3%	√
f	Percutaneous biopsy	1.8%	√
g	Bronchoscopy without biopsy	1.8%	√
h	Bronchoscopy with biopsy	1.8%	√
i	Mediastinoscopy	0.7%	√
j	Thoracoscopy	1.3%	√
k	Thoracotomy	2.9%	√
	Number of procedures following a positive screen		
l	Follow-up chest CT	185	= a * c
m	Follow-up chest radiograph	639	= a * d
n	Follow-up PET/CT scan	106	= a * e
o	Percutaneous biopsy	22	= a * f
p	Bronchoscopy without biopsy	22	= a * g
q	Bronchoscopy with biopsy	22	= a * h
r	Mediastinoscopy	9	= a * i
s	Thoracoscopy	16	= a * j
t	Thoracotomy	36	= a * k
	Unit cost of procedures following a positive screen		
u	Follow-up chest radiograph	$75	√
v	Follow-up chest CT	$184	√
w	Follow-up PET/CT scan	$1,563	√
x	Percutaneous biopsy	$987	√
y	Bronchoscopy without biopsy	$858	√
z	Bronchoscopy with biopsy	$898	√
aa	Mediastinoscopy	$1,091	√
ab	Thoracoscopy	$18,795	√
ac	Thoracotomy	$20,891	√
ad	Follow-up costs of positive screens	**$1,419,002**	= l*u + m*v + n*w + o*x + p*y + q*z + r*aa + s*ab + t*ac
	Estimated patient time (in hours) per follow-up procedure		
ae	Follow-up chest CT	2.0	Assumed
af	Follow-up chest radiograph	2.0	Assumed
ag	Follow-up PET/CT scan	7.5	Assumed
ah	Percutaneous biopsy	7.5	Assumed
ai	Bronchoscopy without biopsy	7.5	Assumed
aj	Bronchoscopy with biopsy	7.5	Assumed
ak	Mediastinoscopy	7.5	Assumed
al	Thoracoscopy	172.5	Assumed
am	Thoracotomy	172.5	Assumed
an	Hours of patient time associated with positive screens	11,965	= l*ae + m*af + n*ag + o*ah + p*ai + q*aj + r*ak + s*al + t*am
ao	Value of patient time per hour	$37.16	√
ap	Total cost of patient time for follow-up procedures	**$444,626**	= ao * ap
aq	**Cost of follow-up procedures**	**$1,863,628**	= ad + ap

- **Costs avoided due to early detection of lung cancers** – As noted in Table 3, screening with LDCT results in the earlier detection of lung cancers, thus potentially reducing the cost of treatment. Research by Cressman et al. suggests that the mean per person cost of treating stage I & II lung cancer is $33,244 (95% CI of $31,553 - $34,935).[716] This increases to $47,796 (95% CI of $43,258 - $52,265) for stage III & IV lung cancers. These costs include the diagnostic work-up, treatment and 2 years of follow-up. Based on the stage distribution noted in Table 3, the weighted cost would be $41,919 for the usual care group and $36,205 for the CT group, resulting in costs avoided of $5,715 in 2013 CAD or $6,565 in 2022 CAD) per lung cancer associated with LDCT screening (see Table 6, row *n*).
- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the estimated cost per QALY would be $2,122 (see Table 6, row u).

Table 6. Summary of Cost Effectiveness (CE) Estimate for Lung Cancer Screening

Row Label	Variable	Base Case	Data Source
	Assessment of patient risk		
a	Proportion of cohort alive at age 55	94.3%	√
b	Total number of primary care provider screens (100% adherence)	37,737	= a * 40,000
c	Adherence with screening	85%	Assumed
d	Cost of 10-minute office visit	$35.97	Ref Doc
e	Value of patient time and travel for office visit	$74.32	Ref Doc
f	Portion of 10-minute office visit for screen	50%	Assumed
g	Cost of primary care provider screening	$1,768,865	=(b*c) * ((d+e) * f)
	Screening for Lung Cancer		
h	Potential screens with 60% adherence	5,298	=Table 4, row l
i	Cost per screen	$222	√
j	Additional physician visits per screening exam	0.14	√
k	Cost of screening	$1,258,050	=(i*h) + ((h*j) * (d+e))
l	Costs Asspociated with Follow-up Procedures	$1,863,628	=Table 5, row aq
m	Total Costs of Screening and Follow-up	$4,890,543	= g + k + l
	Costs Avoided		
n	Treatment costs avoided with earlier detection, per cancer	-$6,565	√
o	Number of incident lung cancers detected earlier	127	= Table 4, row y
p	Treatment costs avoided with earlier detection	-$835,862	= n * o
q	Net screening and patient costs (undiscounted)	$4,054,681	= m + p
r	QALYs saved (undiscounted)	2,060	Table 4, row z
s	Net screening and patient costs (1.5% discount)	$3,510,945	Calculated
t	QALYs saved (1.5% discount)	1,655	Calculated
u	**CE ($/QALY saved)**	$2,122	= s / t

√ = Estimates from the literature

[716] Cressman S, Lam S, Tammemagi MC et al. Resource Utilization and Costs during the Initial Years of Lung Cancer Screening with Computed Tomography in Canada. *Journal of Thoracic Oncology*. 2014; 9(10): 1449-58.

We also modified a number of major assumptions and recalculated the cost per QALY as follows:

- Assume the estimated effectiveness of lung cancer screening in reducing deaths due to lung cancers is reduced from 19.6% to 7.7% (Table 4, row *w*): **CE = $8,199.**
- Assume the estimated effectiveness of lung cancer screening in reducing deaths due to lung cancers is increased from 19.6% to 30.0% (Table 4, row *w*): **CE = $1,157**.
- Assume the adherence rate is reduced from 60% to 50% (Table 4, row *k*): CE = $2,306.
- Assume the adherence rate is increased from 60% to 70% (Table 4, row *k*): CE = $1,991.
- Assume the adherence rate with the assessment of patient risk is reduced from 85% to 75% (Table 6, row *c*): CE = $2,014.
- Assume the adherence rate with the assessment of patient risk is increased from 85% to 95% (Table 6, row *c*): CE = $2,230.
- Assume that the portion of a 10-minute office visit for the assessment of patient risk is reduced from 50% to 33% (Table 6, row *f*): CE = $1,809.
- Assume that the portion of a 10-minute office visit for the assessment of patient risk is increased from 50% to 67% (Table 6, row *f*): CE = $2,434.

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening for lung cancer in adults aged 55 to 74 years who have a 30 pack-year smoking history and currently smoke or have quit within the past 15 years is estimated to be 1,655 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $2,122 per QALY (see Table 7).

Table 7: Lung Cancer Screening Being Offered to a Birth Cohort of 40,000 Between the Ages of 55 and 74
Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Gap between B.C. Current (0%) and 'Best in the World' (60%)			
1.5% Discount Rate	**1,655**	486	2,676
3% Discount Rate	1,538	452	2,486
0% Discount Rate	2,060	605	3,331
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$2,122**	$1,157	$8,199
3% Discount Rate	$2,176	$1,188	$8,394
0% Discount Rate	$1,969	$1,067	$7,645
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$1,243	$613	$5,207
3% Discount Rate	$1,276	$632	$5,333
0% Discount Rate	$1,147	$559	$4,851

United States Preventive Services Task Force Recommendations (2021)

The USPSTF recommends screening for hypertension in adults 18 years or older with office blood pressure measurement (OBPM). The USPSTF recommends obtaining blood pressure measurements outside of the clinical setting for diagnostic confirmation before starting treatment. (A recommendation) [717]

Canadian Task Force on Preventive Health Care (2013)

The CTFPHC recommends blood pressure measurement at all appropriate primary care visits for adults aged 18 years and older without previously diagnosed hypertension. (Strong recommendation, moderate quality evidence)

The CTFPHC recommends that blood pressure be measured according to the current techniques described in the CHEP[718] *recommendations for office and out-of-office blood pressure measurement. (Strong recommendation, moderate quality evidence)*

The CRFPHC recommends, for people who are found to have an elevated blood pressure measurement during screening, that the CHEP criteria for assessment and diagnosis of hypertension should be applied to determine whether the patient meets diagnostic criteria for hypertension. (Strong recommendation, moderate quality evidence) [719]

Definition of Hypertension

- The USPSTF notes that the threshold to define hypertension ranges from 130/80 mm Hg or greater to 140/90 mm Hg or greater and included all thresholds in this range in their evidence review. Hypertension is diagnosed "when a person has repeatedly high blood pressure measurements over time and in various settings." [720]
- The 2018 Hypertension Canada Guidelines suggest that the manner in which blood pressure is measured is important in determining whether blood pressure is high. A mean result of ≥130/80mm Hg is required if ambulatory blood pressure monitoring over a period of 24 hours. A result of ≥135/85mm Hg is required with ambulatory blood pressure monitoring while the individual is awake, using automated equipment in an office setting or home blood pressure measurement. If non-automated equipment is used in an office setting then a result of ≥140/90mm Hg is required.[721]

Best in the World

- Canada has become a world leader in the identification and management of hypertension.[722,723] Based on data from the Canadian Primary Care Sentinel

[717] US Preventive Services Task Force. Screening for hypertension in adults: US Preventive Services Task Force Recommendation statement. *JAMA*. 2021; 325(16): 1650-6.
[718] Canadian Hypertension Education Program
[719] Lindsay P, Gorber S, Joffres M et al. Recommendations on screening for high blood pressure in Canadian adults. *Canadian Family Physician*. 2013; 59: 927-33.
[720] US Preventive Services Task Force. Screening for hypertension in adults: US Preventive Services Task Force Recommendation statement. *JAMA*. 2021; 325(16): 1650-6.
[721] Nerenberg K, Zarnke K, Leung A et al. Hypertension Canada's 2018 guidelines for diagnosis, risk assessment, prevention, and treatment of hypertension in adults and children. *Canadian Journal of Cardiology*. 2018; 34: 506-25.
[722] Schiffrin E, Campbell N, Feldman R et al. Hypertension in Canada: past, present, and future. *Annals of Global Health*. 2016; 82(2): 288-99.
[723] Padwal R and Campbell N. Blood pressure control in Canada: through the looking-glass into a glass half empty? *American Journal of Hypertension*. 2017; 30(3): 223-5.

Surveillance Network (CPCSSN) for 2011 and 2012, 79% of Canadian adults are screened for blood pressure at least once every two years by their family practitioner.[724]

- Based on data from the 2015/16 Canadian Community Health Survey, 88.1% of residents of Alberta, Nova Scotia, P.E.I. and Newfoundland & Labrador had their blood pressure checked within the last two years (see Table 1, 78.0% within the last year, data not shown).[725]

Table 1: Proportion of Canadian Adults
Who Had Their Blood Pressure Checked within the Last Two Years
By Age and Sex, 2015/16

Age	Male	Female	Total
18 - 19	64.9%	77.6%	71.5%
20 - 24	70.7%	81.4%	75.9%
25 - 29	74.4%	89.3%	81.5%
30 - 34	76.4%	87.8%	82.1%
35 - 39	81.4%	86.9%	84.1%
40 - 44	87.6%	90.8%	89.1%
45 - 49	89.1%	92.5%	90.9%
50 - 54	90.5%	92.3%	91.4%
55 - 59	90.5%	95.7%	93.0%
60 - 64	95.8%	96.0%	95.9%
65 - 69	95.8%	96.4%	96.1%
70 - 74	97.6%	96.3%	96.9%
75 - 79	98.7%	98.4%	98.6%
80+	95.0%	95.0%	95.0%
Total 18+	**85.1%**	**91.0%**	**88.1%**

- For modelling purposes, we assume that the ***best in the world*** blood pressure screening rate is 88.1%.

Current Screening Rates in BC

- As noted in footnote #9, BC-specific data on blood pressure screening rates is not included in the 2015/16 CCHS. We are not aware of any other information which indicates the proportion of individuals in BC who routinely have their blood pressure checked.

- For modelling purposes, however, we assume that the current BC blood pressure screening rate is equivalent to the Canadian average identified in Table 1, or 88.1%.

[724] Godwin M, Williamson T, Khan S et al. Prevalence and management of hypertension in primary care practices with electronic medical records: a report from the Canadian Primary Care Sentinel Surveillance Network. *Canadian Medical Association Journal Open*. 2015; 3(1): E76-E82.

[725] The 2015/16 CCHS is the most recent survey where a significant amount of the represented Canadian population (16%) were asked about their blood pressure. In the 2017/18 survey, by comparison, only 0.1% were asked the question. We took everyone who was included in the blood pressure questions (22,914) in the survey and determined the proportion having had their blood pressure checked within the last year and the last two years, broken down by age and sex. Only four provinces (Alberta, Nova Scotia, P.E.I., and Newfoundland & Labrador) were represented by the data. Residents of other provinces were not asked the question. Therefore BC-specific data is not available.

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with screening for and treatment of hypertension in adults 18 years and older in a British Columbia birth cohort of 40,000.

In estimating CPB, we made the following assumptions:

Defining and Estimating the Population at Risk

Prevalence of Hypertension in BC

- Table 2 provides information on the crude prevalence of diagnosed hypertension based on medical records[726] in BC by age and sex.[727] One-quarter (25.0%) of British Columbians ages 20 and older had diagnosed hypertension in 2017/18. As expected, the prevalence of hypertension increases dramatically with increasing age.

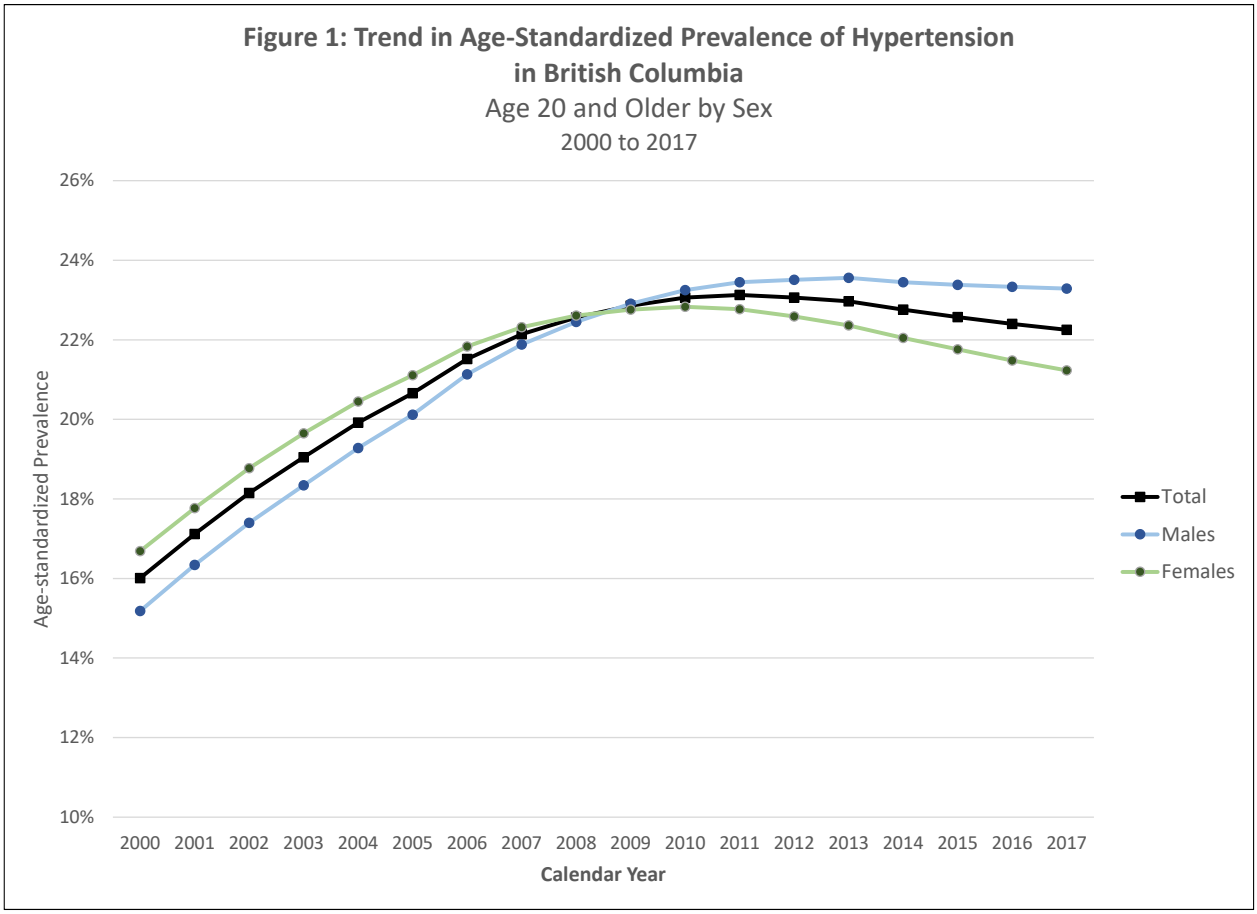
Table 2: Diagnosed Hypertension in BC Adults
Prevalence by Age and Sex, 2017/18

	Prevalence, %		
Age Group	Male	Female	Total
20-34	1.4%	1.0%	1.2%
35-49	9.9%	7.9%	8.9%
50-64	30.6%	26.9%	28.8%
65-79	58.3%	55.8%	57.2%
80+	77.5%	80.5%	79.5%
20 and Older	**25.3%**	**24.7%**	**25.0%**

Source: Canadian Chronic Disease Surveillance System

[726] Based on linked health data indicating one or more hospital separation records, or two or more physician claims within two years with ICD-10 codes I10, I11, I12, I13, I15.
[727] Public Health Agency of Canada. *Canadian Chronic Disease Surveillance System (CCDSS)*. Available at https://health-infobase.canada.ca/ccdss/data-tool/Index. Accessed January 2022.

- The age-standardized[728] prevalence of hypertension in BC has increased from 16.9% in 2000 to 23.1% in 2011 before declining to 22.3% in 2017 (see Figure 1).[729]



Changes in Prevalence, Awareness, Treatment and Control of Hypertension in Canada

- The prevalence of measured hypertension (140/90 mm Hg or greater) in Canadians ages 20-79 has remained relatively stable over time, with rates of 21.6% in 1992,[730] 19.7% in 2009[731] and 23.2% in 2015.[732] The awareness, treatment and control of hypertension, however, has improved dramatically between 1992 and 2009 and then remained stable until at least 2015 (see Table 3). In 1992, 56.9% of Canadians were aware of their hypertension with this increasing to 82.6% in 2009. In 1992, just 34.6% of Canadians with hypertension were being treated for their hypertension with this increasing to 79.1% in 2009. In 1992 just 13.2% of Canadians with hypertension had their hypertension under control, with this increasing to 64.6% in 2009.

[728] Rates are age-standardized to the 2011 Canadian population
[729] Public Health Agency of Canada. *Canadian Chronic Disease Surveillance System (CCDSS)*. Available at https://health-infobase.canada.ca/ccdss/data-tool/Index. Accessed February 2022.
[730] McAlister F, Wilkins K, Joffres M et al. Changes in rates of awareness, treatment and control of hypertension in Canada over the past two decades. *Canadian Medical Journal*. 2011; 183(9): 1007-13.
[731] McAlister F, Wilkins K, Joffres M et al. Changes in rates of awareness, treatment and control of hypertension in Canada over the past two decades. *Canadian Medical Journal*. 2011; 183(9): 1007-13.
[732] DeGuire J, Clarke J, Rouleau K et al. Blood pressure and hypertension. *Health Reports*. 2019; 30(2): 14-21.

Table 3: Hypertension in Canada
Prevalence, Awareness, Treatment and Control
1992, 2009 and 2015

	1992	2009	2015
Prevalence	21.6%	19.7%	23.2%
% Aware of Their Hypertension	56.9%	82.6%	85.4%
% Being Treated for Hypertension	34.6%	79.1%	81.4%
% with Hypertension Under Control	13.2%	64.6%	67.6%

- A key reason for these significant improvements in awareness, treatment and control of hypertension in Canada is the establishment of the Canadian Hypertension Education Program (CHEP) in 1999.[733,734] The goal of CHEP was to act "as a vehicle to more effectively develop, disseminate, and implement optimal management approaches for the treatment of patients with hypertension" in Canada.[735]
- Based on measurements made for the Canadian Health Measures Survey between 2012 and 2015, 23.2% of Canadians ages 20-79 had hypertension (blood pressure ≥ 140/90 mm Hg). Of these individuals, 85.4% were aware of their condition, 81.4% were treated for their condition and 67.6% had controlled hypertension (blood pressure < 140/90 mm Hg) (as noted in Table 3). Table 4 provides additional details on the rates of prevalence, awareness, treatment and control by sex and age group.[736]

[733] Campbell N, Tu K, Brant R et al. The impact of the Canadian Hypertension Education Program on antihypertensive prescribing trends. *Hypertension*. 2006; 47: 22-8.
[734] McAlister F, Feldman R, Wyard K et al. The impact of the Canadian Hypertension Education Program in its first decade. *European Heart Journal*. 2009; 30: 1434-9.
[735] McAlister F, Feldman R, Wyard K et al. The impact of the Canadian Hypertension Education Program in its first decade. *European Heart Journal*. 2009; 30: 1434-9.
[736] DeGuire J, Clarke J, Rouleau K et al. Blood pressure and hypertension. *Health Reports*. 2019; 30(2): 14-21.

Table 4: Hypertension Prevalence, Awareness, Treatment and Control

Canada, 2012 to 2015

By Sex and Age Group

Age Group	Average Blood Pressure	Prevalence	Awareness	Treatment	Control
		Males			
20-39	109/71	4.4%	61.8%	47.5%	44.7%
40-59	116/77	18.4%	81.0%	70.5%	55.3%
60-69	120/75	43.3%	88.1%	86.2%	76.7%
70-79	123/70	63.9%	91.7%	91.1%	75.9%
20-79	**115/74**	**23.8%**	**85.6%**	**81.0%**	**68.9%**
		Females			
20-39	103/68	3.4%	68.1%	65.2%	59.1%
40-59	112/71	14.8%	78.2%	74.8%	64.3%
60-69	120/71	42.6%	89.6%	83.8%	70.8%
70-79	128/70	61.6%	87.6%	86.4%	63.4%
20-79	**112/70**	**22.6%**	**85.3%**	**81.8%**	**66.2%**
		Total Population			
20-39	106/70	3.9%	64.6%	55.2%	51.0%
40-59	114/74	16.6%	79.8%	72.4%	59.3%
60-69	120/73	42.9%	88.8%	85.1%	73.9%
70-79	126/70	62.6%	89.4%	88.5%	68.9%
20-79	**113/72**	**23.2%**	**85.4%**	**81.4%**	**67.6%**

- Adherence to antihypertensive medications is suboptimal and may vary by ethnicity. Over a 10-year period, as few as 40% of patients continuously take their antihypertensive medication while a further 22% temporarily discontinue and then restart treatment.[737] Liu and co-authors found that optimal adherence to antihypertensive medication in British Columbia is 66.2% in the white population, 56.0% in the Chinese population and 40.3% in the South Asian population.[738] Adherence also varies by drug class, with better adherence to angiotensin II receptor blockers and angiotensin-converting enzyme inhibitors and the lowest adherence to diuretics and β-blockers. Adherence, however, is suboptimal regardless of drug class.[739] This suboptimal adherence is likely an important reason for the gap between the proportions of individuals who are aware of their hypertension (85.4%) vs. those with controlled hypertension (67.6%) in Table 4 above.

[737] Van Wijk B, Klugel O, Heerdink E et al. Rate and determinants of 10-year persistence with antihypertensive drugs. *Journal of Hypertension*. 2005; 23(11): 2101-07.

[738] Liu Q, Quan H, Chen G et al. Antihypertensive medication adherence and mortality according to ethnicity: A cohort study. *Canadian Journal of Cardiology*. 2014; 30: 925-31.

[739] Kronish I, Woodward M, Sergie Z et al. Impact of drug class on adherence to antihypertensives. *Circulation*. 2011; 123: 1611-21.

- Based on research by Leung and colleagues, 5.3% (95% CI of 4.5% to 6.2%) of Canadian adults with hypertension have treatment-resistant hypertension. Treatment-resistant hypertension is defined as "uncontrolled blood pressure despite 3 or more antihypertensive medications of different drug classes (and at least 1 agent being a diuretic), or treatment with 4 or more agents regardless of blood pressure".[740] This may be another partial explanation for the gap between the proportions of individuals with treated hypertension (81.4%) vs. controlled hypertension (67.6%) in Table 4 above.

Effectiveness of Screening

Estimated Awareness, Treatment and Control of Hypertension in BC in the Absence/Presence of Screening

- To estimate rates of awareness, treatment and control in a BC birth cohort of 40,000 **in the absence of a screening program**, we used the age and sex-specific data in Table 4 for prevalence, treatment and control, but adjusted the age and sex-specific awareness downwards to match the rates of awareness in 1992. For ages 20-79 this was 56.9% (see Table 3). Note that the overall rates of prevalence and awareness in Table 5 are somewhat higher than in Table 4 because we include individuals ages 80-84 in Table 5 with their generally higher rates of prevalence and awareness. Using this approach, there would be an estimated 589,334 life years lived with hypertension in a BC birth cohort of 40,000. Of these 589,334 life years lived with hypertension, 348,355 (59.1%) would be years in which the individual was aware of their hypertension, individuals within the cohort would be on treatment for hypertension for 333,972 (56.7%) life years and hypertension would be under control during 272,949 life years, or just under half (46.3%) of the 589,334 life years lived with hypertension (see Table 5).
- To estimate rates of awareness, treatment and control in a BC birth cohort of 40,000 **with a screening program**, we again used the age and sex-specific data in Table 4 for prevalence, treatment and control but this time used the 85.4% rate of awareness from Table 4 in those ages 20-79 (see Table 6). Using this approach, there would still be an estimated 589,334 life years lived with hypertension in a BC birth cohort of 40,000. Of these 589,334 life years lived with hypertension, however, 505,742 (85.8%) would be years in which the individual was aware of their hypertension. Using the same rates of treatment and control as in Table 5, but with a much higher base being aware of their hypertension, would mean that individuals within the cohort would be on treatment for hypertension for 484,863 (82.3%) life years and hypertension would be under control during 396,270 life years, or 67.2% of the 589,334 life years lived with hypertension (see Table 6).
- Table 7 provides a summary of the changes we would expect in a BC birth cohort of 40,000 without and with a screening program for hypertension. The key difference with the addition of a screening program is that a further 123,321 life years lived would be ones in which the individual's hypertension was under control.

[740] Leung A, Williams J, Tran K et al. Epidemiology of resistant hypertension in Canada. *Canadian Journal of Cardiology*. 2022; 38: 681-7.

Table 5: Estimated Hypertension Prevalence, Awareness, Treatment and Control

Between the Ages of 18 and 84

In a British Columbia Birth Cohort of 40,000

Without a Screening Program

	Female									*Male*									*Total Population*				
	Total Life	Prevalence		Awareness		Treatment		Control		Total Life	Prevalence		Awareness		Treatment		Control		Total Life				
Age	Years	%	#	%	#	%	#	%	#	Years	%	#	%	#	%	#	%	#	Years	Prevalence	Awareness	Treatment	Control
18	19,894	3.4%	682	46.9%	320	44.9%	306	40.7%	278	19,876	4.4%	869	42.6%	370	32.7%	284	30.8%	268	39,770	1,551	690	591	545
19	19,888	3.4%	682	46.9%	320	44.9%	306	40.7%	278	19,864	4.4%	868	42.6%	370	32.7%	284	30.8%	267	39,752	1,550	690	591	545
20	19,881	3.4%	682	46.9%	320	44.9%	306	40.7%	278	19,851	4.4%	868	42.6%	369	32.7%	284	30.8%	267	39,732	1,550	689	590	545
21	19,874	3.4%	682	46.9%	320	44.9%	306	40.7%	278	19,835	4.4%	867	42.6%	369	32.7%	284	30.8%	267	39,709	1,549	689	590	545
22	19,867	3.4%	681	46.9%	320	44.9%	306	40.7%	277	19,817	4.4%	866	42.6%	369	32.7%	283	30.8%	267	39,684	1,548	688	590	544
23	19,859	3.4%	681	46.9%	320	44.9%	306	40.7%	277	19,796	4.4%	865	42.6%	368	32.7%	283	30.8%	266	39,656	1,547	688	589	544
24	19,851	3.4%	681	46.9%	319	44.9%	306	40.7%	277	19,775	4.4%	864	42.6%	368	32.7%	283	30.8%	266	39,626	1,545	687	589	543
25	19,843	3.4%	681	46.9%	319	44.9%	306	40.7%	277	19,751	4.4%	863	42.6%	368	32.7%	283	30.8%	266	39,594	1,544	687	588	543
26	19,834	3.4%	680	46.9%	319	44.9%	306	40.7%	277	19,727	4.4%	862	42.6%	367	32.7%	282	30.8%	266	39,561	1,543	686	588	542
27	19,825	3.4%	680	46.9%	319	44.9%	305	40.7%	277	19,702	4.4%	861	42.6%	367	32.7%	282	30.8%	265	39,527	1,541	686	587	542
28	19,816	3.4%	680	46.9%	319	44.9%	305	40.7%	277	19,676	4.4%	860	42.6%	366	32.7%	281	30.8%	265	39,492	1,540	685	587	542
29	19,806	3.4%	679	46.9%	319	44.9%	305	40.7%	277	19,649	4.4%	859	42.6%	366	32.7%	281	30.8%	264	39,455	1,538	684	586	541
30	19,796	3.4%	679	46.9%	319	44.9%	305	40.7%	276	19,621	4.4%	858	42.6%	365	32.7%	281	30.8%	264	39,417	1,537	684	586	541
31	19,785	3.4%	679	46.9%	318	44.9%	305	40.7%	276	19,593	4.4%	857	42.6%	365	32.7%	280	30.8%	264	39,378	1,535	683	585	540
32	19,773	3.4%	678	46.9%	318	44.9%	305	40.7%	276	19,564	4.4%	855	42.6%	364	32.7%	280	30.8%	263	39,338	1,533	682	584	539
33	19,761	3.4%	678	46.9%	318	44.9%	304	40.7%	276	19,535	4.4%	854	42.6%	364	32.7%	279	30.8%	263	39,296	1,532	682	584	539
34	19,749	3.4%	677	46.9%	318	44.9%	304	40.7%	276	19,505	4.4%	853	42.6%	363	32.7%	279	30.8%	263	39,254	1,530	681	583	538
35	19,736	3.4%	677	46.9%	318	44.9%	304	40.7%	276	19,474	4.4%	851	42.6%	362	32.7%	279	30.8%	262	39,210	1,528	680	583	538
36	19,722	3.4%	676	46.9%	317	44.9%	304	40.7%	275	19,442	4.4%	850	42.6%	362	32.7%	278	30.8%	262	39,164	1,526	679	582	537
37	19,708	3.4%	676	46.9%	317	44.9%	304	40.7%	275	19,409	4.4%	848	42.6%	361	32.7%	278	30.8%	261	39,117	1,524	678	581	536
38	19,693	3.4%	675	46.9%	317	44.9%	303	40.7%	275	19,375	4.4%	847	42.6%	361	32.7%	277	30.8%	261	39,068	1,522	677	580	536
39	19,677	3.4%	675	46.9%	317	44.9%	303	40.7%	275	19,339	4.4%	845	42.6%	360	32.7%	277	30.8%	260	39,017	1,520	677	580	535
40	19,661	14.8%	2,911	53.9%	1,568	51.5%	1,500	44.3%	1,290	19,303	18.4%	3,557	55.8%	1,985	48.6%	1,727	38.1%	1,355	38,964	6,468	3,553	3,227	2,644
41	19,643	14.8%	2,909	53.9%	1,567	51.5%	1,499	44.3%	1,288	19,264	18.4%	3,550	55.8%	1,981	48.6%	1,724	38.1%	1,352	38,908	6,459	3,548	3,223	2,641
42	19,625	14.8%	2,906	53.9%	1,565	51.5%	1,497	44.3%	1,287	19,225	18.4%	3,542	55.8%	1,977	48.6%	1,720	38.1%	1,349	38,849	6,448	3,542	3,218	2,637
43	19,605	14.8%	2,903	53.9%	1,564	51.5%	1,496	44.3%	1,286	19,183	18.4%	3,535	55.8%	1,972	48.6%	1,717	38.1%	1,347	38,788	6,438	3,536	3,213	2,632
44	19,584	14.8%	2,900	53.9%	1,562	51.5%	1,494	44.3%	1,285	19,140	18.4%	3,527	55.8%	1,968	48.6%	1,713	38.1%	1,343	38,724	6,427	3,530	3,207	2,628
45	19,561	14.8%	2,897	53.9%	1,560	51.5%	1,493	44.3%	1,283	19,094	18.4%	3,518	55.8%	1,963	48.6%	1,709	38.1%	1,340	38,656	6,415	3,524	3,201	2,623
46	19,537	14.8%	2,893	53.9%	1,558	51.5%	1,491	44.3%	1,281	19,047	18.4%	3,510	55.8%	1,958	48.6%	1,704	38.1%	1,337	38,584	6,403	3,517	3,195	2,618
47	19,511	14.8%	2,889	53.9%	1,556	51.5%	1,489	44.3%	1,280	18,996	18.4%	3,500	55.8%	1,953	48.6%	1,700	38.1%	1,333	38,508	6,390	3,509	3,189	2,613
48	19,484	14.8%	2,885	53.9%	1,554	51.5%	1,487	44.3%	1,278	18,943	18.4%	3,491	55.8%	1,948	48.6%	1,695	38.1%	1,330	38,427	6,376	3,502	3,182	2,608
49	19,454	14.8%	2,881	53.9%	1,552	51.5%	1,484	44.3%	1,276	18,887	18.4%	3,480	55.8%	1,942	48.6%	1,690	38.1%	1,326	38,341	6,361	3,494	3,174	2,602
50	19,422	14.8%	2,876	53.9%	1,549	51.5%	1,482	44.3%	1,274	18,827	18.4%	3,469	55.8%	1,936	48.6%	1,685	38.1%	1,322	38,249	6,345	3,485	3,167	2,595
51	19,388	14.8%	2,871	53.9%	1,547	51.5%	1,479	44.3%	1,272	18,763	18.4%	3,457	55.8%	1,929	48.6%	1,679	38.1%	1,317	38,151	6,328	3,476	3,158	2,589
52	19,352	14.8%	2,866	53.9%	1,544	51.5%	1,477	44.3%	1,269	18,695	18.4%	3,445	55.8%	1,922	48.6%	1,673	38.1%	1,312	38,046	6,310	3,466	3,149	2,582
53	19,312	14.8%	2,860	53.9%	1,541	51.5%	1,474	44.3%	1,267	18,622	18.4%	3,431	55.8%	1,915	48.6%	1,666	38.1%	1,307	37,934	6,291	3,455	3,140	2,574
54	19,270	14.8%	2,853	53.9%	1,537	51.5%	1,470	44.3%	1,264	18,545	18.4%	3,417	55.8%	1,907	48.6%	1,659	38.1%	1,302	37,814	6,271	3,444	3,130	2,566
55	19,224	14.8%	2,847	53.9%	1,533	51.5%	1,467	44.3%	1,261	18,461	18.4%	3,402	55.8%	1,898	48.6%	1,652	38.1%	1,296	37,685	6,248	3,432	3,119	2,557
56	19,174	14.8%	2,839	53.9%	1,530	51.5%	1,463	44.3%	1,258	18,372	18.4%	3,385	55.8%	1,889	48.6%	1,644	38.1%	1,290	37,547	6,225	3,418	3,107	2,547
57	19,121	14.8%	2,831	53.9%	1,525	51.5%	1,459	44.3%	1,254	18,277	18.4%	3,368	55.8%	1,879	48.6%	1,636	38.1%	1,283	37,398	6,199	3,404	3,094	2,537
58	19,063	14.8%	2,823	53.9%	1,521	51.5%	1,455	44.3%	1,250	18,175	18.4%	3,349	55.8%	1,869	48.6%	1,626	38.1%	1,276	37,238	6,172	3,389	3,081	2,526
59	19,000	14.8%	2,814	53.9%	1,516	51.5%	1,450	44.3%	1,246	18,065	18.4%	3,329	55.8%	1,857	48.6%	1,617	38.1%	1,268	37,065	6,142	3,373	3,066	2,514
60	18,932	42.6%	8,064	61.7%	4,977	57.7%	4,655	48.8%	3,933	17,947	43.3%	7,765	60.7%	4,712	59.4%	4,611	52.8%	4,103	36,879	15,829	9,689	9,266	8,035
61	18,858	42.6%	8,032	61.7%	4,958	57.7%	4,637	48.8%	3,917	17,820	43.3%	7,710	60.7%	4,679	59.4%	4,578	52.8%	4,074	36,678	15,742	9,637	9,215	7,991
62	18,777	42.6%	7,998	61.7%	4,937	57.7%	4,617	48.8%	3,901	17,684	43.3%	7,651	60.7%	4,643	59.4%	4,543	52.8%	4,042	36,461	15,649	9,580	9,160	7,943
63	18,689	42.6%	7,960	61.7%	4,913	57.7%	4,595	48.8%	3,882	17,537	43.3%	7,587	60.7%	4,605	59.4%	4,505	52.8%	4,009	36,226	15,548	9,518	9,101	7,891
64	18,593	42.6%	7,920	61.7%	4,888	57.7%	4,572	48.8%	3,863	17,379	43.3%	7,519	60.7%	4,563	59.4%	4,465	52.8%	3,973	35,972	15,438	9,451	9,036	7,835
65	18,489	42.6%	7,875	61.7%	4,861	57.7%	4,546	48.8%	3,841	17,208	43.3%	7,445	60.7%	4,518	59.4%	4,421	52.8%	3,934	35,697	15,320	9,379	8,967	7,774
66	18,375	42.6%	7,826	61.7%	4,831	57.7%	4,518	48.8%	3,817	17,024	43.3%	7,365	60.7%	4,470	59.4%	4,374	52.8%	3,892	35,399	15,192	9,301	8,891	7,709
67	18,250	42.6%	7,773	61.7%	4,798	57.7%	4,487	48.8%	3,791	16,826	43.3%	7,280	60.7%	4,418	59.4%	4,323	52.8%	3,846	35,075	15,053	9,216	8,810	7,637
68	18,113	42.6%	7,715	61.7%	4,762	57.7%	4,454	48.8%	3,763	16,612	43.3%	7,187	60.7%	4,362	59.4%	4,268	52.8%	3,797	34,725	14,902	9,124	8,721	7,560
69	17,963	42.6%	7,651	61.7%	4,722	57.7%	4,417	48.8%	3,732	16,381	43.3%	7,087	60.7%	4,301	59.4%	4,208	52.8%	3,744	34,344	14,738	9,023	8,625	7,476
70	17,799	61.6%	10,968	60.3%	6,619	59.5%	6,528	43.7%	4,790	16,132	63.9%	10,312	63.1%	6,512	62.7%	6,469	52.3%	5,390	33,930	21,281	13,130	12,997	10,180
71	17,619	61.6%	10,857	60.3%	6,552	59.5%	6,462	43.7%	4,742	15,863	63.9%	10,140	63.1%	6,403	62.7%	6,361	52.3%	5,300	33,481	20,998	12,955	12,823	10,042
72	17,421	61.6%	10,736	60.3%	6,478	59.5%	6,390	43.7%	4,689	15,573	63.9%	9,955	63.1%	6,286	62.7%	6,245	52.3%	5,203	32,994	20,691	12,764	12,635	9,892
73	17,204	61.6%	10,602	60.3%	6,398	59.5%	6,310	43.7%	4,630	15,260	63.9%	9,755	63.1%	6,160	62.7%	6,119	52.3%	5,098	32,464	20,357	12,557	12,429	9,729
74	16,966	61.6%	10,455	60.3%	6,309	59.5%	6,223	43.7%	4,566	14,923	63.9%	9,540	63.1%	6,024	62.7%	5,984	52.3%	4,986	31,889	19,995	12,333	12,207	9,552
75	16,704	61.6%	10,294	60.3%	6,212	59.5%	6,127	43.7%	4,496	14,560	63.9%	9,308	63.1%	5,877	62.7%	5,839	52.3%	4,865	31,265	19,602	12,089	11,966	9,360
76	16,417	61.6%	10,117	60.3%	6,105	59.5%	6,021	43.7%	4,418	14,170	63.9%	9,058	63.1%	5,720	62.7%	5,682	52.3%	4,734	30,587	19,175	11,825	11,704	9,153
77	16,102	61.6%	9,923	60.3%	5,988	59.5%	5,906	43.7%	4,334	13,751	63.9%	8,790	63.1%	5,551	62.7%	5,514	52.3%	4,594	29,853	18,713	11,538	11,420	8,928
78	15,757	61.6%	9,710	60.3%	5,859	59.5%	5,779	43.7%	4,241	13,301	63.9%	8,503	63.1%	5,369	62.7%	5,334	52.3%	4,444	29,058	18,213	11,228	11,113	8,685
79	15,378	61.6%	9,476	60.3%	5,719	59.5%	5,640	43.7%	4,139	12,820	63.9%	8,195	63.1%	5,175	62.7%	5,141	52.3%	4,283	28,198	17,672	10,893	10,781	8,422
80	14,963	61.6%	9,221	60.3%	5,564	59.5%	5,488	43.7%	4,027	12,306	63.9%	7,867	63.1%	4,967	62.7%	4,935	52.3%	4,112	27,269	17,088	10,532	10,423	8,139
81	14,510	61.6%	8,942	60.3%	5,396	59.5%	5,322	43.7%	3,905	11,759	63.9%	7,517	63.1%	4,747	62.7%	4,716	52.3%	3,929	26,269	16,459	10,143	10,038	7,834
82	14,016	61.6%	8,637	60.3%	5,212	59.5%	5,141	43.7%	3,772	11,179	63.9%	7,146	63.1%	4,512	62.7%	4,483	52.3%	3,735	25,195	15,783	9,725	9,624	7,507
83	13,478	61.6%	8,306	60.3%	5,012	59.5%	4,943	43.7%	3,627	10,565	63.9%	6,754	63.1%	4,265	62.7%	4,237	52.3%	3,530	24,043	15,060	9,277	9,180	7,157
84	12,895	61.6%	7,946	60.3%	4,795	59.5%	4,729	43.7%	3,470	9,919	63.9%	6,341	63.1%	4,004	62.7%	3,978	52.3%	3,314	22,814	14,287	8,799	8,707	6,785
Total	***1,245,898***	***23.9%***	***297,402***	***58.8%***	***174,823***	***56.8%***	***168,822***	***45.0%***	***133,818***	***1,182,557***	***24.7%***	***291,932***	***59.4%***	***173,532***	***56.6%***	***165,151***	***47.7%***	***139,131***	***2,428,455***	***589,334***	***348,355***	***333,972***	***272,949***

Table 6: Estimated Hypertension Prevalence, Awareness, Treatment and Control

Between the Ages of 18 and 84

In a British Columbia Birth Cohort of 40,000

With a Screening Program

	Female									*Male*									*Total Population*				
	Total Life	Prevalence		Awareness		Treatment		Control		Total Life	Prevalence		Awareness		Treatment		Control		Total Life				
Age	Years	%	#	%	#	%	#	%	#	Years	%	#	%	#	%	#	%	#	Years	Prevalence	Awareness	Treatment	Control
18	19,894	3.4%	682	68.1%	465	65.2%	445	59.1%	403	19,876	4.4%	869	61.8%	537	47.5%	413	44.7%	388	39,770	1,551	1,002	858	792
19	19,888	3.4%	682	68.1%	465	65.2%	445	59.1%	403	19,864	4.4%	868	61.8%	537	47.5%	412	44.7%	388	39,752	1,550	1,001	857	791
20	19,881	3.4%	682	68.1%	464	65.2%	445	59.1%	403	19,851	4.4%	868	61.8%	536	47.5%	412	44.7%	388	39,732	1,550	1,001	857	791
21	19,874	3.4%	682	68.1%	464	65.2%	444	59.1%	403	19,835	4.4%	867	61.8%	536	47.5%	412	44.7%	388	39,709	1,549	1,000	856	790
22	19,867	3.4%	681	68.1%	464	65.2%	444	59.1%	403	19,817	4.4%	866	61.8%	535	47.5%	411	44.7%	387	39,684	1,548	999	856	790
23	19,859	3.4%	681	68.1%	464	65.2%	444	59.1%	403	19,796	4.4%	865	61.8%	535	47.5%	411	44.7%	387	39,656	1,547	999	855	789
24	19,851	3.4%	681	68.1%	464	65.2%	444	59.1%	402	19,775	4.4%	864	61.8%	534	47.5%	411	44.7%	386	39,626	1,545	998	855	789
25	19,843	3.4%	681	68.1%	463	65.2%	444	59.1%	402	19,751	4.4%	863	61.8%	534	47.5%	410	44.7%	386	39,594	1,544	997	854	788
26	19,834	3.4%	680	68.1%	463	65.2%	444	59.1%	402	19,727	4.4%	862	61.8%	533	47.5%	410	44.7%	385	39,561	1,543	996	853	788
27	19,825	3.4%	680	68.1%	463	65.2%	443	59.1%	402	19,702	4.4%	861	61.8%	532	47.5%	409	44.7%	385	39,527	1,541	995	852	787
28	19,816	3.4%	680	68.1%	463	65.2%	443	59.1%	402	19,676	4.4%	860	61.8%	532	47.5%	409	44.7%	384	39,492	1,540	994	852	786
29	19,806	3.4%	679	68.1%	463	65.2%	443	59.1%	401	19,649	4.4%	859	61.8%	531	47.5%	408	44.7%	384	39,455	1,538	993	851	785
30	19,796	3.4%	679	68.1%	462	65.2%	443	59.1%	401	19,621	4.4%	858	61.8%	530	47.5%	407	44.7%	383	39,417	1,537	992	850	785
31	19,785	3.4%	679	68.1%	462	65.2%	442	59.1%	401	19,593	4.4%	857	61.8%	529	47.5%	407	44.7%	383	39,378	1,535	991	849	784
32	19,773	3.4%	678	68.1%	462	65.2%	442	59.1%	401	19,564	4.4%	855	61.8%	529	47.5%	406	44.7%	382	39,338	1,533	990	848	783
33	19,761	3.4%	678	68.1%	462	65.2%	442	59.1%	401	19,535	4.4%	854	61.8%	528	47.5%	406	44.7%	382	39,296	1,532	989	848	782
34	19,749	3.4%	677	68.1%	461	65.2%	442	59.1%	400	19,505	4.4%	853	61.8%	527	47.5%	405	44.7%	381	39,254	1,530	988	847	781
35	19,736	3.4%	677	68.1%	461	65.2%	441	59.1%	400	19,474	4.4%	851	61.8%	526	47.5%	404	44.7%	381	39,210	1,528	987	846	781
36	19,722	3.4%	676	68.1%	461	65.2%	441	59.1%	400	19,442	4.4%	850	61.8%	525	47.5%	404	44.7%	380	39,164	1,526	986	845	780
37	19,708	3.4%	676	68.1%	460	65.2%	441	59.1%	399	19,409	4.4%	848	61.8%	524	47.5%	403	44.7%	379	39,117	1,524	985	844	779
38	19,693	3.4%	675	68.1%	460	65.2%	440	59.1%	399	19,375	4.4%	847	61.8%	523	47.5%	402	44.7%	379	39,068	1,522	983	843	778
39	19,677	3.4%	675	68.1%	460	65.2%	440	59.1%	399	19,339	4.4%	845	61.8%	522	47.5%	402	44.7%	378	39,017	1,520	982	842	777
40	19,661	14.8%	2,911	78.2%	2,277	74.8%	2,178	64.3%	1,872	19,303	18.4%	3,557	81.0%	2,881	70.5%	2,508	55.3%	1,967	38,964	6,468	5,158	4,685	3,839
41	19,643	14.8%	2,909	78.2%	2,275	74.8%	2,176	64.3%	1,870	19,264	18.4%	3,550	81.0%	2,875	70.5%	2,503	55.3%	1,963	38,908	6,459	5,150	4,678	3,833
42	19,625	14.8%	2,906	78.2%	2,273	74.8%	2,174	64.3%	1,869	19,225	18.4%	3,542	81.0%	2,869	70.5%	2,497	55.3%	1,959	38,849	6,448	5,142	4,671	3,828
43	19,605	14.8%	2,903	78.2%	2,270	74.8%	2,172	64.3%	1,867	19,183	18.4%	3,535	81.0%	2,863	70.5%	2,492	55.3%	1,955	38,788	6,438	5,133	4,664	3,821
44	19,584	14.8%	2,900	78.2%	2,268	74.8%	2,169	64.3%	1,865	19,140	18.4%	3,527	81.0%	2,857	70.5%	2,486	55.3%	1,950	38,724	6,427	5,124	4,656	3,815
45	19,561	14.8%	2,897	78.2%	2,265	74.8%	2,167	64.3%	1,863	19,094	18.4%	3,518	81.0%	2,850	70.5%	2,480	55.3%	1,946	38,656	6,415	5,115	4,647	3,808
46	19,537	14.8%	2,893	78.2%	2,262	74.8%	2,164	64.3%	1,860	19,047	18.4%	3,510	81.0%	2,843	70.5%	2,474	55.3%	1,941	38,584	6,403	5,105	4,638	3,801
47	19,511	14.8%	2,889	78.2%	2,259	74.8%	2,161	64.3%	1,858	18,996	18.4%	3,500	81.0%	2,835	70.5%	2,468	55.3%	1,936	38,508	6,390	5,095	4,629	3,793
48	19,484	14.8%	2,885	78.2%	2,256	74.8%	2,158	64.3%	1,855	18,943	18.4%	3,491	81.0%	2,827	70.5%	2,461	55.3%	1,930	38,427	6,376	5,083	4,619	3,785
49	19,454	14.8%	2,881	78.2%	2,253	74.8%	2,155	64.3%	1,852	18,887	18.4%	3,480	81.0%	2,819	70.5%	2,453	55.3%	1,925	38,341	6,361	5,072	4,608	3,777
50	19,422	14.8%	2,876	78.2%	2,249	74.8%	2,151	64.3%	1,849	18,827	18.4%	3,469	81.0%	2,810	70.5%	2,446	55.3%	1,918	38,249	6,345	5,059	4,597	3,768
51	19,388	14.8%	2,871	78.2%	2,245	74.8%	2,148	64.3%	1,846	18,763	18.4%	3,457	81.0%	2,800	70.5%	2,437	55.3%	1,912	38,151	6,328	5,046	4,585	3,758
52	19,352	14.8%	2,866	78.2%	2,241	74.8%	2,143	64.3%	1,843	18,695	18.4%	3,445	81.0%	2,790	70.5%	2,429	55.3%	1,905	38,046	6,310	5,031	4,572	3,748
53	19,312	14.8%	2,860	78.2%	2,236	74.8%	2,139	64.3%	1,839	18,622	18.4%	3,431	81.0%	2,779	70.5%	2,419	55.3%	1,898	37,934	6,291	5,016	4,558	3,736
54	19,270	14.8%	2,853	78.2%	2,231	74.8%	2,134	64.3%	1,835	18,545	18.4%	3,417	81.0%	2,768	70.5%	2,409	55.3%	1,890	37,814	6,271	4,999	4,543	3,724
55	19,224	14.8%	2,847	78.2%	2,226	74.8%	2,129	64.3%	1,830	18,461	18.4%	3,402	81.0%	2,755	70.5%	2,398	55.3%	1,881	37,685	6,248	4,982	4,528	3,712
56	19,174	14.8%	2,839	78.2%	2,220	74.8%	2,124	64.3%	1,826	18,372	18.4%	3,385	81.0%	2,742	70.5%	2,387	55.3%	1,872	37,547	6,225	4,963	4,511	3,698
57	19,121	14.8%	2,831	78.2%	2,214	74.8%	2,118	64.3%	1,821	18,277	18.4%	3,368	81.0%	2,728	70.5%	2,374	55.3%	1,862	37,398	6,199	4,942	4,492	3,683
58	19,063	14.8%	2,823	78.2%	2,207	74.8%	2,111	64.3%	1,815	18,175	18.4%	3,349	81.0%	2,713	70.5%	2,361	55.3%	1,852	37,238	6,172	4,920	4,473	3,667
59	19,000	14.8%	2,814	78.2%	2,200	74.8%	2,105	64.3%	1,809	18,065	18.4%	3,329	81.0%	2,696	70.5%	2,347	55.3%	1,841	37,065	6,142	4,896	4,451	3,650
60	18,932	42.6%	8,064	89.6%	7,225	83.8%	6,758	70.8%	5,709	17,947	43.3%	7,765	88.1%	6,841	86.2%	6,693	76.7%	5,956	36,879	15,829	14,066	13,451	11,665
61	18,858	42.6%	8,032	89.6%	7,197	83.8%	6,731	70.8%	5,687	17,820	43.3%	7,710	88.1%	6,792	86.2%	6,646	76.7%	5,913	36,678	15,742	13,989	13,377	11,600
62	18,777	42.6%	7,998	89.6%	7,166	83.8%	6,702	70.8%	5,663	17,684	43.3%	7,651	88.1%	6,740	86.2%	6,595	76.7%	5,868	36,461	15,649	13,907	13,297	11,531
63	18,689	42.6%	7,960	89.6%	7,133	83.8%	6,671	70.8%	5,636	17,537	43.3%	7,587	88.1%	6,684	86.2%	6,540	76.7%	5,819	36,226	15,548	13,817	13,211	11,455
64	18,593	42.6%	7,920	89.6%	7,096	83.8%	6,637	70.8%	5,607	17,379	43.3%	7,519	88.1%	6,624	86.2%	6,481	76.7%	5,767	35,972	15,438	13,720	13,118	11,374
65	18,489	42.6%	7,875	89.6%	7,056	83.8%	6,599	70.8%	5,576	17,208	43.3%	7,445	88.1%	6,559	86.2%	6,418	76.7%	5,710	35,697	15,320	13,615	13,017	11,286
66	18,375	42.6%	7,826	89.6%	7,013	83.8%	6,559	70.8%	5,541	17,024	43.3%	7,365	88.1%	6,489	86.2%	6,349	76.7%	5,649	35,399	15,192	13,501	12,908	11,190
67	18,250	42.6%	7,773	89.6%	6,965	83.8%	6,514	70.8%	5,503	16,826	43.3%	7,280	88.1%	6,413	86.2%	6,275	76.7%	5,583	35,075	15,053	13,378	12,789	11,087
68	18,113	42.6%	7,715	89.6%	6,913	83.8%	6,465	70.8%	5,462	16,612	43.3%	7,187	88.1%	6,332	86.2%	6,195	76.7%	5,512	34,725	14,902	13,244	12,660	10,975
69	17,963	42.6%	7,651	89.6%	6,855	83.8%	6,412	70.8%	5,417	16,381	43.3%	7,087	88.1%	6,244	86.2%	6,109	76.7%	5,436	34,344	14,738	13,099	12,521	10,853
70	17,799	61.6%	10,968	87.6%	9,608	86.4%	9,477	63.4%	6,954	16,132	63.9%	10,312	91.7%	9,456	91.1%	9,394	75.9%	7,827	33,930	21,281	19,065	18,871	14,781
71	17,619	61.6%	10,857	87.6%	9,511	86.4%	9,381	63.4%	6,884	15,863	63.9%	10,140	91.7%	9,299	91.1%	9,238	75.9%	7,697	33,481	20,998	18,810	18,619	14,580
72	17,421	61.6%	10,736	87.6%	9,404	86.4%	9,276	63.4%	6,806	15,573	63.9%	9,955	91.7%	9,129	91.1%	9,069	75.9%	7,556	32,994	20,691	18,533	18,345	14,362
73	17,204	61.6%	10,602	87.6%	9,287	86.4%	9,160	63.4%	6,722	15,260	63.9%	9,755	91.7%	8,945	91.1%	8,887	75.9%	7,404	32,464	20,357	18,233	18,047	14,126
74	16,966	61.6%	10,455	87.6%	9,159	86.4%	9,033	63.4%	6,629	14,923	63.9%	9,540	91.7%	8,748	91.1%	8,691	75.9%	7,241	31,889	19,995	17,907	17,724	13,869
75	16,704	61.6%	10,294	87.6%	9,018	86.4%	8,894	63.4%	6,526	14,560	63.9%	9,308	91.7%	8,535	91.1%	8,479	75.9%	7,065	31,265	19,602	17,553	17,373	13,591
76	16,417	61.6%	10,117	87.6%	8,863	86.4%	8,741	63.4%	6,414	14,170	63.9%	9,058	91.7%	8,306	91.1%	8,252	75.9%	6,875	30,587	19,175	17,169	16,993	13,289
77	16,102	61.6%	9,923	87.6%	8,692	86.4%	8,573	63.4%	6,291	13,751	63.9%	8,790	91.7%	8,061	91.1%	8,008	75.9%	6,672	29,853	18,713	16,753	16,581	12,963
78	15,757	61.6%	9,710	87.6%	8,506	86.4%	8,389	63.4%	6,156	13,301	63.9%	8,503	91.7%	7,797	91.1%	7,746	75.9%	6,454	29,058	18,213	16,303	16,136	12,610
79	15,378	61.6%	9,476	87.6%	8,301	86.4%	8,188	63.4%	6,008	12,820	63.9%	8,195	91.7%	7,515	91.1%	7,466	75.9%	6,220	28,198	17,672	15,816	15,654	12,228
80	14,963	61.6%	9,221	87.6%	8,078	86.4%	7,967	63.4%	5,846	12,306	63.9%	7,867	91.7%	7,214	91.1%	7,167	75.9%	5,971	27,269	17,088	15,291	15,134	11,817
81	14,510	61.6%	8,942	87.6%	7,833	86.4%	7,726	63.4%	5,669	11,759	63.9%	7,517	91.7%	6,893	91.1%	6,848	75.9%	5,706	26,269	16,459	14,726	14,574	11,375
82	14,016	61.6%	8,637	87.6%	7,566	86.4%	7,463	63.4%	5,476	11,179	63.9%	7,146	91.7%	6,553	91.1%	6,510	75.9%	5,424	25,195	15,783	14,119	13,973	10,900
83	13,478	61.6%	8,306	87.6%	7,276	86.4%	7,176	63.4%	5,266	10,565	63.9%	6,754	91.7%	6,193	91.1%	6,153	75.9%	5,126	24,043	15,060	13,469	13,329	10,392
84	12,895	61.6%	7,946	87.6%	6,961	86.4%	6,866	63.4%	5,038	9,919	63.9%	6,341	91.7%	5,815	91.1%	5,777	75.9%	4,813	22,814	14,287	12,776	12,642	9,851
Total	***1,245,898***	***23.9%***	***297,402***	***85.3%***	***253,786***	***82.4%***	***245,074***	***65.3%***	***194,260***	***1,182,557***	***24.7%***	***291,932***	***86.3%***	***251,956***	***82.1%***	***239,789***	***69.2%***	***202,010***	***2,428,455***	***589,334***	***505,742***	***484,863***	***396,270***

Table 7: Life Years Lived with, Aware of, Treatment for and Control of Hypertension

In a BC Cohort of 40,000

Before and After the Implementation of Screening

Screening	Hypertension	Awareness	Treatment	Control
		Females		
Before	297,402	174,823	168,822	133,818
After	297,402	253,786	245,074	194,260
Difference	**0**	**78,963**	**76,252**	**60,442**
		Males		
Before	291,932	173,532	165,151	139,131
After	291,932	251,956	239,789	202,010
Difference	**0**	**78,424**	**74,639**	**62,879**
		Total Population		
Before	589,334	348,355	333,972	272,949
After	589,334	505,742	484,863	396,270
Difference	**0**	**157,387**	**150,891**	**123,321**

Effectiveness of the Intervention

- To this point we have estimated that the implementation of a program achieving screening rates of 88.1% in a BC birth cohort of 40,000 would result in an additional 123,321 life years lived with hypertension under control. We now want to determine what beneficial effect this will have with respect to morbidity and mortality in the birth cohort.

Lifestyle Interventions

- Proposed lifestyle interventions for hypertension include diet, exercise, relaxation, restriction of alcohol and/or sodium intake, and supplementation with calcium, magnesium, potassium or fish oil, or some combination of the above. It is difficult, however, to ascertain which specific factors have clinically important influences on blood pressure, as lifestyle factors are often inter-related. Furthermore, patients may not follow advice or regimens designed to change lifestyles.[741]
- The review by Dickinson et al indicated that a combination of lifestyle interventions results in a net reduction in systolic blood pressure of 5.5 mmHg and in diastolic blood pressure of 4.5 mmHg over a period of 6 months but the net reduction declined when assessed at 12 months.[742] By comparison, antihypertensive medications result in a mean reduction in systolic blood pressure of 15.0 mmHg and in diastolic blood pressure of 7.6 mmHg, as indicated in Table 8 below.[743,744]

[741] Dickenson H, Mason J, Nicolson D et al. Lifestyle interventions to reduce raised blood pressure: A systematic review of randomized controlled trials. *Journal of Hypertension*. 2006; 24: 215-33.
[742] Dickenson H, Mason J, Nicolson D et al. Lifestyle interventions to reduce raised blood pressure: A systematic review of randomized controlled trials. *Journal of Hypertension*. 2006; 24: 215-33.
[743] Musini V, Gueyffier F, Puil L et al. Pharmacotherapy for hypertension in adults aged 18 to 59 years. *Cochrane Database of Systematic Reviews*. 2017; 8.
[744] Musini V, Tejani A, Bassett K et al. Pharmacotherapy for hypertension in adults 60 years or older. *Cochrane Database of Systematic Reviews*. 2020; 6.

- The 2021 Cochrane Review assessing the long-term effects of weight-reducing diets in people with hypertension concluded that "in people with primary hypertension, weight-loss diets reduced body weight and blood pressure, but the magnitude of the effects are uncertain due to the small number of participants and studies included in the analyses. Whether weight loss reduces mortality and morbidity is unknown."[745]

Antihypertensive Drugs

- Two Cochrane Systematic Reviews have assessed the effectiveness of antihypertensive drugs used to treat primarily healthy adults with mild to moderate hypertension, based on randomized controlled clinical trials.[746,747] The reviews divided key outcomes into **cerebrovascular mortality and morbidity** (includes fatal and non-fatal stroke), **coronary heart disease mortality and morbidity** (includes fatal and non-fatal myocardial infarcts and sudden or rapid cardiac death), **total cardiovascular mortality and morbidity** (includes cerebrovascular and coronary heart disease as well as congestive heart failure and other significant vascular deaths such as ruptured aneurysm) and all-cause mortality.
- Table 8 provides a summary of the results from the two Cochrane Systematic Reviews. The primary effectiveness of antihypertensive drugs is in the **prevention of cerebrovascular mortality and morbidity**, in individuals ages 18-59 (RR 0.46 with a 95% CI of 0.34 to 0.64), ages 60-79 (RR 0.66 with a 95% CI of 0.58 to 0.76) and age 80 and older (RR 0.66 with a 95% CI of 0.52 to 0.83). The effectiveness of antihypertensive drugs in the **prevention of coronary heart disease mortality and morbidity** is less clear, with significant improvements in those ages 60-79 (RR 0.79 with a 95% CI of 0.69 to 0.90) **but not in those ages 18-59** (RR 0.99 with a 95% CI of 0.82 to 1.19) **or 80 years of age and older** (RR 0.82 with a 95% CI of 0.56 to 1.20).

[745] Semlitsch T, Krenn C, Jeitler K et al. Long-term effects of weight-reducing diets in people with hypertension. *Cochrane Database of Systematic Reviews*. 2021; 2.
[746] Musini V, Gueyffier F, Puil L et al. Pharmacotherapy for hypertension in adults aged 18 to 59 years. *Cochrane Database of Systematic Reviews*. 2017; 8.
[747] Musini V, Tejani A, Bassett K et al. Pharmacotherapy for hypertension in adults 60 years or older. *Cochrane Database of Systematic Reviews*. 2020; 6.

Table 8: Effectiveness of Antihypertensive Drug Treatment Versus Placebo or No Treatment
In Adults by Age Group

Outcomes	Number of Cardiovascular Events: Control	Antihypertensive Drug Therapy	RR (95% Confidence Interval)
Adults Ages 18 - 59			
Decrease in Diastolic Blood Pressure (DBP)		7.62 (4.69 to 10.55)	
Decrease in Systolic Blood Pressure (SBP)		14.98 (9.52 to 20.44)	
Cerebrovascular Mortality + Morbidity	13 per 1000*	6 per 1000 (5 to 9)	RR 0.46 (0.34 to 0.64)
Coronary Heart Disease Mortality + Morbidity	26 per 1000	26 per 1000 (21 to 31)	RR 0.99 (0.82 to 1.19)
Total Cardiovascular Mortality + Morbidity	41 per 1000	32 per 1000 (27 to 37)	RR 0.78 (0.67 to 0.91)
All-cause Mortality	24 per 1000	23 per 1000 (19 to 28)	RR 0.94 (0.77 to 1.13)
Adults Ages 60 and Older			
Cerebrovascular Mortality + Morbidity	52 per 1000*	34 per 1000 (31 to 39)	RR 0.66 (0.59 to 0.74)
Coronary Heart Disease Mortality + Morbidity	48 per 1000	37 per 1000 (33 to 42)	RR 0.78 (0.69 to 0.88)
Total Cardiovascular Mortality + Morbidity	136 per 1000	98 per 1000 (92 to 104)	RR 0.72 (0.68 to 0.77)
All-cause Mortality	110 per 1000	100 per 1000 (93 to 106)	RR 0.91 (0.85 to 0.97)
Adults Ages 60 - 79			
Cerebrovascular Mortality + Morbidity			RR 0.66 (0.58 to 0.76)
Coronary Heart Disease Mortality + Morbidity			RR 0.79 (0.69 to 0.90)
Total Cardiovascular Mortality + Morbidity			RR 0.71 (0.65 to 0.77)
All-cause Mortality			RR 0.86 (0.79 to 0.95)
Adults Ages 80 and Older			
Cerebrovascular Mortality + Morbidity			RR 0.66 (0.52 to 0.83)
Coronary Heart Disease Mortality + Morbidity			RR 0.82 (0.56 to 1.20)
Total Cardiovascular Mortality + Morbidity			RR 0.75 (0.65 to 0.87)
All-cause Mortality			RR 0.97 (0.87 to 1.10)

*Note: * The rate / 1000 is based on 5 years of follow-up for those ages 18-59 and 3.8 years for those ages 60 and older.*

- Table 9 provides an overview of fatal and non-fatal cardiovascular events in a UK population of 24,014 without diabetes or a history of vascular disease followed for a period of 10 years.[748] In this study, cardiovascular events include ischaemic heart disease (ICD codes I20 – I25), cardiac failure (ICD codes I11, I13, I50), cerebrovascular disease (ICD codes I60 – I69), peripheral artery disease (ICD codes I70 - I79) and aortic aneurysm (ICD code I71). Data on the ratio of non-fatal to fatal cardiovascular disease by age and sex is used in the next phase of our modelling.

[748] Jorstad H, Colkesen E, Boekholdt S et al. Estimated 10-year cardiovascular mortality seriously underestimates overall cardiovascular risk. *Heart*. 2016; 102: 63-8.

Table 9: Cumulative 10-Year Fatal and Non-Fatal Cardiovascular Disease
By Age and Sex

Age Group	Study Population	Fatal CVD	Non-Fatal CVD	Total CVD	% of Total CVD	Ratio of Non-Fatal to Fatal	% of Study Pop. with CVD
			Males				
39-49	2,219	15	166	181	7.1%	11.1	8.16%
50-54	1,780	26	234	260	10.2%	9.0	14.61%
55-59	1,637	34	286	320	12.6%	8.4	19.55%
60-64	1,633	67	395	462	18.2%	5.9	28.29%
65-69	1,622	127	438	565	22.2%	3.4	34.83%
70-74	1,290	209	377	586	23.1%	1.8	45.43%
75-79	328	65	102	167	6.6%	1.6	50.91%
Subtotal	**10,509**	**543**	**1,998**	**2,541**	**100%**	**3.7**	**24.18%**
			Females				
39-49	3,061	5	168	173	7.1%	33.6	5.65%
50-54	2,333	11	214	225	9.2%	19.5	9.64%
55-59	2,129	17	282	299	12.3%	16.6	14.04%
60-64	2,014	43	352	395	16.2%	8.2	19.61%
65-69	1,995	86	470	556	22.8%	5.5	27.87%
70-74	1,607	145	479	624	25.6%	3.3	38.83%
75-79	366	50	115	165	6.8%	2.3	45.08%
Subtotal	**13,505**	**357**	**2,080**	**2,437**	**100%**	**5.8**	**18.05%**
			Total Population				
39-49	5,280	20	334	354	7.1%	16.7	6.70%
50-54	4,113	37	448	485	9.7%	12.1	11.79%
55-59	3,766	51	568	619	12.4%	11.1	16.44%
60-64	3,647	110	747	857	17.2%	6.8	23.50%
65-69	3,617	213	908	1,121	22.5%	4.3	30.99%
70-74	2,897	354	856	1,210	24.3%	2.4	41.77%
75-79	694	115	217	332	6.7%	1.9	47.84%
Total	**24,014**	**900**	**4,078**	**4,978**	**100%**	**4.5**	**20.73%**

- The incidence of stroke in 2015 in a US population is 26 (95% CI 19 to 32) / 100,000 in women ages 20-44 years of age, increasing to 142 (95% CI 125 – 158) in women ages 45 to 64 years of age. In men, the equivalent rates are 31 (95% CI 24 to 38) and 201 (95% CI 181 – 222).[749] The difference in the incidence of stroke in 20-44 and 45-64 year-old females and males is used in the next phase of our modelling.
- Table 10 is based on rates of cerebrovascular morbidity and mortality in the age 18-59 and 60+ **control group** and coronary heart disease morbidity and mortality in the age 60+ **control group** from Table 8. Table 11 is based on the same data but for **those on antihypertensive drug therapy** from Table 8. The ratio of non-fatal to fatal events by age and sex is based on the data in Table 9.
- Without any treatment for hypertension in a BC birth cohort of 40,000, we would expect 5,476 fatal and 19,630 non-fatal cardiovascular events (Table 10). With 100% antihypertensive drug therapy, we would expect 3,826 fatal and 12,971 non-fatal cardiovascular events (Table 11).

[749] Madsen T, Khoury J, Leppert M et al. Temporal trends in stroke incidence over time by sex and age in the GCNKSS. *Stroke*. 2020; 51: 1070-76.

Table 10: Cardiovascular Mortality and Morbidity

Between the Ages of 18 and 84

In a British Columbia Birth Cohort of 40,000

Without Treatment for Hypertension

	Females					*Males*					*Total*				
	# in	# of	**CVD Events**			# in	# of	**CVD Events**			# in	# of	**CVD Events**		
Age	Cohort	Deaths	Total	Fatal	Non-Fatal	Cohort	Deaths	Total	Fatal	Non-Fatal	Cohort	Deaths	Total	Fatal	Non-Fatal
18	19,894					19,876					39,770				
19	19,888	6	19.5	0.6	18.9	19,864	11	16.9	1.4	15.5	39,752	18	36.4	2.0	34.4
20	19,881	7	19.5	0.6	18.9	19,851	14	16.9	1.4	15.5	39,732	20	36.4	2.0	34.4
21	19,874	7	19.5	0.6	18.9	19,835	16	16.9	1.4	15.5	39,709	23	36.3	2.0	34.4
22	19,867	7	19.5	0.6	18.9	19,817	18	16.8	1.4	15.4	39,684	25	36.3	2.0	34.3
23	19,859	8	19.5	0.6	18.9	19,796	20	16.8	1.4	15.4	39,656	28	36.3	2.0	34.3
24	19,851	8	19.4	0.6	18.9	19,775	22	16.8	1.4	15.4	39,626	30	36.3	2.0	34.3
25	19,843	8	19.4	0.6	18.9	19,751	23	16.8	1.4	15.4	39,594	32	36.2	2.0	34.3
26	19,834	9	19.4	0.6	18.9	19,727	24	16.8	1.4	15.4	39,561	33	36.2	2.0	34.2
27	19,825	9	19.4	0.6	18.9	19,702	25	16.8	1.4	15.4	39,527	34	36.2	2.0	34.2
28	19,816	9	19.4	0.6	18.9	19,676	26	16.7	1.4	15.3	39,492	35	36.1	2.0	34.2
29	19,806	10	19.4	0.6	18.8	19,649	27	16.7	1.4	15.3	39,455	37	36.1	2.0	34.2
30	19,796	10	19.4	0.6	18.8	19,621	28	16.7	1.4	15.3	39,417	38	36.1	2.0	34.1
31	19,785	11	19.4	0.6	18.8	19,593	28	16.7	1.4	15.3	39,378	39	36.0	2.0	34.1
32	19,773	11	19.4	0.6	18.8	19,564	29	16.6	1.4	15.2	39,338	40	36.0	2.0	34.1
33	19,761	12	19.4	0.6	18.8	19,535	29	16.6	1.4	15.2	39,296	41	36.0	2.0	34.0
34	19,749	13	19.3	0.6	18.8	19,505	30	16.6	1.4	15.2	39,254	43	35.9	1.9	34.0
35	19,736	13	19.3	0.6	18.8	19,474	31	16.6	1.4	15.2	39,210	44	35.9	1.9	33.9
36	19,722	14	19.3	0.6	18.8	19,442	32	16.5	1.4	15.1	39,164	46	35.9	1.9	33.9
37	19,708	14	19.3	0.6	18.7	19,409	33	16.5	1.4	15.1	39,117	47	35.8	1.9	33.9
38	19,693	15	19.3	0.6	18.7	19,375	34	16.5	1.4	15.1	39,068	49	35.8	1.9	33.8
39	19,677	16	19.3	0.6	18.7	19,339	35	16.4	1.4	15.1	39,017	51	35.7	1.9	33.8
40	19,661	16	19.3	0.6	18.7	19,303	37	16.4	1.4	15.0	38,964	53	35.7	1.9	33.7
41	19,643	18	19.2	0.6	18.7	19,264	38	16.4	1.4	15.0	38,908	56	35.6	1.9	33.7
42	19,625	19	19.2	0.6	18.7	19,225	40	16.3	1.4	15.0	38,849	58	35.6	1.9	33.6
43	19,605	20	19.2	0.6	18.7	19,183	41	16.3	1.4	14.9	38,788	61	35.5	1.9	33.6
44	19,584	21	19.2	0.6	18.6	19,140	43	16.3	1.4	14.9	38,724	64	35.5	1.9	33.5
45	19,561	23	107	3.1	104	19,094	46	110	9	101	38,656	68	217	12	205
46	19,537	24	107	3.1	104	19,047	48	110	9	101	38,584	72	217	12	205
47	19,511	26	107	3.1	104	18,996	50	110	9	101	38,508	76	217	12	204
48	19,484	28	107	3.1	104	18,943	53	109	9	100	38,427	81	216	12	204
49	19,454	30	106	3.1	103	18,887	56	109	9	100	38,341	86	216	12	203
50	19,422	32	106	5.2	101	18,827	60	109	11	98	38,249	92	215	16	199
51	19,388	34	106	5.2	101	18,763	64	108	11	98	38,151	98	215	16	198
52	19,352	37	106	5.2	101	18,695	68	108	11	97	38,046	105	214	16	198
53	19,312	39	106	5.2	101	18,622	73	108	11	97	37,934	112	213	16	197
54	19,270	43	105	5.2	100	18,545	78	107	11	96	37,814	120	213	16	197
55	19,224	46	105	6.0	99	18,461	83	107	11	95	37,685	129	212	17	194
56	19,174	49	105	6.0	99	18,372	89	106	11	95	37,547	138	211	17	194
57	19,121	53	105	6.0	99	18,277	95	106	11	94	37,398	149	210	17	193
58	19,063	58	104	5.9	98	18,175	102	105	11	94	37,238	160	209	17	192
59	19,000	63	104	5.9	98	18,065	110	104	11	93	37,065	173	208	17	191
60	18,932	68	498	54	444	17,947	118	472	70	402	36,879	186	971	124	846
61	18,858	74	496	54	442	17,820	127	469	69	400	36,678	201	965	123	842
62	18,777	81	494	54	440	17,684	136	465	69	397	36,461	217	960	123	837
63	18,689	88	492	54	438	17,537	147	461	68	393	36,226	235	953	122	832
64	18,593	96	489	53	436	17,379	158	457	68	390	35,972	254	947	121	826
65	18,489	105	487	75	411	17,208	171	453	104	349	35,697	275	939	179	760
66	18,375	114	484	75	409	17,024	184	448	103	345	35,399	298	932	177	754
67	18,250	125	480	74	406	16,826	198	443	102	341	35,075	323	923	176	747
68	18,113	137	477	73	403	16,612	214	437	100	337	34,725	351	914	174	740
69	17,963	150	473	73	400	16,381	231	431	99	332	34,344	381	904	172	732
70	17,799	164	468	108	360	16,132	249	425	154	270	33,930	413	893	262	631
71	17,619	180	464	107	357	15,863	269	417	151	266	33,481	449	881	258	623
72	17,421	198	458	106	353	15,573	290	410	149	261	32,994	488	868	254	614
73	17,204	217	453	104	349	15,260	313	402	145	256	32,464	530	854	250	605
74	16,966	238	446	102	344	14,923	337	393	142	251	31,889	575	839	245	595
75	16,704	261	440	131	308	14,560	363	383	151	232	31,265	624	823	282	540
76	16,417	287	432	129	303	14,170	390	373	147	226	30,587	677	805	275	530
77	16,102	315	424	126	298	13,751	419	362	142	220	29,853	734	786	268	518
78	15,757	346	415	123	292	13,301	450	350	137	213	29,058	795	765	260	505
79	15,378	379	405	120	285	12,820	481	337	132	206	28,198	860	742	251	491
80	14,963	415	394	116	278	12,306	514	324	126	198	27,269	928	718	242	476
81	14,510	453	382	112	270	11,759	547	309	120	190	26,269	1,000	691	232	460
82	14,016	494	369	108	261	11,179	580	294	113	181	25,195	1,075	663	221	442
83	13,478	538	355	103	252	10,565	614	278	106	172	24,043	1,151	633	210	423
84	12,895	583	339	98	241	9,919	646	261	99	162	22,814	1,229	600	197	403
Total		**6,999**	**13,202**	**2,418**	**10,784**		**9,956**	**11,904**	**3,058**	**8,846**		**16,956**	**26,042**	**5,476**	**19,630**

Table 11: Cardiovascular Mortality and Morbidity

Between the Ages of 18 and 84

In a British Columbia Birth Cohort of 40,000

With Treatment for Hypertension

	Females				*Males*				*Total*			
	# in	CVD Events			# in	CVD Events			# in	CVD Events		
Age	Cohort	Total	Fatal	Non-Fatal	Cohort	Total	Fatal	Non-Fatal	Cohort	Total	Fatal	Non-Fatal
18	19,894				19,876				39,770			
19	19,888	9.0	0.3	8.7	19,864	7.8	0.6	7.1	39,752	16.8	0.9	15.9
20	19,881	9.0	0.3	8.7	19,851	7.8	0.6	7.1	39,732	16.8	0.9	15.9
21	19,874	9.0	0.3	8.7	19,835	7.8	0.6	7.1	39,709	16.8	0.9	15.9
22	19,867	9.0	0.3	8.7	19,817	7.8	0.6	7.1	39,684	16.8	0.9	15.9
23	19,859	9.0	0.3	8.7	19,796	7.8	0.6	7.1	39,656	16.7	0.9	15.8
24	19,851	9.0	0.3	8.7	19,775	7.8	0.6	7.1	39,626	16.7	0.9	15.8
25	19,843	9.0	0.3	8.7	19,751	7.8	0.6	7.1	39,594	16.7	0.9	15.8
26	19,834	9.0	0.3	8.7	19,727	7.7	0.6	7.1	39,561	16.7	0.9	15.8
27	19,825	9.0	0.3	8.7	19,702	7.7	0.6	7.1	39,527	16.7	0.9	15.8
28	19,816	9.0	0.3	8.7	19,676	7.7	0.6	7.1	39,492	16.7	0.9	15.8
29	19,806	9.0	0.3	8.7	19,649	7.7	0.6	7.1	39,455	16.7	0.9	15.8
30	19,796	9.0	0.3	8.7	19,621	7.7	0.6	7.1	39,417	16.7	0.9	15.8
31	19,785	8.9	0.3	8.7	19,593	7.7	0.6	7.1	39,378	16.6	0.9	15.7
32	19,773	8.9	0.3	8.7	19,564	7.7	0.6	7.0	39,338	16.6	0.9	15.7
33	19,761	8.9	0.3	8.7	19,535	7.7	0.6	7.0	39,296	16.6	0.9	15.7
34	19,749	8.9	0.3	8.7	19,505	7.7	0.6	7.0	39,254	16.6	0.9	15.7
35	19,736	8.9	0.3	8.7	19,474	7.6	0.6	7.0	39,210	16.6	0.9	15.7
36	19,722	8.9	0.3	8.7	19,442	7.6	0.6	7.0	39,164	16.5	0.9	15.7
37	19,708	8.9	0.3	8.7	19,409	7.6	0.6	7.0	39,117	16.5	0.9	15.6
38	19,693	8.9	0.3	8.6	19,375	7.6	0.6	7.0	39,068	16.5	0.9	15.6
39	19,677	8.9	0.3	8.6	19,339	7.6	0.6	7.0	39,017	16.5	0.9	15.6
40	19,661	8.9	0.3	8.6	19,303	7.6	0.6	6.9	38,964	16.5	0.9	15.6
41	19,643	8.9	0.3	8.6	19,264	7.6	0.6	6.9	38,908	16.4	0.9	15.6
42	19,625	8.9	0.3	8.6	19,225	7.5	0.6	6.9	38,849	16.4	0.9	15.5
43	19,605	8.9	0.3	8.6	19,183	7.5	0.6	6.9	38,788	16.4	0.9	15.5
44	19,584	8.9	0.3	8.6	19,140	7.5	0.6	6.9	38,724	16.4	0.9	15.5
45	19,561	49	1.4	48	19,094	51	4.2	47	38,656	100	5.6	95
46	19,537	49	1.4	48	19,047	51	4.2	47	38,584	100	5.6	95
47	19,511	49	1.4	48	18,996	51	4.2	46	38,508	100	5.6	94
48	19,484	49	1.4	48	18,943	51	4.2	46	38,427	100	5.6	94
49	19,454	49	1.4	48	18,887	50	4.2	46	38,341	100	5.6	94
50	19,422	49	2.4	47	18,827	50	5.0	45	38,249	99	7.4	92
51	19,388	49	2.4	47	18,763	50	5.0	45	38,151	99	7.4	92
52	19,352	49	2.4	46	18,695	50	5.0	45	38,046	99	7.4	91
53	19,312	49	2.4	46	18,622	50	5.0	45	37,934	98	7.4	91
54	19,270	49	2.4	46	18,545	49	4.9	45	37,814	98	7.3	91
55	19,224	49	2.8	46	18,461	49	5.2	44	37,685	98	8.0	90
56	19,174	48	2.8	46	18,372	49	5.2	44	37,547	97	8.0	89
57	19,121	48	2.7	46	18,277	49	5.2	44	37,398	97	7.9	89
58	19,063	48	2.7	45	18,175	48	5.2	43	37,238	97	7.9	89
59	19,000	48	2.7	45	18,065	48	5.1	43	37,065	96	7.8	88
60	18,932	354	39	315	17,947	335	49	287	36,879	689	87	602
61	18,858	352	38	314	17,820	333	48	285	36,678	685	87	599
62	18,777	351	38	313	17,684	330	48	282	36,461	681	86	595
63	18,689	349	38	311	17,537	328	48	280	36,226	677	86	591
64	18,593	347	38	310	17,379	325	47	278	35,972	672	85	587
65	18,489	345	53	292	17,208	322	72	249	35,697	667	126	541
66	18,375	343	53	290	17,024	318	72	247	35,399	661	125	537
67	18,250	341	53	288	16,826	314	71	244	35,075	655	123	532
68	18,113	338	52	286	16,612	310	70	241	34,725	649	122	527
69	17,963	336	52	284	16,381	306	69	237	34,344	642	121	521
70	17,799	333	77	255	16,132	301	108	194	33,930	634	185	449
71	17,619	329	77	253	15,863	296	106	191	33,481	626	182	443
72	17,421	325	76	250	15,573	291	104	187	32,994	616	179	437
73	17,204	321	75	247	15,260	285	102	183	32,464	607	176	430
74	16,966	317	74	243	14,923	279	99	179	31,889	596	173	423
75	16,704	312	95	218	14,560	272	106	166	31,265	584	201	384
76	16,417	307	93	214	14,170	265	103	162	30,587	571	196	375
77	16,102	301	91	210	13,751	257	100	157	29,853	558	191	367
78	15,757	294	89	205	13,301	249	97	152	29,058	543	186	357
79	15,378	287	87	200	12,820	240	93	146	28,198	527	180	347
80	14,963	280	85	195	12,306	230	90	140	27,269	510	174	335
81	14,510	271	82	189	11,759	220	86	134	26,269	491	168	323
82	14,016	262	79	183	11,179	209	81	128	25,195	471	161	310
83	13,478	252	76	176	10,565	197	77	121	24,043	449	153	296
84	12,895	241	73	168	9,919	185	72	113	22,814	426	145	281
Total		**8,854**	**1,723**	**7,132**		**6,997**	**2,103**	**5,840**		**16,797**	**3,826**	**12,971**

- Tables 10 and 11 suggest the possibility of a reduction of 1,650 fatal (5,476 from Table 10 minus 3,826 from Table 11) and 6,659 non-fatal (19,630 from Table 10 minus 12,971 from Table 11) cardiovascular events in a BC birth cohort between the ages of 18 and 84 **if all individuals with hypertension were on antihypertensive drug therapy**.
- What we are trying to determine, however, is the benefits of screening adults aged 18 years and older without previously diagnosed hypertension. As noted in Table 3, an estimated 56.9% of individuals with hypertension are aware of their hypertension even in the absence of a comprehensive screening program. This proportion is estimated to increase to 85.4% with a comprehensive screening program (Table 3). This improved awareness associated with a comprehensive screening program is expected to increase controlled hypertension in the BC birth cohort from 46.3% (Table 5) to 67.2% (Table 6).
- In Tables 10 and 11 we assessed the benefits of going from 0% to 100% adherence to antihypertensive medication. **In Tables 12 and 13 we assess the benefits of controlled hypertension improving, on average, from 46.3% to 67.3% in the cohort**. For females, this improved control of hypertension is expected to result in a reduction of 890 cardiovascular events (141 fatal and 748 non-fatal) (Table 12). For males, this improved control of hypertension is expected to result in a reduction of 862 cardiovascular events (219 fatal and 643 non-fatal) (Table 13).

Table 12: Cardiovascular Events Avoided

Females Between the Ages of 18 and 84

In a British Columbia Birth Cohort of 40,000

With a Screening Program

		Hypertension						Cardiovascular Events Avoided					
				Control (No Screening)		Control (With Screening)					Moving from % Control without Screening to % Control with Screening		
Age	Total Life Years	Prevalence %	Prevalence #	%	#	%	#	100% Control Fatal	100% Control Non-Fatal	100% Control Total	Fatal	Non-Fatal	Total
18	19,894	3.4%	682	40.7%	278	59.1%	403						
19	19,888	3.4%	682	40.7%	278	59.1%	403	0.3	10.2	10.5	0.1	1.9	1.9
20	19,881	3.4%	682	40.7%	278	59.1%	403	0.3	10.2	10.5	0.1	1.9	1.9
21	19,874	3.4%	682	40.7%	278	59.1%	403	0.3	10.2	10.5	0.1	1.9	1.9
22	19,867	3.4%	681	40.7%	277	59.1%	403	0.3	10.2	10.5	0.1	1.9	1.9
23	19,859	3.4%	681	40.7%	277	59.1%	403	0.3	10.2	10.5	0.1	1.9	1.9
24	19,851	3.4%	681	40.7%	277	59.1%	402	0.3	10.2	10.5	0.1	1.9	1.9
25	19,843	3.4%	681	40.7%	277	59.1%	402	0.3	10.2	10.5	0.1	1.9	1.9
26	19,834	3.4%	680	40.7%	277	59.1%	402	0.3	10.2	10.5	0.1	1.9	1.9
27	19,825	3.4%	680	40.7%	277	59.1%	402	0.3	10.2	10.5	0.1	1.9	1.9
28	19,816	3.4%	680	40.7%	277	59.1%	402	0.3	10.2	10.5	0.1	1.9	1.9
29	19,806	3.4%	679	40.7%	277	59.1%	401	0.3	10.1	10.4	0.1	1.9	1.9
30	19,796	3.4%	679	40.7%	276	59.1%	401	0.3	10.1	10.4	0.1	1.9	1.9
31	19,785	3.4%	679	40.7%	276	59.1%	401	0.3	10.1	10.4	0.1	1.9	1.9
32	19,773	3.4%	678	40.7%	276	59.1%	401	0.3	10.1	10.4	0.1	1.9	1.9
33	19,761	3.4%	678	40.7%	276	59.1%	401	0.3	10.1	10.4	0.1	1.9	1.9
34	19,749	3.4%	677	40.7%	276	59.1%	400	0.3	10.1	10.4	0.1	1.9	1.9
35	19,736	3.4%	677	40.7%	276	59.1%	400	0.3	10.1	10.4	0.1	1.9	1.9
36	19,722	3.4%	676	40.7%	275	59.1%	400	0.3	10.1	10.4	0.1	1.9	1.9
37	19,708	3.4%	676	40.7%	275	59.1%	399	0.3	10.1	10.4	0.1	1.9	1.9
38	19,693	3.4%	675	40.7%	275	59.1%	399	0.3	10.1	10.4	0.1	1.9	1.9
39	19,677	3.4%	675	40.7%	275	59.1%	399	0.3	10.1	10.4	0.1	1.9	1.9
40	19,661	14.8%	2,911	44.3%	1,290	64.3%	1,872	0.3	10.1	10.4	0.1	2.0	2.1
41	19,643	14.8%	2,909	44.3%	1,288	64.3%	1,870	0.3	10.1	10.4	0.1	2.0	2.1
42	19,625	14.8%	2,906	44.3%	1,287	64.3%	1,869	0.3	10.1	10.4	0.1	2.0	2.1
43	19,605	14.8%	2,903	44.3%	1,286	64.3%	1,867	0.3	10.0	10.3	0.1	2.0	2.1
44	19,584	14.8%	2,900	44.3%	1,285	64.3%	1,865	0.3	10.0	10.3	0.1	2.0	2.1
45	19,561	14.8%	2,897	44.3%	1,283	64.3%	1,863	2	56	58	0.3	11	12
46	19,537	14.8%	2,893	44.3%	1,281	64.3%	1,860	2	56	58	0.3	11	12
47	19,511	14.8%	2,889	44.3%	1,280	64.3%	1,858	2	56	57	0.3	11	12
48	19,484	14.8%	2,885	44.3%	1,278	64.3%	1,855	2	56	57	0.3	11	11
49	19,454	14.8%	2,881	44.3%	1,276	64.3%	1,852	2	56	57	0.3	11	11
50	19,422	14.8%	2,876	44.3%	1,274	64.3%	1,849	3	54	57	0.6	11	11
51	19,388	14.8%	2,871	44.3%	1,272	64.3%	1,846	3	54	57	0.6	11	11
52	19,352	14.8%	2,866	44.3%	1,269	64.3%	1,843	3	54	57	0.6	11	11
53	19,312	14.8%	2,860	44.3%	1,267	64.3%	1,839	3	54	57	0.6	11	11
54	19,270	14.8%	2,853	44.3%	1,264	64.3%	1,835	3	54	57	0.6	11	11
55	19,224	14.8%	2,847	44.3%	1,261	64.3%	1,830	3	53	57	0.6	11	11
56	19,174	14.8%	2,839	44.3%	1,258	64.3%	1,826	3	53	56	0.6	11	11
57	19,121	14.8%	2,831	44.3%	1,254	64.3%	1,821	3	53	56	0.6	11	11
58	19,063	14.8%	2,823	44.3%	1,250	64.3%	1,815	3	53	56	0.6	11	11
59	19,000	14.8%	2,814	44.3%	1,246	64.3%	1,809	3	53	56	0.6	11	11
60	18,932	42.6%	8,064	48.8%	3,933	70.8%	5,709	16	129	144	3	28	32
61	18,858	42.6%	8,032	48.8%	3,917	70.8%	5,687	16	128	144	3	28	32
62	18,777	42.6%	7,998	48.8%	3,901	70.8%	5,663	16	128	143	3	28	32
63	18,689	42.6%	7,960	48.8%	3,882	70.8%	5,636	15	127	143	3	28	31
64	18,593	42.6%	7,920	48.8%	3,863	70.8%	5,607	15	127	142	3	28	31
65	18,489	42.6%	7,875	48.8%	3,841	70.8%	5,576	22	119	141	5	26	31
66	18,375	42.6%	7,826	48.8%	3,817	70.8%	5,541	22	119	140	5	26	31
67	18,250	42.6%	7,773	48.8%	3,791	70.8%	5,503	21	118	139	5	26	31
68	18,113	42.6%	7,715	48.8%	3,763	70.8%	5,462	21	117	138	5	26	30
69	17,963	42.6%	7,651	48.8%	3,732	70.8%	5,417	21	116	137	5	26	30
70	17,799	61.6%	10,968	43.7%	4,790	63.4%	6,954	31	105	136	6	21	27
71	17,619	61.6%	10,857	43.7%	4,742	63.4%	6,884	30	104	134	6	21	27
72	17,421	61.6%	10,736	43.7%	4,689	63.4%	6,806	30	103	133	6	20	26
73	17,204	61.6%	10,602	43.7%	4,630	63.4%	6,722	29	102	131	6	20	26
74	16,966	61.6%	10,455	43.7%	4,566	63.4%	6,629	29	101	129	6	20	26
75	16,704	61.6%	10,294	43.7%	4,496	63.4%	6,526	37	91	127	7	18	25
76	16,417	61.6%	10,117	43.7%	4,418	63.4%	6,414	36	90	125	7	18	25
77	16,102	61.6%	9,923	43.7%	4,334	63.4%	6,291	35	88	123	7	17	24
78	15,757	61.6%	9,710	43.7%	4,241	63.4%	6,156	34	87	120	7	17	24
79	15,378	61.6%	9,476	43.7%	4,139	63.4%	6,008	33	85	117	6	17	23
80	14,963	61.6%	9,221	43.7%	4,027	63.4%	5,846	31	83	114	6	16	23
81	14,510	61.6%	8,942	43.7%	3,905	63.4%	5,669	30	81	111	6	16	22
82	14,016	61.6%	8,637	43.7%	3,772	63.4%	5,476	28	79	107	6	15	21
83	13,478	61.6%	8,306	43.7%	3,627	63.4%	5,266	27	76	103	5	15	20
84	12,895	61.6%	7,946	43.7%	3,470	63.4%	5,038	25	73	98	5	14	19
Total	***1,245,898***	***23.9%***	***297,402***	***45.0%***	***133,818***	***65.3%***	***194,260***	***695***	***3,653***	***4,348***	***141***	***748***	***890***

Table 13: Cardiovascular Events Avoided

Males Between the Ages of 18 and 84

In a British Columbia Birth Cohort of 40,000

With a Screening Program

		Hypertension						Cardiovascular Events Avoided					
				Control (No Screening)		Control (With Screening)		100% Control			Moving from % Control without Screening to % Control with Screening		
Age	Total Life Years	Prevalence %	#	%	#	%	#	Fatal	Non-Fatal	Total	Fatal	Non-Fatal	Total
18	19,876	4.4%	869	30.8%	268	44.7%	388						
19	19,864	4.4%	868	30.8%	267	44.7%	388	0.8	8.3	9.1	0.1	1.2	1.3
20	19,851	4.4%	868	30.8%	267	44.7%	388	0.8	8.3	9.1	0.1	1.2	1.3
21	19,835	4.4%	867	30.8%	267	44.7%	388	0.8	8.3	9.1	0.1	1.2	1.3
22	19,817	4.4%	866	30.8%	267	44.7%	387	0.8	8.3	9.1	0.1	1.2	1.3
23	19,796	4.4%	865	30.8%	266	44.7%	387	0.8	8.3	9.1	0.1	1.2	1.3
24	19,775	4.4%	864	30.8%	266	44.7%	386	0.8	8.3	9.1	0.1	1.2	1.3
25	19,751	4.4%	863	30.8%	266	44.7%	386	0.8	8.3	9.0	0.1	1.2	1.3
26	19,727	4.4%	862	30.8%	266	44.7%	385	0.8	8.3	9.0	0.1	1.2	1.3
27	19,702	4.4%	861	30.8%	265	44.7%	385	0.8	8.3	9.0	0.1	1.1	1.3
28	19,676	4.4%	860	30.8%	265	44.7%	384	0.8	8.3	9.0	0.1	1.1	1.3
29	19,649	4.4%	859	30.8%	264	44.7%	384	0.8	8.2	9.0	0.1	1.1	1.3
30	19,621	4.4%	858	30.8%	264	44.7%	383	0.8	8.2	9.0	0.1	1.1	1.2
31	19,593	4.4%	857	30.8%	264	44.7%	383	0.8	8.2	9.0	0.1	1.1	1.2
32	19,564	4.4%	855	30.8%	263	44.7%	382	0.8	8.2	9.0	0.1	1.1	1.2
33	19,535	4.4%	854	30.8%	263	44.7%	382	0.8	8.2	8.9	0.1	1.1	1.2
34	19,505	4.4%	853	30.8%	263	44.7%	381	0.8	8.2	8.9	0.1	1.1	1.2
35	19,474	4.4%	851	30.8%	262	44.7%	381	0.8	8.2	8.9	0.1	1.1	1.2
36	19,442	4.4%	850	30.8%	262	44.7%	380	0.8	8.1	8.9	0.1	1.1	1.2
37	19,409	4.4%	848	30.8%	261	44.7%	379	0.8	8.1	8.9	0.1	1.1	1.2
38	19,375	4.4%	847	30.8%	261	44.7%	379	0.8	8.1	8.9	0.1	1.1	1.2
39	19,339	4.4%	845	30.8%	260	44.7%	378	0.8	8.1	8.9	0.1	1.1	1.2
40	19,303	18.4%	3,557	38.1%	1,355	55.3%	1,967	0.8	8.1	8.8	0.1	1.4	1.5
41	19,264	18.4%	3,550	38.1%	1,352	55.3%	1,963	0.8	8.1	8.8	0.1	1.4	1.5
42	19,225	18.4%	3,542	38.1%	1,349	55.3%	1,959	0.8	8.1	8.8	0.1	1.4	1.5
43	19,183	18.4%	3,535	38.1%	1,347	55.3%	1,955	0.7	8.0	8.8	0.1	1.4	1.5
44	19,140	18.4%	3,527	38.1%	1,343	55.3%	1,950	0.7	8.0	8.8	0.1	1.4	1.5
45	19,094	18.4%	3,518	38.1%	1,340	55.3%	1,946	5	54	59	0.9	9	10
46	19,047	18.4%	3,510	38.1%	1,337	55.3%	1,941	5	54	59	0.9	9	10
47	18,996	18.4%	3,500	38.1%	1,333	55.3%	1,936	5	54	59	0.9	9	10
48	18,943	18.4%	3,491	38.1%	1,330	55.3%	1,930	5	54	59	0.9	9	10
49	18,887	18.4%	3,480	38.1%	1,326	55.3%	1,925	5	54	59	0.9	9	10
50	18,827	18.4%	3,469	38.1%	1,322	55.3%	1,918	6	53	59	1.0	9	10
51	18,763	18.4%	3,457	38.1%	1,317	55.3%	1,912	6	52	58	1.0	9	10
52	18,695	18.4%	3,445	38.1%	1,312	55.3%	1,905	6	52	58	1.0	9	10
53	18,622	18.4%	3,431	38.1%	1,307	55.3%	1,898	6	52	58	1.0	9	10
54	18,545	18.4%	3,417	38.1%	1,302	55.3%	1,890	6	52	58	1.0	9	10
55	18,461	18.4%	3,402	38.1%	1,296	55.3%	1,881	6	51	57	1.1	9	10
56	18,372	18.4%	3,385	38.1%	1,290	55.3%	1,872	6	51	57	1.1	9	10
57	18,277	18.4%	3,368	38.1%	1,283	55.3%	1,862	6	51	57	1.1	9	10
58	18,175	18.4%	3,349	38.1%	1,276	55.3%	1,852	6	50	57	1.1	9	10
59	18,065	18.4%	3,329	38.1%	1,268	55.3%	1,841	6	50	56	1.1	9	10
60	17,947	43.3%	7,765	52.8%	4,103	76.7%	5,956	21	116	137	5	28	33
61	17,820	43.3%	7,710	52.8%	4,074	76.7%	5,913	21	115	136	5	27	32
62	17,684	43.3%	7,651	52.8%	4,042	76.7%	5,868	21	114	135	5	27	32
63	17,537	43.3%	7,587	52.8%	4,009	76.7%	5,819	21	113	134	5	27	32
64	17,379	43.3%	7,519	52.8%	3,973	76.7%	5,767	21	112	133	5	27	32
65	17,208	43.3%	7,445	52.8%	3,934	76.7%	5,710	32	100	131	8	24	31
66	17,024	43.3%	7,365	52.8%	3,892	76.7%	5,649	31	99	130	7	24	31
67	16,826	43.3%	7,280	52.8%	3,846	76.7%	5,583	31	98	128	7	23	31
68	16,612	43.3%	7,187	52.8%	3,797	76.7%	5,512	30	96	127	7	23	30
69	16,381	43.3%	7,087	52.8%	3,744	76.7%	5,436	30	95	125	7	23	30
70	16,132	63.9%	10,312	52.3%	5,390	75.9%	7,827	47	76	123	11	18	29
71	15,863	63.9%	10,140	52.3%	5,300	75.9%	7,697	46	75	121	11	18	29
72	15,573	63.9%	9,955	52.3%	5,203	75.9%	7,556	45	74	119	11	18	28
73	15,260	63.9%	9,755	52.3%	5,098	75.9%	7,404	44	73	116	10	17	28
74	14,923	63.9%	9,540	52.3%	4,986	75.9%	7,241	43	71	114	10	17	27
75	14,560	63.9%	9,308	52.3%	4,865	75.9%	7,065	45	66	111	11	16	26
76	14,170	63.9%	9,058	52.3%	4,734	75.9%	6,875	44	65	108	10	15	26
77	13,751	63.9%	8,790	52.3%	4,594	75.9%	6,672	42	63	105	10	15	25
78	13,301	63.9%	8,503	52.3%	4,444	75.9%	6,454	40	61	102	9	14	24
79	12,820	63.9%	8,195	52.3%	4,283	75.9%	6,220	38	60	98	9	14	23
80	12,306	63.9%	7,867	52.3%	4,112	75.9%	5,971	36	58	94	9	14	22
81	11,759	63.9%	7,517	52.3%	3,929	75.9%	5,706	34	56	90	8	13	21
82	11,179	63.9%	7,146	52.3%	3,735	75.9%	5,424	32	53	85	8	13	20
83	10,565	63.9%	6,754	52.3%	3,530	75.9%	5,126	30	51	81	7	12	19
84	9,919	63.9%	6,341	52.3%	3,314	75.9%	4,813	27	49	76	6	11	18
Total	***1,182,557***	***24.7%***	***291,932***	***47.7%***	***139,131***	***69.2%***	***202,010***	***955***	***3,006***	***3,961***	***219***	***643***	***862***

Change in Number of Deaths and Life Years Lost

- Based on the information in Tables 12 and 13, screening for and treatment of hypertension in adults 18 years and older in a British Columbia birth cohort of 40,000 would result in 1,752 fewer cardiovascular events (360 of which would be fatal and 1,391 would not immediately be fatal). In calculating life years lost we need to account for fatal events as well as the reduced life-expectancy associated with a non-fatal event.
- For example, based on available international studies, the life expectancy (compared with the general population) for a stroke survivor by sex, age and modified Rankin Scale (mRS) score is summarized in Table 14.[750]

Table 14: Life Expectancy for a Stroke Survivor (in years)
By Age, Sex and Grade on the modified Rankin Scale

Age Group		General Population	Modified Rankin Scale Score 0	1	2	3	4	5
			Males					
50	Life Expectancy	30	28	27	22	17	13	9
	% of Life Years Lost		*6.7%*	*10.0%*	*26.7%*	*43.3%*	*56.7%*	*70.0%*
60	Life Expectancy	22	20	19	16	13	9	7
	% of Life Years Lost		*9.1%*	*13.6%*	*27.3%*	*40.9%*	*59.1%*	*68.2%*
70	Life Expectancy	14	13	13	11	8	6	5
	% of Life Years Lost		*7.1%*	*7.1%*	*21.4%*	*42.9%*	*57.1%*	*64.3%*
80	Life Expectancy	8	7	7	6	5	4	3
	% of Life Years Lost		*12.5%*	*12.5%*	*25.0%*	*37.5%*	*50.0%*	*62.5%*
			Females					
50	Life Expectancy	33	32	30	25	19	14	9
	% of Life Years Lost		*3.0%*	*9.1%*	*24.2%*	*42.4%*	*57.6%*	*72.7%*
60	Life Expectancy	25	24	22	18	14	10	7
	% of Life Years Lost		*4.0%*	*12.0%*	*28.0%*	*44.0%*	*60.0%*	*72.0%*
70	Life Expectancy	17	16	15	12	9	7	5
	% of Life Years Lost		*5.9%*	*11.8%*	*29.4%*	*47.1%*	*58.8%*	*70.6%*
80	Life Expectancy	10	9	9	7	6	4	3
	% of Life Years Lost		*10.0%*	*10.0%*	*30.0%*	*40.0%*	*60.0%*	*70.0%*

- mRS grade descriptions are as follows:
  - 0 - No symptoms or disabilities due to stroke.
  - 1 - No significant disability following stroke, despite symptoms: Able to carry out all usual duties and activities.
  - 2 - Slight disability: Unable to carry out all previous activities but able to look after own affairs without assistance.
  - 3 - Moderate disability: Requiring some help with daily activities, but is able to walk without assistance.
  - 4 - Moderately severe disability: Unable to walk without assistance, and unable to attend to own bodily needs.

[750] Shavelle R, Brooks J, Strauss D et al. Life expectancy after stroke based on age, sex, and Rankin grade of disability: A synthesis. *Journal of Stroke and Cerebrovascular Diseases*. 2019; 28(12): 104450.

- 5 - Severe disability: Bedridden, incontinent, and requires constant nursing care and attention.

- For modelling purposes, we estimated that 25.5% of stroke survivors in BC have a modified Rankin Scale (mRS) score of 0, 21.5% a 1, 11.3% a 2, 18.5% a 3, 18.6% a 4 and 4.6% a 5.[751]
- Research from the US suggests that the life expectancy of an acute myocardial infarction (AMI) survivor is approximately 34% shorter than that of the general population of the same age and sex, although this varies by age, sex and race (see Table 15).[752]

Table 15: Life Expectancy for an Acute Myocardial Infarction Survivor
By Age, Sex and Race in the US (in years)

		General Population				*AMI Survivor*			
Age		**White**		**Black**		**White**		**Black**	
Group		Males	Females	Males	Females	Males	Females	Males	Females
65	Life Expectancy	17.6	21.7	14.2	18.8	12.5	11.7	9.1	8.6
	% of Life Years Lost					*29.1%*	*46.1%*	*36.3%*	*54.4%*
70	Life Expectancy	13.2	16.5	11.3	14.9	9.0	8.8	6.9	6.9
	% of Life Years Lost					*32.2%*	*46.9%*	*39.0%*	*53.9%*
75	Life Expectancy	9.8	12.3	9.0	11.7	6.2	6.4	5.1	5.4
	% of Life Years Lost					*36.6%*	*47.8%*	*42.8%*	*53.6%*
80	Life Expectancy	7.2	8.9	7.1	9.1	4.1	4.5	3.7	4.2
	% of Life Years Lost					*42.5%*	*49.4%*	*47.4%*	*53.9%*

- To estimate the number of life years gained associated with screening for and treatment of hypertension in adults 18 years and older in a British Columbia birth cohort of 40,000, we first combined information on the number of fatal cardiovascular events avoided (Tables 12 & 13) with age- and sex-specific life expectancy. To calculate life years lost associated with non-fatal stroke events, we distributed the events by mRS score as noted above and then applied an age-, sex- and mRS score specific reduction in life expectancy starting at age 50 as indicated in Table 14. To calculate life years lost associated with non-fatal AMI events we applied an age- and sex-specific reduction in white AMI survivors starting at age 65 as indicated on Table 15.
- Based on this approach, a total of 6,449 life years would be gained associated with screening for and treatment of hypertension in females (Table 16) and 6,160 in males (Table 17).

[751] Krueger H, Lindsay P, Cote R et al. Cost avoidance associated with optimal stroke care in Canada. *Stroke*. 2012; 43(8): 2198-206.
[752] Bucholz E, Normand S, Wang Y et al. Life expectancy and years of potential life lost after acute myocardial infarction by sex and race: a cohort-based study of Medicare beneficiaries. *Journal of the American College of Cardiology*. 2015; 66(6): 645-55.

Table 16: Life Years Gained

Females Between the Ages of 18 and 84

In a British Columbia Birth Cohort of 40,000

With a Screening Program

	Fatal CV Events Avoided			Non-Fatal CV Events Avoided					
Age	**Total**	LE	LYs Gained	**Total**	# of Stroke	Stroke LYs Gained	# of AMI	AMI LYs Gained	**Total LYs Gained**
18									
19	0.06	66	**3.7**	1.9	1.9				**3.7**
20	0.06	65	**3.6**	1.9	1.9				**3.6**
21	0.06	64	**3.6**	1.9	1.9				**3.6**
22	0.06	63	**3.5**	1.9	1.9				**3.5**
23	0.06	62	**3.5**	1.9	1.9				**3.5**
24	0.06	62	**3.4**	1.9	1.9				**3.4**
25	0.06	61	**3.4**	1.9	1.9				**3.4**
26	0.06	60	**3.3**	1.9	1.9				**3.3**
27	0.06	59	**3.3**	1.9	1.9				**3.3**
28	0.06	58	**3.2**	1.9	1.9				**3.2**
29	0.06	57	**3.2**	1.9	1.9				**3.2**
30	0.06	56	**3.1**	1.9	1.9				**3.1**
31	0.06	55	**3.0**	1.9	1.9				**3.0**
32	0.06	54	**3.0**	1.9	1.9				**3.0**
33	0.06	53	**2.9**	1.9	1.9				**2.9**
34	0.06	52	**2.9**	1.9	1.9				**2.9**
35	0.06	51	**2.8**	1.9	1.9				**2.8**
36	0.06	50	**2.8**	1.9	1.9				**2.8**
37	0.06	49	**2.7**	1.9	1.9				**2.7**
38	0.06	48	**2.7**	1.9	1.9				**2.7**
39	0.06	47	**2.6**	1.9	1.9				**2.6**
40	0.06	46	**2.8**	2.0	2.0				**2.8**
41	0.06	45	**2.7**	2.0	2.0				**2.7**
42	0.06	44	**2.7**	2.0	2.0				**2.7**
43	0.06	43	**2.6**	2.0	2.0				**2.6**
44	0.06	42	**2.5**	2.0	2.0				**2.5**
45	0.33	41	**14**	11	11				**14**
46	0.33	40	**13**	11	11				**13**
47	0.33	39	**13**	11	11				**13**
48	0.33	38	**13**	11	11				**13**
49	0.33	37	**12**	11	11				**12**
50	0.56	37	**21**	11	11	**109**			**129**
51	0.56	36	**20**	11	11	**106**			**126**
52	0.56	35	**19**	11	11	**103**			**122**
53	0.56	34	**19**	11	11	**100**			**119**
54	0.56	33	**18**	11	11	**97**			**115**
55	0.65	32	**21**	11	11	**93**			**114**
56	0.64	31	**20**	11	11	**90**			**110**
57	0.64	30	**19**	11	11	**87**			**107**
58	0.64	29	**19**	11	11	**84**			**103**
59	0.64	28	**18**	11	11	**82**			**100**
60	3.47	27	**95**	28	14	**109**	15		**204**
61	3.45	26	**91**	28	14	**105**	15		**196**
62	3.43	26	**88**	28	13	**101**	15		**189**
63	3.41	25	**84**	28	13	**97**	15		**181**
64	3.39	24	**81**	28	13	**93**	15		**174**
65	4.78	23	**109**	26	13	**85**	14	**145**	**339**
66	4.74	22	**104**	26	13	**81**	14	**138**	**324**
67	4.69	21	**99**	26	12	**77**	14	**132**	**309**
68	4.64	20	**94**	26	12	**74**	13	**126**	**294**
69	4.59	20	**89**	26	12	**70**	13	**120**	**280**
70	6.09	19	**114**	21	10	**56**	11	**95**	**264**
71	6.00	18	**107**	21	10	**53**	11	**90**	**250**
72	5.90	17	**101**	20	10	**50**	11	**85**	**236**
73	5.80	16	**94**	20	10	**47**	10	**80**	**222**
74	5.68	15	**88**	20	10	**45**	10	**75**	**208**
75	7.24	15	**107**	18	9	**38**	9	**66**	**211**
76	7.06	14	**99**	18	8	**36**	9	**61**	**196**
77	6.86	13	**91**	17	8	**33**	9	**57**	**182**
78	6.65	13	**83**	17	8	**31**	9	**53**	**167**
79	6.42	12	**76**	17	8	**29**	9	**49**	**154**
80	6.17	11	**69**	16	8	**26**	9	**47**	**142**
81	5.90	10	**62**	16	8	**24**	8	**43**	**129**
82	5.61	10	**55**	15	7	**22**	8	**39**	**116**
83	5.30	9	**49**	15	7	**20**	8	**35**	**104**
84	4.97	9	**43**	14	7	**18**	8	**32**	**92**
Total	***141***	***17.7***	***2,509***	***748***	***469***	***2,370***	***279***	***1,569***	***6,449***

Table 17: Life Years Gained

Males Between the Ages of 18 and 84

In a British Columbia Birth Cohort of 40,000

With a Screening Program

	Fatal CV Events Avoided			Non-Fatal CV Events Avoided					
Age	Total	LE	LYs Gained	**Total**	# of Stroke	Stroke LYs Gained	# of AMI	AMI LYs Gained	**Total LYs Gained**
18									
19	0.11	61	**6.5**	1.2	1.2				**6.5**
20	0.11	60	**6.4**	1.2	1.2				**6.4**
21	0.11	60	**6.3**	1.2	1.2				**6.3**
22	0.11	59	**6.2**	1.2	1.2				**6.2**
23	0.11	58	**6.1**	1.2	1.2				**6.1**
24	0.11	57	**6.0**	1.2	1.2				**6.0**
25	0.11	56	**5.9**	1.2	1.2				**5.9**
26	0.11	55	**5.8**	1.2	1.2				**5.8**
27	0.11	54	**5.7**	1.1	1.1				**5.7**
28	0.11	53	**5.6**	1.1	1.1				**5.6**
29	0.11	52	**5.5**	1.1	1.1				**5.5**
30	0.11	51	**5.4**	1.1	1.1				**5.4**
31	0.11	50	**5.3**	1.1	1.1				**5.3**
32	0.10	49	**5.2**	1.1	1.1				**5.2**
33	0.10	48	**5.1**	1.1	1.1				**5.1**
34	0.10	47	**5.0**	1.1	1.1				**5.0**
35	0.10	46	**4.9**	1.1	1.1				**4.9**
36	0.10	46	**4.8**	1.1	1.1				**4.8**
37	0.10	45	**4.7**	1.1	1.1				**4.7**
38	0.10	44	**4.6**	1.1	1.1				**4.6**
39	0.10	43	**4.5**	1.1	1.1				**4.5**
40	0.13	42	**5.4**	1.4	1.4				**5.4**
41	0.13	41	**5.3**	1.4	1.4				**5.3**
42	0.13	40	**5.2**	1.4	1.4				**5.2**
43	0.13	39	**5.0**	1.4	1.4				**5.0**
44	0.13	38	**4.9**	1.4	1.4				**4.9**
45	0.86	37	**32**	9	9				**32**
46	0.86	36	**31**	9	9				**31**
47	0.85	36	**30**	9	9				**30**
48	0.85	35	**29**	9	9				**29**
49	0.85	34	**29**	9	9				**29**
50	1.02	33	**34**	9	9	**85**			**119**
51	1.02	32	**33**	9	9	**83**			**115**
52	1.02	31	**32**	9	9	**80**			**112**
53	1.02	30	**31**	9	9	**77**			**108**
54	1.01	29	**30**	9	9	**75**			**104**
55	1.07	28	**30**	9	9	**72**			**102**
56	1.07	28	**29**	9	9	**69**			**99**
57	1.06	27	**28**	9	9	**67**			**95**
58	1.06	26	**27**	9	9	**64**			**91**
59	1.05	25	**26**	9	9	**62**			**88**
60	5.06	24	**122**	28	13	**96**	14		**218**
61	5.03	23	**117**	27	13	**92**	14		**209**
62	5.00	22	**112**	27	13	**88**	14		**200**
63	4.96	22	**107**	27	13	**84**	14		**191**
64	4.91	21	**102**	27	13	**80**	14		**183**
65	7.54	20	**151**	24	11	**69**	12	**72**	**292**
66	7.45	19	**144**	24	11	**65**	12	**69**	**278**
67	7.36	19	**136**	23	11	**62**	12	**65**	**263**
68	7.26	18	**129**	23	11	**59**	12	**62**	**249**
69	7.15	17	**121**	23	11	**55**	12	**58**	**235**
70	11.04	16	**179**	18	9	**38**	9	**49**	**267**
71	10.82	15	**168**	18	9	**36**	9	**46**	**250**
72	10.59	15	**156**	18	8	**34**	9	**43**	**234**
73	10.34	14	**145**	17	8	**32**	9	**41**	**218**
74	10.06	13	**135**	17	8	**29**	9	**38**	**202**
75	10.65	13	**135**	16	7	**26**	8	**38**	**199**
76	10.29	12	**124**	15	7	**24**	8	**35**	**183**
77	9.91	11	**113**	15	7	**22**	8	**32**	**167**
78	9.50	11	**102**	14	7	**20**	8	**30**	**152**
79	9.05	10	**92**	14	7	**19**	7	**27**	**138**
80	8.58	10	**82**	14	7	**17**	7	**29**	**128**
81	8.07	9	**72**	13	6	**16**	7	**26**	**114**
82	7.54	8	**63**	13	6	**14**	7	**23**	**101**
83	6.98	8	**55**	12	6	**13**	6	**21**	**88**
84	6.40	7	**47**	11	6	**11**	6	**19**	**77**
Total	***219***	***16.0***	***3,502***	***643***	***395***	***1,834***	***249***	***824***	***6,160***

Change in Quality-Adjusted Life Years Gained

- Research suggests that **a survivor's QoL is affected following a cardiovascular event**. Avoiding the event through screening and treatment for hypertension would thus result in QALYs gained associated with the implementation of the screening / treatment program.
- The GBD study groups the long term consequences following a stroke into five levels of severity.[753] Level 1 ("has some difficulty in moving around and some weakness in one hand, but is able to walk without help") is associated with a utility of -0.019 (95% CI of -0.010 to -0.032). Level 2 ("has some difficulty in moving around, and in using the hands for lifting and holding things, dressing and grooming") is associated with a utility of -0.070 (95% CI of -0.046 to -0.099). Level 3 ("has some difficulty in moving around, in using the hands for lifting and holding things, dressing and grooming, and in speaking. The person is often forgetful and confused") is associated with a utility of -0.316 (95% CI of -0.206 to -0.437). Level 4 ("is confined to a bed or a wheelchair, has difficulty speaking and depends on others for feeding, toileting and dressing") is associated with a utility of -0.552 (95% CI of -0.377 to -0.707). Level 5 ("is confined to a bed or a wheelchair, depends on others for feeding, toileting and dressing, and has difficulty speaking, thinking clearly and remembering things") is associated with a utility of -0.588 (95% CI of -0.411 to -0.744).
- We have assumed that the five severity levels identified by the GBD are approximately comparable to mRS scores of 1 through 5. Furthermore, an estimated 25.5% of stroke survivors have a mRS score of 0, 21.5% a 1, 11.3% a 2, 18.5% a 3, 18.6% a 4 and 4.6% a 5.[754] The average utility associated with a stroke would therefore be -0.200 (95% CI of -0.134 to -0.265) ((0.255*0) + (0.215*-0.019) + (0.113*-0.070) + (0.185*-0.316) + (0.186*-0.552) + (0.046*-0.588)).
- The GBD study estimated a disutility of -0.432 (95% CI of -0.288 to -0.579) during days 1 and 2 following an AMI and a disutility of -0.074 (95% CI of -0.049 to -0.105) during days 3 to 28.[755] This results in a combined disutility of -0.098 (95% CI of -0.065 to -0.137) for a period of one month or a total disutility of -0.008 (95% CI of -0.005 to -0.011) over a year.
- In calculating QALYs gained with AMIs avoided, we applied a one-time benefit of 0.008 (95% CI of 0.005 to 0.011) adjusted to reflect the QoL in the general population (see Reference document re: details on calculating changes in QoL).
- In calculating QALYs gained with strokes avoided, we applied an annual benefit of 0.200 (95% CI of 0.134 to 0.265) adjusted to reflect the QoL in the general population. The number of expected life years for stroke survivors were adjusted to reflect a shorter life expectancy as indicated in Table 14.

[753] Institute for Health Metrics and Evaluation. *GBD 2016 sequelae, health states, health state lay descriptions, and disability weights*. Available online at http://ghdx.healthdata.org/record/global-burden-disease-study-2016-gbd-2016-disability-weights. Accessed February 2022.
[754] Krueger H, Lindsay P, Cote R et al. Cost avoidance associated with optimal stroke care in Canada. *Stroke.* 2012; 43(8): 2198-206.
[755] Institute for Health Metrics and Evaluation. *GBD 2016 sequelae, health states, health state lay descriptions, and disability weights*. Available online at http://ghdx.healthdata.org/record/global-burden-disease-study-2016-gbd-2016-disability-weights. Accessed February 2022.

- Based on this approach, a total of 2,593 QALYs would be gained associated with screening for and treatment of hypertension in females and 1,865 QALYs in males (Table 18).

Table 18: Estimated QALYs Gained
Between the Ages of 18 and 84
In a British Columbia Birth Cohort of 40,000
With a Co-ordinated Screening Program

	Females					Males				
	Non-Fatal Events Avoided					Non-Fatal Events Avoided				
Age	# AMI	QALYs Gained	# Stroke	LE	QALYs Gained	# AMI	QALYs Gained	# Stroke	LE	QALYs Gained
18										
19			2	66	27			1	61	16
20			2	65	27			1	60	15
21			2	64	26			1	60	15
22			2	63	26			1	59	15
23			2	62	26			1	58	15
24			2	62	25			1	57	14
25			2	61	25			1	56	14
26			2	60	24			1	55	14
27			2	59	24			1	54	14
28			2	58	24			1	53	13
29			2	57	23			1	52	13
30			2	56	23			1	51	13
31			2	55	23			1	50	13
32			2	54	22			1	49	13
33			2	53	22			1	48	12
34			2	52	22			1	47	12
35			2	51	21			1	46	12
36			2	50	21			1	46	12
37			2	49	20			1	45	11
38			2	48	20			1	44	11
39			2	47	20			1	43	11
40			2	46	22			1	42	14
41			2	45	21			1	41	13
42			2	44	21			1	40	13
43			2	43	20			1	39	13
44			2	42	20			1	38	12
45			11	41	108			9	37	82
46			11	40	105			9	36	80
47			11	39	103			9	36	77
48			11	38	100			9	35	75
49			11	37	98			9	34	73
50			11	37	70			9	33	52
51			11	36	68			9	32	50
52			11	35	67			9	31	49
53			11	34	65			9	30	47
54			11	33	63			9	29	45
55			11	32	60			9	28	44
56			11	31	58			9	28	42
57			11	30	57			9	27	41
58			11	29	55			9	26	39
59			11	28	53			9	25	37
60	15	0.15	14	27	66	14	0.15	13	24	56
61	15	0.15	14	26	63	14	0.15	13	23	54
62	15	0.15	13	26	61	14	0.14	13	22	51
63	15	0.15	13	25	58	14	0.14	13	22	49
64	15	0.15	13	24	56	14	0.14	13	21	47
65	14	0.14	13	23	51	12	0.13	11	20	40
66	14	0.14	13	22	49	12	0.13	11	19	38
67	14	0.14	12	21	47	12	0.12	11	19	36
68	13	0.14	12	20	44	12	0.12	11	18	34
69	13	0.14	12	20	42	12	0.12	11	17	32
70	11	0.12	10	19	34	9	0.10	9	16	27
71	11	0.12	10	18	32	9	0.10	9	15	25
72	11	0.11	10	17	31	9	0.10	8	15	24
73	10	0.11	10	16	29	9	0.10	8	14	22
74	10	0.11	10	15	27	9	0.09	8	13	21
75	9	0.10	9	15	23	8	0.09	7	13	18
76	9	0.10	8	14	22	8	0.09	7	12	17
77	9	0.10	8	13	20	8	0.08	7	11	16
78	9	0.10	8	13	19	8	0.08	7	11	14
79	9	0.09	8	12	17	7	0.08	7	10	13
80	9	0.10	8	11	18	7	0.08	7	10	13
81	8	0.10	8	10	16	7	0.08	6	9	12
82	8	0.09	7	10	15	7	0.08	6	8	11
83	8	0.09	7	9	13	6	0.07	6	8	9
84	8	0.09	7	9	12	6	0.07	6	7	8
	279	**3.0**	**469**		**2,590**	**249**	**2.6**	**395**		**1,863**

Potential Harms Associated with the Intervention(s)

- The disutility of taking pills for preventing adverse health outcomes is estimated at 0.24% (95% confidence interval [CI] of 0.17% to 0.33%).[756, 757, 758] The studies by Hutchins and colleagues also found that a significant proportion of respondents (9.5% using the willingness-to-pay approach, 57.5% using the standard gamble approach and 87% using the time trade-off approach) identified no disutility associated with taking one pill daily. In the sensitivity analysis, we therefore ranged the disutility from 0% to 0.33%.
- In the Systolic Blood Pressure Intervention Trial (SPRINT), the following serious adverse events were observed in patients in the standard treatment intervention (in which medications were adjusted to target a systolic blood pressure of 135 to 139 mm Hg). In total, the probability of an adverse event was 0.00264 per month[759] or 2.88 per 100 person-years of treatment.[760]
    - Hypotension (decreased blood pressure below accepted values) – in 1.41% of patients
    - Syncope (fainting or passing out) – 1.71%
    - Electrolyte abnormality – 2.28%
    - Acute kidney injury or acute renal failure – 2.50%
- Richman et al estimated a disutility of -0.5 for one week associated with the serious adverse events identified in the SPRINT study.[761]
- In modelling potential harms associated with screening and treatment, we first calculated the additional years of treatment associated with a screening program (Table 6 minus Table 5). Serious adverse events (SAEs) were estimated to occur at a rate of 2.88 per 100 person-years of treatment.[762] Each SAE was associated with a disutility of 0.0096 (0.5 / 52 weeks[763]). Each year on treatment was associated with a disutility of 0.0024 associated with taking preventative medication. Based on these assumptions, the harms associated with screening and treatment resulted in 263 QALYs lost in females and 257 in males (see Table 19).

[756] Thompson A, Guthrie B and Payne K. Do pills have no ills? capturing the impact of direct treatment disutility. *PharmacoEconomics*. 2016; 34(4): 333-6.
[757] Hutchins R, Pignone M, Sheridan S et al. Quantifying the utility of taking pills for preventing adverse health outcomes: a cross-sectional survey. *British Medical Journal Open*. 2015; 5(e006505): 1-9.
[758] Hutchins R, Viera AJ, Sheridan SL et al. Quantifying the utility of taking pills for cardiovascular prevention. *Circulation: Cardiovascular Quality and Outcomes*. 2015; 8(2): 155-63.
[759] The SPRINT Research Group. A randomized trial of intensive versus standard blood-pressure control. *New England Journal of Medicine*. 2015; 373(22): 2103-16.
[760] Bress A, Bellows B, King J et al. Cost-effectiveness of intensive versus standard blood-pressure control. *New England Journal of Medicine*. 2017; 377(8): 745-55.
[761] Richman I, Fairley M, Jorgensen M et al. Cost-effectiveness of intensive blood pressure management. *JAMA Cardiology*. 2016; 8: 872-9.
[762] Bress A, Bellows B, King J et al. Cost-effectiveness of intensive versus standard blood-pressure control. *New England Journal of Medicine*. 2017; 377(8): 745-55.
[763] Richman I, Fairley M, Jorgensen M et al. Cost-effectiveness of intensive blood pressure management. *JAMA Cardiology*. 2016; 8: 872-9.

Table 19: Estimated QALYs Lost

Between the Ages of 18 and 84

In a British Columbia Birth Cohort of 40,000

With a Co-ordinated Screening Program

	Females				Males			
	Additional		QALYs Lost		Additional		QALYs Lost	
Age	Yrs of Tmt	# SAE	SAE	Meds	Yrs of Tmt	# SAE	SAE	Meds
18	138	4	0.04	0.4	128	4	0.04	0.3
19	138	4	0.04	0.4	128	4	0.04	0.3
20	138	4	0.04	0.4	128	4	0.04	0.3
21	138	4	0.04	0.4	128	4	0.04	0.3
22	138	4	0.04	0.4	128	4	0.04	0.3
23	138	4	0.04	0.4	128	4	0.04	0.3
24	138	4	0.04	0.4	128	4	0.04	0.3
25	138	4	0.04	0.4	128	4	0.04	0.3
26	138	4	0.04	0.4	127	4	0.04	0.3
27	138	4	0.04	0.4	127	4	0.04	0.3
28	138	4	0.04	0.4	127	4	0.04	0.3
29	138	4	0.04	0.4	127	4	0.04	0.3
30	138	4	0.04	0.4	127	4	0.04	0.3
31	138	4	0.04	0.4	127	4	0.04	0.3
32	138	4	0.04	0.4	126	4	0.04	0.3
33	137	4	0.04	0.4	126	4	0.04	0.3
34	137	4	0.04	0.4	126	4	0.04	0.3
35	137	4	0.04	0.4	126	4	0.04	0.3
36	137	4	0.04	0.4	126	4	0.04	0.3
37	137	4	0.04	0.4	125	4	0.04	0.3
38	137	4	0.04	0.4	125	4	0.04	0.3
39	137	4	0.04	0.4	125	4	0.04	0.3
40	678	20	0.22	1.9	780	22	0.25	2.2
41	677	19	0.22	1.9	779	22	0.25	2.2
42	676	19	0.22	1.9	777	22	0.25	2.2
43	676	19	0.22	1.9	775	22	0.25	2.2
44	675	19	0.22	1.9	774	22	0.25	2.2
45	674	19	0.22	1.9	772	22	0.25	2.2
46	673	19	0.22	1.9	770	22	0.25	2.2
47	672	19	0.22	1.9	768	22	0.25	2.2
48	671	19	0.22	1.9	766	22	0.25	2.2
49	670	19	0.22	1.9	763	22	0.25	2.1
50	669	19	0.23	2.0	761	22	0.26	2.2
51	668	19	0.23	2.0	758	22	0.26	2.2
52	667	19	0.23	2.0	756	22	0.26	2.2
53	666	19	0.22	1.9	753	22	0.25	2.2
54	664	19	0.22	1.9	750	22	0.25	2.2
55	663	19	0.22	1.9	746	21	0.25	2.2
56	661	19	0.22	1.9	743	21	0.25	2.2
57	659	19	0.22	1.9	739	21	0.25	2.2
58	657	19	0.22	1.9	735	21	0.25	2.2
59	655	19	0.22	1.9	730	21	0.25	2.1
60	2,103	61	0.73	6.3	2,083	60	0.72	6.3
61	2,094	60	0.73	6.3	2,068	60	0.72	6.2
62	2,085	60	0.72	6.3	2,052	59	0.71	6.2
63	2,076	60	0.72	6.2	2,035	59	0.71	6.1
64	2,065	59	0.72	6.2	2,017	58	0.70	6.1
65	2,053	59	0.71	6.2	1,997	58	0.69	6.0
66	2,041	59	0.71	6.1	1,975	57	0.68	5.9
67	2,027	58	0.70	6.1	1,952	56	0.68	5.9
68	2,012	58	0.70	6.0	1,928	56	0.67	5.8
69	1,995	57	0.69	6.0	1,901	55	0.66	5.7
70	2,949	85	1.08	9.3	2,925	84	1.07	9.3
71	2,919	84	1.07	9.3	2,877	83	1.05	9.1
72	2,886	83	1.06	9.1	2,824	81	1.03	9.0
73	2,850	82	1.04	9.0	2,767	80	1.01	8.8
74	2,811	81	1.03	8.9	2,706	78	0.99	8.6
75	2,767	80	1.01	8.8	2,640	76	0.97	8.4
76	2,720	78	0.99	8.6	2,570	74	0.94	8.1
77	2,668	77	0.98	8.5	2,494	72	0.91	7.9
78	2,610	75	0.95	8.3	2,412	69	0.88	7.6
79	2,548	73	0.93	8.1	2,325	67	0.85	7.4
80	2,479	71	0.98	8.5	2,232	64	0.89	7.7
81	2,404	69	0.96	8.3	2,133	61	0.85	7.3
82	2,322	67	0.92	8.0	2,027	58	0.81	7.0
83	2,233	64	0.89	7.7	1,916	55	0.76	6.6
84	2,136	62	0.85	7.4	1,799	52	0.71	6.2
	76,252	**2,196**	**27**	**236**	**74,639**	**2,150**	**27**	**230**

Summary of CPB – Males and Females

- Other assumptions used in assessing CPB are detailed in the Reference Document.

Based on these assumptions, the CPB associated with screening for and treatment of hypertension in adults 18 years and older in a British Columbia birth cohort of 40,000 is 16,548 QALYs (Table 20, row ab). The CPB of 16,548 represents the gap between no coverage and the 'best in the world' screening coverage estimated at 88.1%.

Table 20: CPB of Screening and Treatment for Hypertension
Ages 18 - 84
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
a	Age to start screening	18	√
b	Age to stop screening	84	√
c	Prevalence of hypertension	24.3%	= e/d
d	Life years lived in cohort	2,428,455	Table 5
e	Life years lived with hypertension	589,334	Table 5
	Without a Screening Program		
f	Life years lived **aware** of hypertension	348,355	Table 5
g	% of life years lived with hypertension and **aware** of the hypertension	59.1%	= f/e
h	Life years lived on **treatment** for hypertension	333,972	Table 5
i	% of life years lived with hypertension and **on treatment** for hypertension	56.7%	= h/e
j	Life years lived with hypertension **under control**	272,949	Table 5
k	% of life years lived with hypertension and hypertension **controlled**	46.3%	= j/e
	With a Screening Program		
l	Life years lived **aware** of hypertension	505,742	Table 6
m	% of life years lived with hypertension and **aware** of the hypertension	85.8%	= l/e
n	Life years lived on **treatment** for hypertension	484,863	Table 6
o	% of life years lived with hypertension and **on treatment** for hypertension	82.3%	= n/e
p	Life years lived with hypertension **under control**	396,270	Table 6
q	% of life years lived with hypertension and hypertension **controlled**	67.2%	= p/e
r	Life years gained - avoid fatal CV events (females)	2,509	Table 16
s	QALYs gained - avoid non-fatal AMI (females)	1,572	Tables 16 & 18
t	QALYs gained - avoid non-fatal stroke (females)	4,960	Tables 16 & 18
u	**Total QALYs gained - Females**	**9,042**	= r + s + t
v	Life years gained - avoid fatal CV (males)	3,502	Table 17
w	QALYs gained - avoid non-fatal AMI (males)	826	Tables 17 & 18
x	QALYs gained - avoid non-fatal stroke (males)	3,697	Tables 17 & 18
y	**Total QALYs gained - Males**	**8,026**	= v + w + x
	Harms		
z	QALYs lost due to harms - Females	263	Table 19
aa	QALYs lost due to harms - Males	257	Table 19
	Net QALYs Gained With Screening		
ab	**Net QALYs gained (CPB) -** No screening to 88.1%	**16,548**	= u + y - z - aa

√ = Estimates from the literature

Sensitivity Analysis – Males and Females

We also modified several major assumptions and recalculated the CPB as follows:

- The rate of cerebrovascular mortality and morbidity in those ages 18-59 on treatment for hypertension decreases from 6 to 5 per 1,000 over a 5-year period and from 34 to 31 per 1,000 over a 3.8-year period for those ages 60 and older; the rate of coronary heart disease mortality and morbidity in those ages 60 and older decreases from 37 to 33 per 1,000 over a 3.8-year period (see Table 8). **CPB = 20,142**
- The rate of cerebrovascular mortality and morbidity in those ages 18-59 on treatment for hypertension increases from 6 to 9 per 1,000 over a 5-year period and from 34 to 39 per 1,000 over a 3.8-year period for those ages 60 and older; the rate of coronary heart disease mortality and morbidity in those ages 60 and older increases decreases from 37 to 42 per 1,000 over a 3.8-year period (see Table 8). **CPB = 10,222**
- The average disutility of living with a stroke is increased from 0.200 to 0.265. CPB = 17,995
- The average disutility of living with a stroke is decreased from 0.200 to 0.134. CPB = 15,078
- The disutility associated with taking preventive medication is increased from 0.0024 to 0.0033. CPB = 16,373
- The disutility associated with taking preventive medication is reduced from 0.0024 to 0.0. CPB = 17,014

Summary of CPB – Females Only

Based on these assumptions, the CPB associated with screening for and treatment of hypertension in females 18 years and older in a British Columbia birth cohort of 40,000 is 8,778 QALYs (Table 21, row ab). The CPB of 8,778 represents the gap between no coverage and the 'best in the world' screening coverage estimated at 88.1%.

Table 21: CPB of Screening and Treatment for Hypertension
Females Ages 18 - 84
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
a	Age to start screening	18	√
b	Age to stop screening	84	√
c	Prevalence of hypertension	23.9%	= e/d
d	Life years lived in cohort	1,245,898	Table 5
e	Life years lived with hypertension	297,402	Table 5
	Without a Screening Program		
f	Life years lived **aware** of hypertension	174,823	Table 5
g	% of life years lived with hypertension and **aware** of the hypertension	58.8%	= f/e
h	Life years lived on **treatment** for hypertension	168,822	Table 5
i	% of life years lived with hypertension and **on treatment** for hypertension	56.8%	= h/e
j	Life years lived with hypertension **under control**	133,818	Table 5
k	% of life years lived with hypertension and hypertension **controlled**	45.0%	= j/e
	With a Screening Program		
l	Life years lived **aware** of hypertension	253,786	Table 6
m	% of life years lived with hypertension and **aware** of the hypertension	85.3%	= l/e
n	Life years lived on **treatment** for hypertension	245,074	Table 6
o	% of life years lived with hypertension and **on treatment** for hypertension	82.4%	= n/e
p	Life years lived with hypertension **under control**	194,260	Table 6
q	% of life years lived with hypertension and hypertension **controlled**	65.3%	= p/e
r	Life years gained - avoid fatal CV events (females)	2,509	Table 16
s	QALYs gained - avoid non-fatal AMI (females)	1,572	Tables 16 & 18
t	QALYs gained - avoid non-fatal stroke (females)	4,960	Tables 16 & 18
u	**Total QALYs gained - Females**	**9,042**	= r + s + t
v	Life years gained - avoid fatal CV (males)		Table 17
w	QALYs gained - avoid non-fatal AMI (males)		Tables 17 & 18
x	QALYs gained - avoid non-fatal stroke (males)		Tables 17 & 18
y	**Total QALYs gained - Males**		= v + w + x
	Harms		
z	QALYs lost due to harms - Females	263	Table 19
aa	QALYs lost due to harms - Males		Table 19
	Net QALYs Gained With Screening		
ab	**Net QALYs gained (CPB) -** No screening to 88.1%	**8,778**	= u + y - z - aa

√ = Estimates from the literature

Sensitivity Analysis – Females Only

We also modified several major assumptions and recalculated the CPB for females as follows:

- The rate of cerebrovascular mortality and morbidity in females ages 18-59 on treatment for hypertension decreases from 6 to 5 per 1,000 over a 5-year period and from 34 to 31 per 1,000 over a 3.8-year period for females ages 60 and older; the rate of coronary heart disease mortality and morbidity in females ages 60 and older decreases from 37 to 33 per 1,000 over a 3.8-year period (see Table 8). **CPB = 10,687**
- The rate of cerebrovascular mortality and morbidity in females ages 18-59 on treatment for hypertension increases from 6 to 9 per 1,000 over a 5-year period and from 34 to 39 per 1,000 over a 3.8-year period for females ages 60 and older; the rate of coronary heart disease mortality and morbidity in females ages 60 and older increases decreases from 37 to 42 per 1,000 over a 3.8-year period (see Table 8). **CPB = 5,395**
- The average disutility of living with a stroke is increased from 0.200 to 0.265. CPB = 9,620
- The average disutility of living with a stroke is decreased from 0.200 to 0.134. CPB = 7,924
- The disutility associated with taking preventive medication is increased from 0.0024 to 0.0033. CPB = 8,690
- The disutility associated with taking preventive medication is reduced from 0.0024 to 0.0. CPB = 9,014

Summary of CPB – Males Only

Based on these assumptions, the CPB associated with screening for and treatment of hypertension in males 18 years and older in a British Columbia birth cohort of 40,000 is 7,769 QALYs (Table 22, row ab). The CPB of 7,769 represents the gap between no coverage and the 'best in the world' screening coverage estimated at 88.1%.

Table 22: CPB of Screening and Treatment for Hypertension
Males Ages 18 - 84
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
a	Age to start screening	18	√
b	Age to stop screening	84	√
c	Prevalence of hypertension	24.7%	= e/d
d	Life years lived in cohort	1,182,557	Table 5
e	Life years lived with hypertension	291,932	Table 5
	Without a Screening Program		
f	Life years lived **aware** of hypertension	173,532	Table 5
g	% of life years lived with hypertension and **aware** of the hypertension	59.4%	= f/e
h	Life years lived on **treatment** for hypertension	165,151	Table 5
i	% of life years lived with hypertension and **on treatment** for hypertension	56.6%	= h/e
j	Life years lived with hypertension **under control**	139,131	Table 5
k	% of life years lived with hypertension and hypertension **controlled**	47.7%	= j/e
	With a Screening Program		
l	Life years lived **aware** of hypertension	251,956	Table 6
m	% of life years lived with hypertension and **aware** of the hypertension	86.3%	= l/e
n	Life years lived on **treatment** for hypertension	239,789	Table 6
o	% of life years lived with hypertension and **on treatment** for hypertension	82.1%	= n/e
p	Life years lived with hypertension **under control**	202,010	Table 6
q	% of life years lived with hypertension and hypertension **controlled**	69.2%	= p/e
r	Life years gained - avoid fatal CV events (females)		Table 16
s	QALYs gained - avoid non-fatal AMI (females)		Tables 16 & 18
t	QALYs gained - avoid non-fatal stroke (females)		Tables 16 & 18
u	**Total QALYs gained - Females**		= r + s + t
v	Life years gained - avoid fatal CV (males)	3,502	Table 17
w	QALYs gained - avoid non-fatal AMI (males)	826	Tables 17 & 18
x	QALYs gained - avoid non-fatal stroke (males)	3,697	Tables 17 & 18
y	**Total QALYs gained - Males**	**8,026**	= v + w + x
	Harms		
z	QALYs lost due to harms - Females		Table 19
aa	QALYs lost due to harms - Males	257	Table 19
	Net QALYs Gained With Screening		
ab	**Net QALYs gained (CPB) -** No screening to 88.1%	**7,769**	= u + y - z - aa

√ = Estimates from the literature

Sensitivity Analysis – Males Only

We also modified several major assumptions and recalculated the CPB for males as follows:

- The rate of cerebrovascular mortality and morbidity in males ages 18-59 on treatment for hypertension decreases from 6 to 5 per 1,000 over a 5-year period and from 34 to 31 per 1,000 over a 3.8-year period for males ages 60 and older; the rate of coronary heart disease mortality and morbidity in males ages 60 and older decreases from 37 to 33 per 1,000 over a 3.8-year period (see Table 8). **CPB = 9,454**
- The rate of cerebrovascular mortality and morbidity in males ages 18-59 on treatment for hypertension increases from 6 to 9 per 1,000 over a 5-year period and from 34 to 39 per 1,000 over a 3.8-year period for males ages 60 and older; the rate of coronary heart disease mortality and morbidity in males ages 60 and older increases decreases from 37 to 42 per 1,000 over a 3.8-year period (see Table 8). **CPB = 4,827**
- The average disutility of living with a stroke is increased from 0.200 to 0.265. CPB = 8,375
- The average disutility of living with a stroke is decreased from 0.200 to 0.134. CPB = 7,155
- The disutility associated with taking preventive medication is increased from 0.0024 to 0.0033. CPB = 7,683
- The disutility associated with taking preventive medication is reduced from 0.0024 to 0.0. CPB = 7,999

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with screening for and treatment of hypertension in adults 18 years and older in a British Columbia birth cohort of 40,000.

In estimating CE, we made the following assumptions:

Cost of Screening and Interventions

- The use of an automated office blood pressure (AOBP) electronic device should be used when measuring BP in a physician's office, with the patient seated quietly for at least 5 minutes and BP measured in both arms. The patient is to refrain from caffeine or cigarette smoking for at least 30 minutes prior to the measurement.[764]
- In order to rule out an overestimation (white-coat hypertension) or an underestimation (masked hypertension) of BP values, 24-hour ambulatory blood pressure monitoring (ABPM), or standardized home blood pressure monitoring, should be considered to confirm a hypertension diagnosis in all patients.[765]
- ABPM involves wearing a blood pressure cuff and a recording device for a period of 24 hours. BP measurements are taken every 15 or 30 minutes thus providing a high number of BP readings in a variety of situations. A daytime (awake) mean of

[764] BC Guidelines.ca. *Hypertension – Diagnosis and Management*. April 15, 2020. Available online at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/bc-guidelines/htn-full-guideline.pdf. Accessed February 2022.
[765] BC Guidelines.ca. *Hypertension – Diagnosis and Management*. April 15, 2020. Available online at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/bc-guidelines/htn-full-guideline.pdf. Accessed February 2022.

≥135/85, a night-time (asleep) mean of ≥120/70 or a 24-hour mean of ≥130/80 would result in a diagnosis of hypertension.[766]

- AOBP screening resulting in a normal reading would require 0.5 of an office visit. A high reading would require a full office visit to assess risk factors as well as a recommendation for a 24-hour ABPM. Reading and interpreting the results of the ABPM would require a further full office visit.
- BC Hypertension guidelines suggest that a follow-up visit is required two weeks after initiating medication usage with an estimated glomerular filtration rate (eGFR) to monitor kidney function and to assess adherence with the medication. Then monthly follow-up visits until BP is in the desired range for 2 consecutive visits. Visits every 3 – 6 months when the patient is stable.[767]
- Research from Alberta indicates that patients with incident hypertension visit their primary care physician an average of 3.5 – 4.0 times (for a hypertension-related visit) in the year following diagnosis and then 2.0 times per year thereafter.[768]
- The estimated 5.3% of patients with hypertension that is treatment-resistant may see a primary care physician more frequently and are more likely to be referred to a specialist physician. [769]
- For modelling purposes, we have assumed that 8 physician visits would be required in the first year for every newly diagnosed patient with hypertension, 2 for the diagnosis and 6 for medication adherence and stabilization. Each of these visits would take 0.5 of an office visit. Once stable, 3 physician visits would be required per year for maintenance, also each requiring 0.5 of an office visit.
- The BC Hypertension Guidelines state the following tests should be ordered twice a year for monitoring purposes:[770]
    - Urinalysis - albumin to creatinine ratio (ACR), hematuria
    - Blood chemistry - potassium, sodium, creatinine/estimated glomerular filtration rate (eGFR)
    - Fasting blood glucose or hemoglobin A1c level
    - Blood lipids – non-HDL cholesterol and triglycerides (non-fasting is acceptable)
    - Electrocardiogram (ECG) standard 12-lead

The diagnostic tests required and their unit costs are as follows:

[766] BC Guidelines.ca. *Hypertension – Diagnosis and Management*. April 15, 2020. Available online at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/bc-guidelines/htn-full-guideline.pdf. Accessed February 2022.
[767] BC Guidelines.ca. *Hypertension – Diagnosis and Management*. April 15, 2020. Available online at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/bc-guidelines/htn-full-guideline.pdf. Accessed February 2022.
[768] Clement F, Chen G, Khan N et al. Primary care physician visits by patients with incident hypertension. *Canadian Journal of Cardiology*. 2014; 30: 653-60.
[769] Leung A, Williams J, Tran K et al. Epidemiology of resultant hypertension in Canada. *Canadian Journal of Cardiology*. 2022; 38: 681-7.
[770] BC Guidelines.ca. *Hypertension – Diagnosis and Management*. April 15, 2020. Available online at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/bc-guidelines/htn-full-guideline.pdf. Accessed February 2022.

    - 12-lead ECG - $24.57[771]
    - Urinalysis (fee item 92385) - $2.05[772]
    - Albumin to creatinine ratio (ACR) (fee item 91985) - $11.41
    - Potassium (fee item 92100 - $1.39
    - Sodium (fee item 92231) - $1.38
    - Creatinine/eGFR (fee item 91421) - $1.52
    - Glucose (fasting) (fee item 91707) - $1.46
    - Primary base fee (fee item 91000) - $15.62
    - Hemoglobin A1c (fee item 91745) - $5.30
    - Cholesterol (fee item 91375) - $6.87
    - Triglycerides (fee item 92350) - $6.59
    - Parathyroid hormone (PTH) (fee item 92030) - $17.52
    - Calcium total (fee item 91326) - $1.55
    - Phosphate (fee item 92071) - $1.62
    - **Total - $98.85**

- Actual rates of laboratory testing may be sub-optimal. Research from Alberta found that only 42.3% of patients with newly-diagnosed hypertension received laboratory investigations for renal function, serum electrolytes, low-density lipoprotein cholesterol and diabetes in the year following their diagnosis. Approximately three-quarters received at least one of these guideline-recommended tests.[773]
- Average annual cost of antihypertensive medication – Calculated based on an estimated average cost per day of treatment for antihypertensive medication in Canada of $0.62 (365 * $0.62 = $226.30).[774]
- Capital cost of equipment for automated office blood pressure (AOBP) measurement and ambulatory blood pressure monitoring (ABPM) are not included. ABPM machines cost approximately $2,000[775] each while AOBP machines cost approximately $400 - $900 each.[776,777]
- Based on these assumption, the cost of implementing a co-ordinated hypertension screening and treatment program in a BC birth cohort of 40,000 would be $88.5 million in females (see Tables 23) and $85.4 million in males (see Table 24).

[771] Medical Services Plan. *MSP Fee-For-Service Payment Analysis: 2016/17 to 2020/21.* Available at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msp_ffs_payment_analysis_2016/2017_to_2020/2021.pdf. Accessed March 2024. 2020/21 average FFS for fee item 33016 (ECG and Interpretaion – Office – Cardiology).

[772] The following tests, fee item numbers and unit costs were provided by Jillian Hannah, Policy Analyst with the BC Ministry of Health: Laboratory and Blood Services Branch. July 2022.

[773] Quan S, Chen G, Padwal R et al. Frequency of laboratory testing and associated abnormalities in patients with hypertension. *Journal of Clinical Hypertension*. 2020; 22: 2077-83.

[774] Centre for Health Services and Policy Research. *The Canadian Rx Atlas: Third Edition*. 2013. Available at http://www.chspr.ubc.ca/sites/default/files/file_upload/publications/2013/RxAtlas/canadianrxatlas2013.pdf. Accessed March 2024.

[775] See https://www.cardiacdirect.com/product-category/24-hour-abp-monitors/. Accessed July 2022.

[776] See https://medical.andonline.com/product/professional-office-blood-pressure-monitor-um-211/. Accessed July 2022.

[777] Dr. Martin Dawes, Professor of Family Practice, Department of Family Practice, Faculty of Medicine, UBC. Personal communication, April 2022.

Table 23: Costs Associated with Implementing a Co-ordinated Screening Program

Females Between the Ages of 18 and 84

In a British Columbia Birth Cohort of 40,000

Age	Total Life Years	Prevalence %	Prevalence #	% with BP Check	# of BP Screens	GP Visits Screens	GP Visits Monitoring	Monitoring Tests	Costs GP	Costs Tests	Costs Medication	Costs Patient	Total
18	19,894	3.4%	682	58.8%	11,379	6,195	208	277	$230,316	$27,366	$31,325	$475,871	**$764,877**
19	19,888	3.4%	682	58.8%	11,230	5,615	208	277	$209,446	$27,357	$31,315	$432,750	**$700,868**
20	19,881	3.4%	682	68.2%	13,100	6,550	207	277	$243,062	$27,348	$31,304	$502,206	**$803,920**
21	19,874	3.4%	682	68.2%	13,095	6,548	207	277	$242,978	$27,339	$31,294	$502,034	**$803,645**
22	19,867	3.4%	681	68.2%	13,090	6,545	207	276	$242,888	$27,329	$31,282	$501,846	**$803,345**
23	19,859	3.4%	681	68.2%	13,085	6,543	207	276	$242,792	$27,318	$31,270	$501,649	**$803,029**
24	19,851	3.4%	681	68.2%	13,080	6,540	207	276	$242,694	$27,307	$31,257	$501,447	**$802,705**
25	19,843	3.4%	681	77.8%	14,981	7,490	207	276	$276,877	$27,296	$31,244	$572,073	**$907,490**
26	19,834	3.4%	680	77.8%	14,974	7,487	207	276	$276,754	$27,284	$31,230	$571,819	**$907,087**
27	19,825	3.4%	680	77.8%	14,967	7,484	207	276	$276,628	$27,271	$31,216	$571,559	**$906,675**
28	19,816	3.4%	680	77.8%	14,960	7,480	207	276	$276,497	$27,258	$31,201	$571,288	**$906,245**
29	19,806	3.4%	679	77.8%	14,953	7,476	207	276	$276,360	$27,245	$31,186	$571,005	**$905,796**
30	19,796	3.4%	679	75.5%	14,478	7,239	207	275	$267,817	$27,231	$31,170	$553,355	**$879,574**
31	19,785	3.4%	679	75.5%	14,470	7,235	206	275	$267,668	$27,216	$31,153	$553,047	**$879,084**
32	19,773	3.4%	678	75.5%	14,462	7,231	206	275	$267,514	$27,200	$31,135	$552,728	**$878,577**
33	19,761	3.4%	678	75.5%	14,453	7,226	206	275	$267,351	$27,183	$31,116	$552,392	**$878,043**
34	19,749	3.4%	677	75.5%	14,444	7,222	206	275	$267,181	$27,166	$31,096	$552,039	**$877,482**
35	19,736	3.4%	677	76.5%	14,642	7,321	206	275	$270,744	$27,148	$31,076	$559,403	**$888,371**
36	19,722	3.4%	676	76.5%	14,632	7,316	206	274	$270,558	$27,129	$31,054	$559,017	**$887,758**
37	19,708	3.4%	676	76.5%	14,621	7,311	206	274	$270,363	$27,110	$31,032	$558,614	**$887,118**
38	19,693	3.4%	675	76.5%	14,610	7,305	206	274	$270,156	$27,089	$31,008	$558,188	**$886,442**
39	19,677	3.4%	675	76.5%	14,599	7,299	205	274	$269,942	$27,068	$30,984	$557,745	**$885,739**
40	19,661	14.8%	2,911	80.6%	15,393	9,676	1,016	1,355	$384,588	$133,957	$153,336	$794,623	**$1,466,503**
41	19,643	14.8%	2,909	80.6%	13,562	6,781	1,015	1,354	$280,442	$133,837	$153,198	$579,440	**$1,146,917**
42	19,625	14.8%	2,906	80.6%	13,549	6,775	1,014	1,353	$280,174	$133,710	$153,053	$578,887	**$1,145,824**
43	19,605	14.8%	2,903	80.6%	13,535	6,768	1,013	1,351	$279,889	$133,575	$152,899	$578,297	**$1,144,661**
44	19,584	14.8%	2,900	80.6%	13,521	6,760	1,012	1,350	$279,583	$133,431	$152,734	$577,666	**$1,143,414**
45	19,561	14.8%	2,897	82.7%	13,915	6,957	1,011	1,348	$286,633	$133,277	$152,557	$592,232	**$1,164,700**
46	19,537	14.8%	2,893	82.7%	13,898	6,949	1,010	1,347	$286,275	$133,112	$152,369	$591,493	**$1,163,249**
47	19,511	14.8%	2,889	82.7%	13,879	6,940	1,009	1,345	$285,894	$132,936	$152,167	$590,705	**$1,161,702**
48	19,484	14.8%	2,885	82.7%	13,859	6,930	1,007	1,343	$285,486	$132,748	$151,952	$589,861	**$1,160,047**
49	19,454	14.8%	2,881	82.7%	13,838	6,919	1,006	1,341	$285,048	$132,547	$151,721	$588,956	**$1,158,272**
50	19,422	14.8%	2,876	79.9%	13,260	6,630	1,004	1,339	$274,587	$132,330	$151,473	$567,343	**$1,125,734**
51	19,388	14.8%	2,871	79.9%	13,236	6,618	1,002	1,336	$274,102	$132,098	$151,208	$566,340	**$1,123,749**
52	19,352	14.8%	2,866	79.9%	13,211	6,605	1,000	1,334	$273,579	$131,849	$150,923	$565,260	**$1,121,610**
53	19,312	14.8%	2,860	79.9%	13,184	6,592	998	1,331	$273,016	$131,580	$150,615	$564,096	**$1,119,308**
54	19,270	14.8%	2,853	79.9%	13,154	6,577	996	1,328	$272,407	$131,290	$150,283	$562,838	**$1,116,818**
55	19,224	14.8%	2,847	90.0%	15,067	7,534	994	1,325	$306,734	$130,978	$149,926	$633,763	**$1,221,401**
56	19,174	14.8%	2,839	90.0%	15,028	7,514	991	1,322	$305,938	$130,642	$149,541	$632,119	**$1,218,239**
57	19,121	14.8%	2,831	90.0%	14,986	7,493	988	1,318	$305,077	$130,278	$149,124	$630,340	**$1,214,820**
58	19,063	14.8%	2,823	90.0%	14,940	7,470	985	1,314	$304,142	$129,883	$148,672	$628,408	**$1,211,104**
59	19,000	14.8%	2,814	90.0%	14,890	7,445	982	1,310	$303,130	$129,455	$148,182	$626,316	**$1,207,083**
60	18,932	42.6%	8,064	88.4%	14,541	6,254	3,154	4,205	$338,400	$415,674	$475,806	$699,190	**$1,929,070**
61	18,858	42.6%	8,032	88.4%	9,450	4,725	3,141	4,189	$282,954	$414,044	$473,942	$584,629	**$1,755,569**
62	18,777	42.6%	7,998	88.4%	9,407	4,703	3,128	4,171	$281,698	$412,275	$471,916	$582,035	**$1,747,924**
63	18,689	42.6%	7,960	88.4%	9,360	4,680	3,113	4,151	$280,325	$410,343	$469,704	$579,197	**$1,739,569**
64	18,593	42.6%	7,920	88.4%	9,309	4,654	3,097	4,130	$278,831	$408,239	$467,297	$576,111	**$1,730,478**
65	18,489	42.6%	7,875	91.2%	9,774	4,887	3,080	4,107	$286,571	$405,943	$464,668	$592,103	**$1,749,285**
66	18,375	42.6%	7,826	91.2%	9,710	4,855	3,061	4,081	$284,731	$403,435	$461,798	$588,301	**$1,738,264**
67	18,250	42.6%	7,773	91.2%	9,639	4,820	3,040	4,054	$282,714	$400,691	$458,656	$584,135	**$1,726,196**
68	18,113	42.6%	7,715	91.2%	9,562	4,781	3,017	4,023	$280,508	$397,687	$455,218	$579,575	**$1,712,988**
69	17,963	42.6%	7,651	91.2%	9,478	4,739	2,992	3,990	$278,091	$394,398	$451,453	$574,581	**$1,698,523**
70	17,799	61.6%	10,968	91.7%	9,460	7,728	4,423	5,897	$437,070	$582,936	$667,265	$903,058	**$2,590,329**
71	17,619	61.6%	10,857	91.7%	6,542	3,271	4,378	5,837	$275,144	$577,034	$660,510	$568,493	**$2,081,181**
72	17,421	61.6%	10,736	91.7%	6,458	3,229	4,329	5,772	$271,870	$570,562	$653,102	$561,728	**$2,057,261**
73	17,204	61.6%	10,602	91.7%	6,366	3,183	4,275	5,700	$268,271	$563,455	$644,967	$554,292	**$2,030,985**
74	16,966	61.6%	10,455	91.7%	6,265	3,132	4,216	5,621	$264,321	$555,654	$636,037	$546,132	**$2,002,144**
75	16,704	61.6%	10,294	95.0%	6,703	3,351	4,151	5,535	$269,857	$547,093	$626,237	$557,568	**$2,000,755**
76	16,417	61.6%	10,117	95.0%	6,571	3,286	4,080	5,439	$264,923	$537,686	$615,470	$547,374	**$1,965,454**
77	16,102	61.6%	9,923	95.0%	6,427	3,214	4,001	5,335	$259,516	$527,370	$603,661	$536,204	**$1,926,751**
78	15,757	61.6%	9,710	95.0%	6,269	3,134	3,915	5,221	$253,583	$516,051	$590,705	$523,946	**$1,884,285**
79	15,378	61.6%	9,476	95.0%	6,096	3,048	3,821	5,095	$247,084	$503,645	$576,504	$510,517	**$1,837,749**
80	14,963	61.6%	9,221	93.2%	5,639	2,819	3,718	4,958	$235,159	$490,066	$560,961	$485,877	**$1,772,062**
81	14,510	61.6%	8,942	93.2%	5,441	2,720	3,606	4,808	$227,545	$475,230	$543,978	$470,145	**$1,716,898**
82	14,016	61.6%	8,637	93.2%	5,225	2,612	3,483	4,644	$219,245	$459,044	$525,451	$452,997	**$1,656,737**
83	13,478	61.6%	8,306	93.2%	4,990	2,495	3,349	4,466	$210,225	$441,430	$505,289	$434,360	**$1,591,304**
84	12,895	61.6%	7,946	93.2%	4,737	2,369	3,204	4,272	$200,457	$422,323	$483,418	$414,177	**$1,520,375**
Total	***1,245,898***	***23.9%***	***297,402***		***781,626***	***395,280***	***114,378***	***152,505***	**$18,332,401**	**$15,075,078**	**$17,255,893**	**$37,877,787**	**$88,541,159**

Table 24: Costs Associated with Implementing a Co-ordinated Screening Program

Males Between the Ages of 18 and 84

In a British Columbia Birth Cohort of 40,000

Age	Total Life Years	Prevalence %	Prevalence #	% with BP Check	# of BP Screens	GP Visits Screens	GP Visits Monitoring	Monitoring Tests	Costs GP	Costs Tests	Costs Medication	Costs Patient	Total
18	19,876	4.4%	869	46.7%	8,914	5,042	193	257	$188,278	$25,387	$35,788	$389,014	**$638,468**
19	19,864	4.4%	868	46.7%	8,742	4,371	193	257	$164,140	$25,373	$35,768	$339,142	**$564,422**
20	19,851	4.4%	868	54.2%	10,213	5,107	192	257	$190,602	$25,355	$35,743	$393,816	**$645,517**
21	19,835	4.4%	867	54.2%	10,205	5,102	192	256	$190,448	$25,335	$35,715	$393,496	**$644,993**
22	19,817	4.4%	866	54.2%	10,195	5,098	192	256	$190,274	$25,312	$35,682	$393,137	**$644,405**
23	19,796	4.4%	865	54.2%	10,185	5,092	192	256	$190,077	$25,286	$35,645	$392,730	**$643,738**
24	19,775	4.4%	864	54.2%	10,174	5,087	192	256	$189,867	$25,258	$35,606	$392,296	**$643,027**
25	19,751	4.4%	863	59.2%	11,163	5,582	191	255	$207,652	$25,228	$35,564	$429,044	**$697,488**
26	19,727	4.4%	862	59.2%	11,149	5,575	191	255	$207,397	$25,197	$35,521	$428,517	**$696,632**
27	19,702	4.4%	861	59.2%	11,135	5,568	191	255	$207,132	$25,165	$35,475	$427,969	**$695,741**
28	19,676	4.4%	860	59.2%	11,120	5,560	191	254	$206,858	$25,132	$35,428	$427,403	**$694,821**
29	19,649	4.4%	859	59.2%	11,105	5,553	190	254	$206,576	$25,097	$35,380	$426,820	**$693,874**
30	19,621	4.4%	858	62.6%	11,756	5,878	190	254	$218,275	$25,062	$35,330	$450,992	**$729,660**
31	19,593	4.4%	857	62.6%	11,739	5,870	190	253	$217,961	$25,026	$35,280	$450,343	**$728,610**
32	19,564	4.4%	855	62.6%	11,722	5,861	190	253	$217,640	$24,989	$35,228	$449,681	**$727,538**
33	19,535	4.4%	854	62.6%	11,704	5,852	189	252	$217,313	$24,952	$35,175	$449,004	**$726,444**
34	19,505	4.4%	853	62.6%	11,686	5,843	189	252	$216,979	$24,913	$35,121	$448,314	**$725,327**
35	19,474	4.4%	851	67.4%	12,605	6,303	189	252	$233,497	$24,874	$35,065	$482,443	**$775,878**
36	19,442	4.4%	850	67.4%	12,585	6,292	188	251	$233,113	$24,833	$35,007	$481,650	**$774,602**
37	19,409	4.4%	848	67.4%	12,563	6,282	188	251	$232,717	$24,791	$34,948	$480,831	**$773,286**
38	19,375	4.4%	847	67.4%	12,541	6,271	188	250	$232,306	$24,747	$34,886	$479,983	**$771,921**
39	19,339	4.4%	845	67.4%	12,518	6,259	187	250	$231,881	$24,702	$34,822	$479,104	**$770,509**
40	19,303	18.4%	3,557	77.2%	14,378	9,757	1,170	1,560	$393,072	$154,244	$217,439	$812,152	**$1,576,906**
41	19,264	18.4%	3,550	77.2%	11,990	5,995	1,168	1,557	$257,655	$153,938	$217,009	$532,358	**$1,160,960**
42	19,225	18.4%	3,542	77.2%	11,965	5,983	1,166	1,554	$257,118	$153,620	$216,560	$531,249	**$1,158,548**
43	19,183	18.4%	3,535	77.2%	11,939	5,970	1,163	1,551	$256,560	$153,289	$216,094	$530,096	**$1,156,039**
44	19,140	18.4%	3,527	77.2%	11,912	5,956	1,160	1,547	$255,977	$152,944	$215,607	$528,891	**$1,153,420**
45	19,094	18.4%	3,518	77.3%	11,895	5,948	1,158	1,544	$255,580	$152,580	$215,094	$528,071	**$1,151,324**
46	19,047	18.4%	3,510	77.3%	11,865	5,933	1,155	1,540	$254,934	$152,198	$214,555	$526,736	**$1,148,423**
47	18,996	18.4%	3,500	77.3%	11,834	5,917	1,152	1,536	$254,255	$151,797	$213,990	$525,334	**$1,145,375**
48	18,943	18.4%	3,491	77.3%	11,800	5,900	1,148	1,531	$253,532	$151,370	$213,388	$523,838	**$1,142,128**
49	18,887	18.4%	3,480	77.3%	11,764	5,882	1,145	1,527	$252,768	$150,919	$212,753	$522,261	**$1,138,702**
50	18,827	18.4%	3,469	81.3%	12,484	6,242	1,141	1,522	$265,574	$150,442	$212,079	$548,721	**$1,176,816**
51	18,763	18.4%	3,457	81.3%	12,441	6,220	1,138	1,517	$264,663	$149,932	$211,360	$546,838	**$1,172,793**
52	18,695	18.4%	3,445	81.3%	12,395	6,197	1,133	1,511	$263,689	$149,387	$210,592	$544,825	**$1,168,492**
53	18,622	18.4%	3,431	81.3%	12,346	6,173	1,129	1,505	$262,652	$148,807	$209,774	$542,683	**$1,163,916**
54	18,545	18.4%	3,417	81.3%	12,294	6,147	1,124	1,499	$261,543	$148,187	$208,900	$540,392	**$1,159,022**
55	18,461	18.4%	3,402	82.5%	12,465	6,233	1,119	1,492	$264,448	$147,522	$207,963	$546,394	**$1,166,326**
56	18,372	18.4%	3,385	82.5%	12,404	6,202	1,114	1,485	$263,157	$146,811	$206,960	$543,725	**$1,160,653**
57	18,277	18.4%	3,368	82.5%	12,339	6,169	1,108	1,477	$261,772	$146,048	$205,886	$540,864	**$1,154,569**
58	18,175	18.4%	3,349	82.5%	12,269	6,134	1,102	1,469	$260,288	$145,232	$204,735	$537,799	**$1,148,053**
59	18,065	18.4%	3,329	82.5%	12,193	6,097	1,095	1,460	$258,694	$144,354	$203,498	$534,504	**$1,141,050**
60	17,947	43.3%	7,765	89.9%	13,440	11,233	3,124	4,165	$516,429	$411,712	$580,395	$1,067,028	**$2,575,565**
61	17,820	43.3%	7,710	89.9%	9,182	4,591	3,102	4,136	$276,706	$408,803	$576,294	$571,722	**$1,833,526**
62	17,684	43.3%	7,651	89.9%	9,108	4,554	3,078	4,104	$274,516	$405,674	$571,883	$567,196	**$1,819,269**
63	17,537	43.3%	7,587	89.9%	9,028	4,514	3,052	4,070	$272,154	$402,302	$567,129	$562,315	**$1,803,900**
64	17,379	43.3%	7,519	89.9%	8,941	4,471	3,025	4,033	$269,613	$398,673	$562,013	$557,065	**$1,787,363**
65	17,208	43.3%	7,445	92.7%	9,324	4,662	2,995	3,994	$275,421	$394,759	$556,496	$569,066	**$1,795,742**
66	17,024	43.3%	7,365	92.7%	9,218	4,609	2,963	3,951	$272,372	$390,538	$550,546	$562,765	**$1,776,221**
67	16,826	43.3%	7,280	92.7%	9,105	4,552	2,929	3,905	$269,089	$385,991	$544,136	$555,982	**$1,755,198**
68	16,612	43.3%	7,187	92.7%	8,982	4,491	2,891	3,855	$265,541	$381,082	$537,216	$548,651	**$1,732,489**
69	16,381	43.3%	7,087	92.7%	8,849	4,425	2,851	3,802	$261,711	$375,783	$529,745	$540,739	**$1,707,978**
70	16,132	63.9%	10,312	95.8%	9,211	8,113	4,388	5,851	$449,656	$578,358	$815,319	$929,065	**$2,772,398**
71	15,863	63.9%	10,140	95.8%	5,741	2,871	4,315	5,753	$258,465	$568,721	$801,733	$534,031	**$2,162,950**
72	15,573	63.9%	9,955	95.8%	5,621	2,810	4,236	5,648	$253,464	$558,324	$787,076	$523,699	**$2,122,563**
73	15,260	63.9%	9,755	95.8%	5,491	2,746	4,151	5,535	$248,071	$547,109	$771,266	$512,556	**$2,079,003**
74	14,923	63.9%	9,540	95.8%	5,352	2,676	4,059	5,413	$242,265	$535,027	$754,234	$500,560	**$2,032,085**
75	14,560	63.9%	9,308	93.2%	4,826	2,413	3,961	5,281	$229,269	$522,020	$735,897	$473,707	**$1,960,893**
76	14,170	63.9%	9,058	93.2%	4,675	2,338	3,855	5,139	$222,733	$508,030	$716,176	$460,204	**$1,907,143**
77	13,751	63.9%	8,790	93.2%	4,513	2,257	3,741	4,987	$215,716	$493,001	$694,989	$445,706	**$1,849,412**
78	13,301	63.9%	8,503	93.2%	4,340	2,170	3,618	4,824	$208,198	$476,881	$672,265	$430,172	**$1,787,517**
79	12,820	63.9%	8,195	93.2%	4,155	2,077	3,487	4,650	$200,162	$459,629	$647,945	$413,567	**$1,721,303**
80	12,306	63.9%	7,867	92.9%	3,915	1,958	3,348	4,463	$190,825	$441,208	$621,976	$394,276	**$1,648,285**
81	11,759	63.9%	7,517	92.9%	3,708	1,854	3,199	4,265	$181,752	$421,597	$594,330	$375,530	**$1,573,209**
82	11,179	63.9%	7,146	92.9%	3,490	1,745	3,041	4,055	$172,145	$400,788	$564,996	$355,679	**$1,493,608**
83	10,565	63.9%	6,754	92.9%	3,260	1,630	2,874	3,832	$162,010	$378,789	$533,983	$334,739	**$1,409,521**
84	9,919	63.9%	6,341	92.9%	3,020	1,510	2,698	3,598	$151,372	$355,635	$501,343	$312,760	**$1,321,110**
Total	***1,182,557***	***24.7%***	***291,932***		***657,188***	***339,768***	***111,958***	***149,277***	**$16,248,568**	**$14,756,065**	**$20,801,797**	**$33,572,242**	**$85,378,671**

Costs Associated with Harms

- As noted earlier, pharmaceutical treatment for hypertension is associated with an increased rate of hypotension, syncope, electrolyte abnormalities, and acute kidney injury.[778]
- Bress and co-authors calculated the cost per serious adverse event (SAE) to be as follows:[779]
    - Hypotension - $7,314 in 2017 USD ($7,401 in 2022 CAD)
    - Syncope - $6,697 in 2017 USD ($6,776 in 2022 CAD)
    - Electrolyte abnormality - $7,142 in 2017 USD ($7,226 in 2022 CAD)
    - Acute kidney injury - $10,041 in 2017 USD ($10,160 in 2022 CAD)

  If one of the above SAE occurs, the probability of that occurrence is 20.4% / 24.8% / 28.4% / 26.4%, respectively.[780] The weighted cost per SAE would therefore be $7,925 in 2022 CAD.
- Richman et al assumed a 4 day hospital stay associated with each SAE with an estimated cost of $7,151 (in 2016 USD) per event.[781] We converted this to $7,373 in 2022 CAD.
- Tran et al estimated the cost of a hospitalization with a primary diagnosis of syncope (ICD-10 code R55) to be $4,481 in 2018 CAD (or $5,309 in 2022 CAD).[782]
- For modelling purposes, we took the difference for the cost of treating syncope in the Bress study ($6,776) and the Tran study ($5,309), or -$1,467 (-21.7%) and reduced the weighted cost per SAE from the Bress study ($7,925) by this 21.7% ($6,209). We also assumed that each SAE is associated with four days in hospital when calculating the value of lost patient time.
- Based on these assumptions, the cost of harms associated with implementing a co-ordinated hypertension screening and treatment program in a BC birth cohort of 40,000 would be $16.1 million in females and $15.7 million in males (see Table 25).

[778] Sheppard J, Stevens S, Stevens R et al. Benefits and harms of antihypertensive treatment in low-risk patients with mild hypertension. *JAMA Internal Medicine*. 2018; 178(12): 1626-34.
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Table 25: Estimated Cost of Harms

Between the Ages of 18 and 84

In a British Columbia Birth Cohort of 40,000

With a Co-ordinated Screening Program

	Females				Males			
Age	# of SAEs Table 19	Treatment Costs	Patient Time Costs	Total Costs	# of SAEs Table 19	Treatment Costs	Patient Time Costs	Total Costs
18	4.0	$24,752	$4,444	$29,196	3.7	$22,963	$4,123	$27,085
19	4.0	$24,745	$4,443	$29,187	3.7	$22,949	$4,120	$27,070
20	4.0	$24,736	$4,441	$29,178	3.7	$22,934	$4,118	$27,051
21	4.0	$24,728	$4,440	$29,168	3.7	$22,915	$4,114	$27,030
22	4.0	$24,719	$4,438	$29,157	3.7	$22,894	$4,111	$27,005
23	4.0	$24,709	$4,436	$29,145	3.7	$22,871	$4,106	$26,977
24	4.0	$24,699	$4,435	$29,134	3.7	$22,846	$4,102	$26,947
25	4.0	$24,689	$4,433	$29,122	3.7	$22,819	$4,097	$26,916
26	4.0	$24,678	$4,431	$29,109	3.7	$22,791	$4,092	$26,883
27	4.0	$24,667	$4,429	$29,095	3.7	$22,762	$4,087	$26,848
28	4.0	$24,655	$4,427	$29,082	3.7	$22,731	$4,081	$26,813
29	4.0	$24,643	$4,425	$29,067	3.7	$22,701	$4,076	$26,776
30	4.0	$24,630	$4,422	$29,052	3.7	$22,669	$4,070	$26,739
31	4.0	$24,616	$4,420	$29,036	3.6	$22,636	$4,064	$26,700
32	4.0	$24,602	$4,417	$29,019	3.6	$22,603	$4,058	$26,661
33	4.0	$24,587	$4,415	$29,002	3.6	$22,569	$4,052	$26,621
34	4.0	$24,572	$4,412	$28,983	3.6	$22,534	$4,046	$26,580
35	4.0	$24,555	$4,409	$28,964	3.6	$22,498	$4,039	$26,538
36	4.0	$24,539	$4,406	$28,944	3.6	$22,461	$4,033	$26,494
37	3.9	$24,521	$4,403	$28,923	3.6	$22,423	$4,026	$26,449
38	3.9	$24,502	$4,399	$28,901	3.6	$22,384	$4,019	$26,402
39	3.9	$24,483	$4,396	$28,879	3.6	$22,343	$4,012	$26,354
40	19.5	$121,164	$21,754	$142,918	22.5	$139,513	$25,049	$164,562
41	19.5	$121,055	$21,735	$142,790	22.4	$139,237	$24,999	$164,236
42	19.5	$120,941	$21,714	$142,655	22.4	$138,949	$24,948	$163,897
43	19.5	$120,819	$21,692	$142,511	22.3	$138,650	$24,894	$163,544
44	19.4	$120,688	$21,669	$142,357	22.3	$138,338	$24,838	$163,176
45	19.4	$120,549	$21,644	$142,193	22.2	$138,008	$24,779	$162,787
46	19.4	$120,400	$21,617	$142,017	22.2	$137,663	$24,717	$162,379
47	19.4	$120,241	$21,589	$141,829	22.1	$137,300	$24,652	$161,951
48	19.3	$120,071	$21,558	$141,629	22.1	$136,914	$24,582	$161,496
49	19.3	$119,888	$21,525	$141,414	22.0	$136,506	$24,509	$161,015
50	19.3	$119,692	$21,490	$141,182	21.9	$136,074	$24,432	$160,506
51	19.2	$119,483	$21,453	$140,935	21.8	$135,613	$24,349	$159,962
52	19.2	$119,257	$21,412	$140,669	21.8	$135,120	$24,260	$159,380
53	19.2	$119,014	$21,369	$140,383	21.7	$134,595	$24,166	$158,761
54	19.1	$118,752	$21,321	$140,073	21.6	$134,034	$24,065	$158,100
55	19.1	$118,469	$21,271	$139,740	21.5	$133,433	$23,957	$157,390
56	19.0	$118,165	$21,216	$139,381	21.4	$132,790	$23,842	$156,632
57	19.0	$117,836	$21,157	$138,993	21.3	$132,100	$23,718	$155,818
58	18.9	$117,479	$21,093	$138,571	21.2	$131,362	$23,585	$154,947
59	18.9	$117,091	$21,023	$138,115	21.0	$130,568	$23,443	$154,011
60	60.6	$375,976	$67,505	$443,481	60.0	$372,392	$66,862	$439,254
61	60.3	$374,502	$67,240	$441,743	59.6	$369,761	$66,389	$436,151
62	60.1	$372,902	$66,953	$439,855	59.1	$366,931	$65,881	$432,812
63	59.8	$371,154	$66,639	$437,793	58.6	$363,881	$65,333	$429,214
64	59.5	$369,252	$66,298	$435,549	58.1	$360,598	$64,744	$425,342
65	59.1	$367,174	$65,925	$433,099	57.5	$357,059	$64,108	$421,167
66	58.8	$364,906	$65,517	$430,424	56.9	$353,241	$63,423	$416,664
67	58.4	$362,424	$65,072	$427,496	56.2	$349,128	$62,684	$411,813
68	57.9	$359,707	$64,584	$424,291	55.5	$344,688	$61,887	$406,575
69	57.5	$356,732	$64,050	$420,782	54.7	$339,895	$61,027	$400,921
70	84.9	$527,264	$94,668	$621,932	84.3	$523,124	$93,925	$617,048
71	84.1	$521,926	$93,710	$615,636	82.8	$514,407	$92,360	$606,767
72	83.1	$516,072	$92,659	$608,731	81.3	$505,003	$90,671	$595,674
73	82.1	$509,644	$91,504	$601,148	79.7	$494,859	$88,850	$583,709
74	80.9	$502,588	$90,238	$592,825	77.9	$483,931	$86,888	$570,818
75	79.7	$494,844	$88,847	$583,691	76.0	$472,166	$84,775	$556,941
76	78.3	$486,336	$87,320	$573,656	74.0	$459,512	$82,503	$542,016
77	76.8	$477,005	$85,644	$562,649	71.8	$445,918	$80,063	$525,981
78	75.2	$466,767	$83,806	$550,573	69.5	$431,338	$77,445	$508,783
79	73.4	$455,545	$81,791	$537,337	67.0	$415,734	$74,643	$490,377
80	71.4	$443,263	$79,586	$522,850	64.3	$399,072	$71,652	$470,723
81	69.2	$429,844	$77,177	$507,021	61.4	$381,333	$68,467	$449,800
82	66.9	$415,204	$74,548	$489,752	58.4	$362,512	$65,087	$427,599
83	64.3	$399,272	$71,688	$470,960	55.2	$342,614	$61,515	$404,129
84	61.5	$381,990	$68,585	$450,575	51.8	$321,671	$57,755	$379,426
	2,196	**$13,635,373**	**$2,448,174**	**$16,083,548**	**2,150**	**$13,346,827**	**$2,396,367**	**$15,743,194**

Costs Avoided Due to a Reduction in Hypertension

Strokes Avoided

- Goeree et al estimated the costs associated with the *acute phase of a fatal stroke* in Canada to be $9,364 (in 2004 CAD).[783] We converted this to $13,501 in 2022 CAD.
- Goeree et al estimated the *first year costs* associated with a stroke in Canada by age as follows:[784]
    - <55 years of age - $15,926 in 2004 CAD, converted to $22,196 in 2022 CAD
    - 55-64 - $12,955 ($18,056)
    - 65-74 - $24,593 ($34,276)
    - 75-84 - $28,608 ($39,872)
    - ≥85 - $29,210 ($40,711)
- Gloede and coauthors in Australia estimated the *ongoing annual costs* (including informal care and out-of-pocket costs) associated with an ischemic stroke to be $7,996 (in 2010 AUD) while costs associated with a haemorrhagic stroke were $10,251.[785] Based on a mix of 85% ischemic strokes in Canada,[786] the weighted cost would be $8,335. We converted this to $8,524 in 2022 CAD.

Myocardial Infarctions Avoided

- Anis et al estimated the cost of the *acute phase of a fatal MI* at St. Paul's Hospital in BC to be $6,289 (in 2002 CAD).[787] We converted this to $9,346 in 2022 CAD.
- Cohen and colleagues estimated the *first year costs* associated with an MI in Ontario to be $20,794 (in 2008 CAD).[788] We converted this to $25,500 in 2022 CAD.
- Cohen and colleagues estimated the *ongoing annual costs* following a myocardial infarct to be $1,325 (in 2008 CAD).[789] We converted this to $1,626 in 2022 CAD.
- Based on these assumption, the costs avoided associated with implementing a co-ordinated hypertension screening and treatment program in a BC birth cohort of 40,000 would be $114.5 million in females (see Tables 26) and $86.8 million in males (see Table 27).

[783] Goeree R, Blackhouse G, Petrovic R et al. Cost of stroke in Canada: A 1-year prospective study. *Journal of Medical Economics*. 2005; 8: 147-67.
[784] Goeree R, Blackhouse G, Petrovic R et al. Cost of stroke in Canada: A 1-year prospective study. *Journal of Medical Economics*. 2005; 8: 147-67.
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[789] Cohen D, Manuel D, Tugwell P et al. Direct healthcare costs of acute myocardial infarction in Canada's elderly across the continuum of care. *The Journal of Economics of Ageing*. 2014; 3: 44-49

Table 26: Estimated Costs Avoided due to the Increase in Controlled Hypertension

Females Between the Ages of 18 and 84

In a British Columbia Birth Cohort of 40,000

With a Co-ordinated Screening Program

	Fatal CV Events & Costs Avoided				Non-Fatal CV Events & Year 1 Costs Avoided				Non-Fatal CV Events & Ongoing Costs Avoided				
Age	AMI	Stroke	Total	Costs	AMI	Stroke	Total	Costs	AMI LY	Stroke LY	Total LY	Costs	Total
18													
19		0.1	0.1	$753		1.9	1.9	$41,583		122	122	$1,044,066	$1,086,402
20		0.1	0.1	$753		1.9	1.9	$41,569		121	121	$1,028,074	$1,070,396
21		0.1	0.1	$753		1.9	1.9	$41,555		119	119	$1,012,082	$1,054,390
22		0.1	0.1	$752		1.9	1.9	$41,539		117	117	$996,229	$1,038,521
23		0.1	0.1	$752		1.9	1.9	$41,523		115	115	$980,207	$1,022,482
24		0.1	0.1	$752		1.9	1.9	$41,506		113	113	$964,347	$1,006,604
25		0.1	0.1	$752		1.9	1.9	$41,488		111	111	$948,329	$990,569
26		0.1	0.1	$752		1.9	1.9	$41,470		109	109	$932,453	$974,675
27		0.1	0.1	$752		1.9	1.9	$41,451		108	108	$916,583	$958,785
28		0.1	0.1	$751		1.9	1.9	$41,431		106	106	$900,548	$942,730
29		0.1	0.1	$751		1.9	1.9	$41,410		104	104	$884,670	$926,831
30		0.1	0.1	$751		1.9	1.9	$41,388		102	102	$868,788	$910,928
31		0.1	0.1	$751		1.9	1.9	$41,365		100	100	$852,888	$895,004
32		0.1	0.1	$751		1.9	1.9	$41,341		98	98	$836,990	$879,081
33		0.1	0.1	$751		1.9	1.9	$41,315		96	96	$821,243	$863,308
34		0.1	0.1	$750		1.9	1.9	$41,288		94	94	$805,332	$847,370
35		0.1	0.1	$750		1.9	1.9	$41,261		93	93	$789,425	$831,436
36		0.1	0.1	$750		1.9	1.9	$41,232		91	91	$773,675	$815,656
37		0.1	0.1	$749		1.9	1.9	$41,202		89	89	$757,765	$799,716
38		0.1	0.1	$749		1.9	1.9	$41,171		87	87	$742,005	$783,925
39		0.1	0.1	$748		1.9	1.9	$41,138		85	85	$726,248	$768,134
40		0.1	0.1	$814		2.0	2.0	$44,720		91	91	$772,999	$818,533
41		0.1	0.1	$813		2.0	2.0	$44,680		89	89	$755,833	$801,326
42		0.1	0.1	$812		2.0	2.0	$44,637		87	87	$738,659	$784,108
43		0.1	0.1	$811		2.0	2.0	$44,592		85	85	$721,472	$766,876
44		0.1	0.1	$811		2.0	2.0	$44,544		83	83	$704,439	$749,793
45		0.3	0.3	$4,516		11.2	11.2	$248,531		450	450	$3,839,713	$4,092,759
46		0.3	0.3	$4,510		11.2	11.2	$248,223		439	439	$3,744,400	$3,997,133
47		0.3	0.3	$4,504		11.2	11.2	$247,895		428	428	$3,649,017	$3,901,416
48		0.3	0.3	$4,498		11.2	11.2	$247,545		417	417	$3,554,497	$3,806,539
49		0.3	0.3	$4,491		11.1	11.1	$247,169		406	406	$3,458,927	$3,710,587
50		0.6	0.6	$7,583		10.9	10.9	$241,668		278	278	$2,367,556	$2,616,807
51		0.6	0.6	$7,569		10.9	10.9	$241,247		270	270	$2,300,847	$2,549,663
52		0.6	0.6	$7,554		10.8	10.8	$240,793		262	262	$2,233,387	$2,481,734
53		0.6	0.6	$7,537		10.8	10.8	$240,306		254	254	$2,166,532	$2,414,374
54		0.6	0.6	$7,518		10.8	10.8	$239,778		246	246	$2,100,246	$2,347,542
55		0.6	0.6	$8,721		10.7	10.7	$192,959		237	237	$2,016,153	$2,217,833
56		0.6	0.6	$8,695		10.7	10.7	$192,468		229	229	$1,950,299	$2,151,462
57		0.6	0.6	$8,668		10.6	10.6	$191,936		221	221	$1,885,027	$2,085,631
58		0.6	0.6	$8,638		10.6	10.6	$191,359		213	213	$1,819,651	$2,019,648
59		0.6	0.6	$8,605		10.6	10.6	$190,735		206	206	$1,754,203	$1,953,542
60	1.3	2.2	3.5	$41,409	14.8	13.6	28.4	$621,971	389	248	637	$2,747,705	$3,411,085
61	1.3	2.1	3.5	$41,194	14.7	13.5	28.2	$619,630	374	239	613	$2,643,581	$3,304,406
62	1.3	2.1	3.4	$40,958	14.7	13.5	28.1	$617,092	359	229	589	$2,539,358	$3,197,408
63	1.3	2.1	3.4	$40,700	14.6	13.4	28.0	$614,322	345	220	565	$2,436,028	$3,091,050
64	1.3	2.1	3.4	$40,414	14.5	13.3	27.9	$611,315	331	211	541	$2,332,623	$2,984,352
65	1.8	3.0	4.8	$56,968	13.7	12.6	26.3	$781,328	155	191	347	$1,881,250	$2,719,546
66	1.8	2.9	4.7	$56,480	13.6	12.5	26.2	$776,841	148	182	331	$1,795,329	$2,628,650
67	1.8	2.9	4.7	$55,941	13.5	12.4	26.0	$771,941	141	174	315	$1,710,228	$2,538,111
68	1.8	2.9	4.6	$55,351	13.4	12.4	25.8	$766,581	134	165	299	$1,625,950	$2,447,881
69	1.7	2.8	4.6	$54,701	13.3	12.3	25.6	$760,719	127	157	284	$1,541,668	$2,357,088
70	2.3	3.8	6.1	$72,605	10.8	9.9	20.7	$615,031	96	119	215	$1,173,146	$1,860,782
71	2.3	3.7	6.0	$71,552	10.7	9.8	20.5	$609,596	91	113	203	$1,107,296	$1,788,444
72	2.2	3.7	5.9	$70,398	10.6	9.7	20.3	$603,635	85	106	191	$1,042,868	$1,716,901
73	2.2	3.6	5.8	$69,134	10.5	9.6	20.1	$597,081	80	100	180	$979,187	$1,645,402
74	2.2	3.5	5.7	$67,749	10.3	9.5	19.9	$589,877	75	93	168	$916,304	$1,573,931
75	2.7	4.5	7.2	$86,336	9.3	8.6	17.9	$579,880	62	80	142	$779,353	$1,445,569
76	2.7	4.4	7.1	$84,188	9.2	8.5	17.7	$571,712	58	74	132	$724,241	$1,380,141
77	2.6	4.3	6.9	$81,843	9.1	8.3	17.4	$562,724	53	69	122	$671,128	$1,315,695
78	2.5	4.1	6.6	$79,298	8.9	8.2	17.1	$552,788	49	63	112	$618,851	$1,250,937
79	2.4	4.0	6.4	$76,534	8.7	8.0	16.7	$541,829	45	58	103	$567,505	$1,185,867
80	2.3	3.8	6.2	$73,544	8.5	7.8	16.4	$529,736	39	53	93	$518,579	$1,121,859
81	2.2	3.7	5.9	$70,318	8.3	7.6	15.9	$516,411	36	48	84	$470,371	$1,057,101
82	2.1	3.5	5.6	$66,853	8.1	7.4	15.5	$501,729	32	44	76	$423,854	$992,436
83	2.0	3.3	5.3	$63,154	7.8	7.2	15.0	$485,557	28	39	68	$379,102	$927,813
84	1.9	3.1	5.0	$59,225	7.5	6.9	14.4	$467,786	25	35	60	$336,227	$863,238
	50	**91**	**141**	**$1,700,288**	**279**	**469**	**748**	**$19,762,123**	**3,359**	**10,279**	**13,638**	**$93,077,532**	**$114,539,943**

Table 27: Estimated Costs Avoided due to the Increase in Controlled Hypertension
Males Between the Ages of 18 and 84
In a British Columbia Birth Cohort of 40,000
With a Co-ordinated Screening Program

	Fatal CV Events & Costs Avoided				Non-Fatal CV Events & Year 1 Costs Avoided				Non-Fatal CV Events & Ongoing Costs Avoided				
Age	AMI	Stroke	Total	Costs	AMI	Stroke	Total	Costs	AMI LY	Stroke LY	Total LY	Costs	Total
18													
19		0.1	0.1	$1,425		1.2	1.2	$25,731		70	70	$597,247	$624,404
20		0.1	0.1	$1,424		1.2	1.2	$25,713		69	69	$587,349	$614,486
21		0.1	0.1	$1,424		1.2	1.2	$25,692		68	68	$577,490	$604,606
22		0.1	0.1	$1,423		1.2	1.2	$25,668		67	67	$567,688	$594,779
23		0.1	0.1	$1,422		1.2	1.2	$25,641		65	65	$557,829	$584,892
24		0.1	0.1	$1,421		1.2	1.2	$25,612		64	64	$547,946	$574,978
25		0.1	0.1	$1,420		1.2	1.2	$25,580		63	63	$538,029	$565,029
26		0.1	0.1	$1,420		1.2	1.2	$25,546		62	62	$528,205	$555,171
27		0.1	0.1	$1,419		1.1	1.1	$25,511		61	61	$518,371	$545,301
28		0.1	0.1	$1,419		1.1	1.1	$25,475		60	60	$508,537	$535,431
29		0.1	0.1	$1,419		1.1	1.1	$25,438		59	59	$498,705	$525,561
30		0.1	0.1	$1,418		1.1	1.1	$25,399		57	57	$488,976	$515,793
31		0.1	0.1	$1,418		1.1	1.1	$25,360		56	56	$479,161	$505,939
32		0.1	0.1	$1,418		1.1	1.1	$25,320		55	55	$469,361	$496,099
33		0.1	0.1	$1,417		1.1	1.1	$25,279		54	54	$459,674	$486,370
34		0.1	0.1	$1,417		1.1	1.1	$25,238		53	53	$449,906	$476,560
35		0.1	0.1	$1,416		1.1	1.1	$25,195		52	52	$440,140	$466,750
36		0.1	0.1	$1,415		1.1	1.1	$25,150		51	51	$430,485	$457,050
37		0.1	0.1	$1,414		1.1	1.1	$25,105		49	49	$420,840	$447,359
38		0.1	0.1	$1,413		1.1	1.1	$25,058		48	48	$411,201	$437,673
39		0.1	0.1	$1,412		1.1	1.1	$25,010		47	47	$401,476	$427,898
40		0.1	0.1	$1,746		1.4	1.4	$30,879		57	57	$484,781	$517,406
41		0.1	0.1	$1,744		1.4	1.4	$30,815		55	55	$473,004	$505,564
42		0.1	0.1	$1,743		1.4	1.4	$30,748		54	54	$461,118	$493,609
43		0.1	0.1	$1,741		1.4	1.4	$30,679		53	53	$449,359	$481,779
44		0.1	0.1	$1,738		1.4	1.4	$30,607		51	51	$437,493	$469,838
45		0.9	0.9	$11,563		9.4	9.4	$207,939		340	340	$2,899,559	$3,119,061
46		0.9	0.9	$11,545		9.3	9.3	$207,401		331	331	$2,820,362	$3,039,308
47		0.9	0.9	$11,525		9.3	9.3	$206,836		321	321	$2,740,402	$2,958,763
48		0.9	0.9	$11,504		9.3	9.3	$206,237		312	312	$2,661,182	$2,878,923
49		0.9	0.9	$11,480		9.3	9.3	$205,605		303	303	$2,581,970	$2,799,055
50		1.0	1.0	$13,821		9.1	9.1	$201,047		203	203	$1,730,492	$1,945,359
51		1.0	1.0	$13,786		9.0	9.0	$200,345		197	197	$1,675,590	$1,889,721
52		1.0	1.0	$13,748		9.0	9.0	$199,597		190	190	$1,620,651	$1,833,996
53		1.0	1.0	$13,707		9.0	9.0	$198,803		184	184	$1,566,257	$1,778,766
54		1.0	1.0	$13,661		8.9	8.9	$197,955		177	177	$1,511,844	$1,723,460
55		1.1	1.1	$14,461		8.8	8.8	$159,158		170	170	$1,447,593	$1,621,212
56		1.1	1.1	$14,402		8.8	8.8	$158,377		164	164	$1,394,607	$1,567,385
57		1.1	1.1	$14,337		8.7	8.7	$157,541		157	157	$1,341,600	$1,513,478
58		1.1	1.1	$14,267		8.7	8.7	$156,647		151	151	$1,289,133	$1,460,047
59		1.1	1.1	$14,189		8.6	8.6	$155,689		145	145	$1,236,668	$1,406,546
60	1.9	3.1	5.1	$60,363	14.4	13.2	27.6	$605,936	333	210	543	$2,333,526	$2,999,824
61	1.9	3.1	5.0	$59,985	14.3	13.1	27.4	$601,564	319	201	520	$2,232,388	$2,893,938
62	1.9	3.1	5.0	$59,567	14.2	13.0	27.2	$596,885	305	192	497	$2,132,384	$2,788,836
63	1.9	3.1	5.0	$59,100	14.1	12.9	27.0	$591,871	291	183	474	$2,032,529	$2,683,500
64	1.9	3.0	4.9	$58,580	13.9	12.8	26.7	$586,507	277	174	451	$1,933,896	$2,578,984
65	2.9	4.7	7.5	$89,870	12.4	11.4	23.8	$707,025	164	149	313	$1,534,333	$2,331,228
66	2.8	4.6	7.5	$88,882	12.3	11.3	23.6	$699,533	156	141	296	$1,453,750	$2,242,165
67	2.8	4.6	7.4	$87,787	12.1	11.1	23.3	$691,538	147	133	280	$1,374,351	$2,153,676
68	2.8	4.5	7.3	$86,582	12.0	11.0	23.0	$682,964	139	126	264	$1,296,100	$2,065,646
69	2.7	4.4	7.1	$85,253	11.8	10.9	22.7	$673,778	130	118	249	$1,219,064	$1,978,095
70	4.2	6.9	11.0	$131,672	9.4	8.6	18.1	$536,296	94	93	187	$948,995	$1,616,964
71	4.1	6.7	10.8	$129,001	9.3	8.5	17.8	$528,549	88	87	176	$888,643	$1,546,193
72	4.0	6.6	10.6	$126,256	9.1	8.4	17.5	$519,849	82	82	164	$829,379	$1,475,484
73	3.9	6.4	10.3	$123,256	9.0	8.2	17.2	$510,564	76	76	152	$771,945	$1,405,764
74	3.8	6.2	10.1	$119,973	8.8	8.1	16.9	$500,686	71	70	141	$715,214	$1,335,873
75	4.0	6.6	10.6	$126,973	8.1	7.5	15.6	$505,657	57	62	119	$617,589	$1,250,219
76	3.9	6.4	10.3	$122,748	8.0	7.3	15.3	$494,339	53	57	109	$568,451	$1,185,538
77	3.8	6.2	9.9	$118,177	7.8	7.1	14.9	$482,266	48	52	100	$520,637	$1,121,080
78	3.6	5.9	9.5	$113,249	7.6	6.9	14.5	$469,388	44	47	91	$474,726	$1,057,363
79	3.4	5.6	9.1	$107,953	7.3	6.7	14.1	$455,663	40	43	83	$430,265	$993,881
80	3.3	5.3	8.6	$102,293	7.1	6.5	13.6	$441,022	32	38	70	$378,509	$921,824
81	3.1	5.0	8.1	$96,276	6.8	6.3	13.1	$425,412	28	34	63	$338,950	$860,637
82	2.9	4.7	7.5	$89,918	6.6	6.0	12.6	$408,775	25	31	56	$301,423	$800,116
83	2.6	4.3	7.0	$83,251	6.3	5.8	12.1	$391,040	22	27	49	$265,955	$740,246
84	2.4	4.0	6.4	$76,318	6.0	5.5	11.5	$372,145	19	24	43	$232,586	$681,048
	76	**143**	**219**	**$2,639,779**	**249**	**395**	**643**	**$16,985,880**	**3,040**	**7,295**	**10,336**	**$67,127,866**	**$86,753,526**

Summary of CE – Males and Females

- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the CE associated with screening for and treatment of hypertension in adults 18 years and older in a British Columbia birth cohort of 40,000 is cost-saving (Table 28, row v).

Table 28: CE of Screening and Treatment for Hypertension
Ages 18 - 84
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
	Cost of Screening Program		
a	Physician costs (in millions) - Females	$18.33	Table 23
b	Lab test costs (in millions) - Females	$15.08	Table 23
c	Medication costs (in millions) - Females	$17.26	Table 23
d	Patient time costs (in millions) - Females	$37.88	Table 23
e	Physician costs (in millions) - Males	$16.25	Table 24
f	Lab test costs (in millions) - Males	$14.76	Table 24
g	Medication costs (in millions) - Males	$20.80	Table 24
h	Patient time costs (in millions) - Males	$33.57	Table 24
i	**Total Screening Program Costs**	**$173.92**	Sum a...h
	Cost of Harms		
j	Treatment costs for SAE (in millions) - Females	$13.6	Table 25
k	Patient time costs for SAE (in millions) - Females	$2.4	Table 25
l	Treatment costs for SAE (in millions) - Males	$13.3	Table 25
m	Patient time costs for SAE (in millions) - Males	$2.4	Table 25
n	**Total Cost of Harms**	**$31.83**	Sum j...m
	Treatment Costs Avoided with a Screening Program		
o	Cost of treating new AMI and strokes avoided (in millions) - Females	$19.76	Table 26
p	Cost of treating those living with AMI or stroke avoided (in millions) - Females	$93.08	Table 26
q	Cost of treating those who die due to AMI or stroke avoided (in millions) - Females	$1.70	Table 26
r	Cost of treating new AMI and strokes avoided (in millions) - Males	$16.99	Table 26
s	Cost of treating those living with AMI or stroke avoided (in millions) - Males	$67.13	Table 26
t	Cost of treating those who die due to AMI or stroke avoided (in millions) - Males	$2.64	Table 26
p	**Total Treatment Costs Avoided**	**$201.29**	Sum o...t
	CE per QALY Gained		
q	Net cost of screening and treatment (in millions)	$4.45	= i + n - p
r	Total QALYs gained	16,548	Table 20
s	CE ($/QALY gained)	$269	q / r * 1,000,000
t	Net cost of screening and treatment (in millions, 1.5% discount)	-$1.84	Calculated
u	Total QALYs gained, 1.5% Discount	8,876	Calculated
v	**CE ($/QALY gained), 1.5% Discount**	Cost Saving	Calculated

Sensitivity Analysis – Males and Females

We also modified several major assumptions and recalculated the CE as follows:

- The rate of cerebrovascular mortality and morbidity in those ages 18-59 on treatment for hypertension decreases from 6 to 5 per 1,000 over a 5-year period and from 34 to 31 per 1,000 over a 3.8-year period for those ages 60 and older; the rate of coronary heart disease mortality and morbidity in those ages 60 and older decreases from 37 to 33 per 1,000 over a 3.8-year period (see Table 8). CE = Cost-saving
- The rate of cerebrovascular mortality and morbidity in those ages 18-59 on treatment for hypertension increases from 6 to 9 per 1,000 over a 5-year period and from 34 to 39 per 1,000 over a 3.8-year period for those ages 60 and older; the rate of coronary heart disease mortality and morbidity in those ages 60 and older increases decreases from 37 to 42 per 1,000 over a 3.8-year period (see Table 8). **CE = $8,506**
- The average disutility of living with a stroke is increased from 0.200 to 0.265. CE = Cost-saving
- The average disutility of living with a stroke is decreased from 0.200 to 0.134. CE = Cost-saving
- The disutility associated with taking preventive medication is increased from 0.0024 to 0.0033. CE = Cost-saving
- The disutility associated with taking preventive medication is reduced from 0.0024 to 0.0. CE = Cost-saving
- Assume that those visits to a physician's office requiring 0.5 of an office visit would instead take a full office visit. CE = $7,439
- Assume that the annual costs associated with care following a stroke are reduced by 25% from $8,524 to $6,393. CE = $2,458
- Assume that the annual costs associated with care following a stroke are increased by 25% from $8,524 to $10,655. CE = Cost-saving

Summary of CE – Females Only

Based on these assumptions, the CE associated with screening for and treatment of hypertension in females 18 years and older in a British Columbia birth cohort of 40,000 is cost-saving (Table 29, row v).

Table 29: CE of Screening and Treatment for Hypertension
Females Ages 18 - 84
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
	Cost of Screening Program		
a	Physician costs (in millions) - Females	$18.33	Table 23
b	Lab test costs (in millions) - Females	$15.08	Table 23
c	Medication costs (in millions) - Females	$17.26	Table 23
d	Patient time costs (in millions) - Females	$37.88	Table 23
e	Physician costs (in millions) - Males		Table 24
f	Lab test costs (in millions) - Males		Table 24
g	Medication costs (in millions) - Males		Table 24
h	Patient time costs (in millions) - Males		Table 24
i	**Total Screening Program Costs**	**$88.54**	Sum a...h
	Cost of Harms		
j	Treatment costs for SAE (in millions) - Females	$13.6	Table 25
k	Patient time costs for SAE (in millions) - Females	$2.4	Table 25
l	Treatment costs for SAE (in millions) - Males		Table 25
m	Patient time costs for SAE (in millions) - Males		Table 25
n	**Total Cost of Harms**	**$16.08**	Sum j...m
	Treatment Costs Avoided with a Screening Program		
o	Cost of treating new AMI and strokes avoided (in millions) - Females	$19.76	Table 26
p	Cost of treating those living with AMI or stroke avoided (in millions) - Females	$93.08	Table 26
q	Cost of treating those who die due to AMI or stroke avoided (in millions) - Females	$1.70	Table 26
r	Cost of treating new AMI and strokes avoided (in millions) - Males		Table 26
s	Cost of treating those living with AMI or stroke avoided (in millions) - Males		Table 26
t	Cost of treating those who die due to AMI or stroke avoided (in millions) - Males		Table 26
p	**Total Treatment Costs Avoided**	**$114.54**	Sum o...t
	CE per QALY Gained		
q	Net cost of screening and treatment (in millions)	-$9.92	= i + n - p
r	Total QALYs gained	8,778	Table 21
s	CE ($/QALY gained)	-$1,129	q / r * 1,000,000
t	Net cost of screening and treatment (in millions, 1.5% discount)	-$8.73	Calculated
u	Total QALYs gained, 1.5% Discount	4,730	Calculated
v	**CE ($/QALY gained), 1.5% Discount**	Cost Saving	Calculated

Sensitivity Analysis – Females Only

We also modified several major assumptions and recalculated the CE for females as follows:

- The rate of cerebrovascular mortality and morbidity in females ages 18-59 on treatment for hypertension decreases from 6 to 5 per 1,000 over a 5-year period and from 34 to 31 per 1,000 over a 3.8-year period for females ages 60 and older; the rate of coronary heart disease mortality and morbidity in females ages 60 and older decreases from 37 to 33 per 1,000 over a 3.8-year period (see Table 8). CE = Cost-saving
- The rate of cerebrovascular mortality and morbidity in females ages 18-59 on treatment for hypertension increases from 6 to 9 per 1,000 over a 5-year period and from 34 to 39 per 1,000 over a 3.8-year period for females ages 60 and older; the rate of coronary heart disease mortality and morbidity in females ages 60 and older increases decreases from 37 to 42 per 1,000 over a 3.8-year period (see Table 8). **CE = $6,597**
- The average disutility of living with a stroke is increased from 0.200 to 0.265. CE = Cost-saving
- The average disutility of living with a stroke is decreased from 0.200 to 0.134. CE = Cost-saving
- The disutility associated with taking preventive medication is increased from 0.0024 to 0.0033. CE = Cost-saving
- The disutility associated with taking preventive medication is reduced from 0.0024 to 0.0. CE = Cost-saving
- Assume that those visits to a physician's office requiring 0.5 of an office visit would instead take a full office visit. CE = $5,806
- Assume that the annual costs associated with care following a stroke are reduced by 25% from $8,524 to $6,393. CE = $1,106
- Assume that the annual costs associated with care following a stroke are increased by 25% from $8,524 to $10,655. CE = Cost-saving

Summary of CE – Males Only

Based on these assumptions, the CE associated with screening for and treatment of hypertension in males 18 years and older in a British Columbia birth cohort of 40,000 000 is $1,162 (Table 30, row v).

Table 30: CE of Screening and Treatment for Hypertension
Ages 18 - 84
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
	Cost of Screening Program		
a	Physician costs (in millions) - Females		Table 23
b	Lab test costs (in millions) - Females		Table 23
c	Medication costs (in millions) - Females		Table 23
d	Patient time costs (in millions) - Females		Table 23
e	Physician costs (in millions) - Males	$16.25	Table 24
f	Lab test costs (in millions) - Males	$14.76	Table 24
g	Medication costs (in millions) - Males	$20.80	Table 24
h	Patient time costs (in millions) - Males	$33.57	Table 24
i	**Total Screening Program Costs**	**$85.38**	Sum a...h
	Cost of Harms		
j	Treatment costs for SAE (in millions) - Females		Table 25
k	Patient time costs for SAE (in millions) - Females		Table 25
l	Treatment costs for SAE (in millions) - Males	$13.3	Table 25
m	Patient time costs for SAE (in millions) - Males	$2.4	Table 25
n	**Total Cost of Harms**	**$15.74**	Sum j...m
	Treatment Costs Avoided with a Screening Program		
o	Cost of treating new AMI and strokes avoided (in millions) - Females		Table 26
p	Cost of treating those living with AMI or stroke avoided (in millions) - Females		Table 26
q	Cost of treating those who die due to AMI or stroke avoided (in millions) - Females		Table 26
r	Cost of treating new AMI and strokes avoided (in millions) - Males	$16.99	Table 26
s	Cost of treating those living with AMI or stroke avoided (in millions) - Males	$67.13	Table 26
t	Cost of treating those who die due to AMI or stroke avoided (in millions) - Males	$2.64	Table 26
p	**Total Treatment Costs Avoided**	**$86.75**	Sum o...t
	CE per QALY Gained		
q	Net cost of screening and treatment (in millions)	$14.37	= i + n - p
r	Total QALYs gained	7,769	Table 22
s	CE ($/QALY gained)	$1,849	q / r * 1,000,000
t	Net cost of screening and treatment (in millions, 1.5% discount)	$6.89	Calculated
u	Total QALYs gained, 1.5% Discount	4,146	Calculated
v	**CE ($/QALY gained), 1.5% Discount**	$1,662	Calculated

Sensitivity Analysis – Males Only

We also modified several major assumptions and recalculated the CE for males as follows:

- The rate of cerebrovascular mortality and morbidity in males ages 18-59 on treatment for hypertension decreases from 6 to 5 per 1,000 over a 5-year period and from 34 to 31 per 1,000 over a 3.8-year period for males ages 60 and older; the rate of coronary heart disease mortality and morbidity in males ages 60 and older decreases from 37 to 33 per 1,000 over a 3.8-year period (see Table 8). CE = Cost-saving
- The rate of cerebrovascular mortality and morbidity in males ages 18-59 on treatment for hypertension increases from 6 to 9 per 1,000 over a 5-year period and from 34 to 39 per 1,000 over a 3.8-year period for males ages 60 and older; the rate of coronary heart disease mortality and morbidity in males ages 60 and older increases decreases from 37 to 42 per 1,000 over a 3.8-year period (see Table 8). **CE = $10,663**
- The average disutility of living with a stroke is increased from 0.200 to 0.265. CE = $1,526
- The average disutility of living with a stroke is decreased from 0.200 to 0.134. CE = $1,828
- The disutility associated with taking preventive medication is increased from 0.0024 to 0.0033. CE = $1,680
- The disutility associated with taking preventive medication is reduced from 0.0024 to 0.0. CE = $1,617
- Assume that those visits to a physician's office requiring 0.5 of an office visit would instead take a full office visit. CE = $9,304
- Assume that the annual costs associated with care following a stroke are reduced by 25% from $8,524 to $6,393. CE = $4,000
- Assume that the annual costs associated with care following a stroke are increased by 25% from $8,524 to $10,655. CE = Cost-saving

Summary – Males and Females

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening for and treatment of hypertension in adults 18 years and older in a British Columbia birth cohort of 40,000 is estimated to be 8,876 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be cost-saving (see Table 31).

Table 31: Screening and Treatment for Hypertension
Ages 18-84
in a BC Birth Cohort of 40,000
Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume Current Service (Screening rate of 88.1%)			
1.5% Discount Rate	**8,876**	5,434	10,733
3% Discount Rate	4,785	2,895	5,739
0% Discount Rate	16,548	10,222	20,142
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**Cost Saving**	Cost-Saving	$8,506
3% Discount Rate	Cost-Saving	Cost-Saving	$9,510
0% Discount Rate	$269	Cost-Saving	$8,125
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	Cost-Saving	Cost-Saving	Cost-Saving
3% Discount Rate	Cost-Saving	Cost-Saving	Cost-Saving
0% Discount Rate	Cost-Saving	Cost-Saving	Cost-Saving

Summary – Females Only

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening for and treatment of hypertension in females 18 years and older in a British Columbia birth cohort of 40,000 is estimated to be 4,730 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be cost-saving (see Table 32).

Table 32: Screening and Treatment for Hypertension
Females Ages 18-84
in a BC Birth Cohort of 40,000
Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume Current Service (Screening rate of 88.1%)			
1.5% Discount Rate	**4,730**	2,882	5,719
3% Discount Rate	2,568	1,547	3,079
0% Discount Rate	8,778	5,395	10,687
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**Cost Saving**	Cost-Saving	$6,597
3% Discount Rate	Cost-Saving	Cost-Saving	$7,258
0% Discount Rate	Cost-Saving	Cost-Saving	$6,462
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	Cost-Saving	Cost-Saving	Cost-Saving
3% Discount Rate	Cost-Saving	Cost-Saving	Cost-Saving
0% Discount Rate	Cost-Saving	Cost-Saving	Cost-Saving

Summary – Males Only

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening for and treatment of hypertension in males 18 years and older in a British Columbia birth cohort of 40,000 is estimated to be 4,146 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $1,662 per QALY (see Table 33).

Table 33: Screening and Treatment for Hypertension
Males Ages 18-84
in a BC Birth Cohort of 40,000
Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume Current Service (Screening rate of 88.1%)			
1.5% Discount Rate	**4,146**	2,552	5,014
3% Discount Rate	2,217	1,348	2,660
0% Discount Rate	7,769	4,827	9,454
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$1,662**	Cost-Saving	$10,663
3% Discount Rate	$1,703	Cost-Saving	$12,093
0% Discount Rate	$1,849	Cost-Saving	$9,985
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	Cost-Saving	Cost-Saving	Cost-Saving
3% Discount Rate	Cost-Saving	Cost-Saving	Cost-Saving
0% Discount Rate	Cost-Saving	Cost-Saving	Cost-Saving

United States Preventive Services Task Force Recommendations (2016)

The USPSTF recommends initiating use of low- to moderate-dose statins in adults aged 40 to 75 years without a history of CVD who have 1 or more CVD risk factors (dyslipidemia, diabetes, hypertension, or smoking) and a calculated 10-year CVD event risk of 10% or greater. (B recommendation)

Identification of dyslipidemia and calculation of 10-year CVD event risk requires universal lipids screening in adults aged 40-74 years.

The USPSTF recommends using the ACC/AHA Pooled Cohort Equations to calculate the 10-year risk of CVD events. The calculator derived from these equations takes into account age, sex, race, cholesterol levels, blood pressure level, antihypertension treatment, presence of diabetes, and smoking status as risk factors. [790]

The CTFPHC has not completed a recent update due to the review completed by the Canadian Cardiovascular Society (CCS) in 2016.[791] A number of the CCS recommendations, particularly those associated with screening and primary prevention, are highlighted below.

Canadian Cardiovascular Society (2016)

Screening
We recommend that a CV risk assessment be completed every 5 years for men and women aged 40 to 75 years using the modified FRS (Framingham Heart Study Risk Score) or CLEM (Cardiovascular Life Expectancy Model) to guide therapy to reduce major CV events. A risk assessment might also be completed whenever a patient's expected risk status changes. (Strong Recommendation; High Quality Evidence).

Primary Prevention
We recommend management that does not include statin therapy for individuals at low risk (modified FRS < 10%) to decrease the risk of CVD events. (Strong Recommendation; High-Quality Evidence).

We recommend management that includes statin therapy for individuals at high risk (modified FRS ≥ 20%) to decrease the risk of CVD events. (Strong Recommendation; High-Quality Evidence).

We recommend management that includes statin therapy for individuals at IR (intermediate risk: modified FRS 10%-19%) with LDL-C ≥ 3.5 mmol/L to decrease the risk of CVD events. Statin therapy should also be considered for IR persons with LDL-C < 3.5 mmol/L but with apoB ≥ 1.2 g/L or non-HDL-C ≥ 4.3 mmol/L or in men 50 years of age and older and women 60 years of age and older with ≥ 1 CV risk factor. (Strong Recommendation; High-Quality Evidence). [792]

[790] Bibbins-Domingo K, Grossman D, Curry S et al. Statin use for the primary prevention of cardiovascular disease in adults: US Preventive Services Task Force recommendation statement. *Journal of the American Medical Association*. 2016; 316(19): 1997-2007.
[791] Dr. Richard Birtwhistle, Member, Canadian Task Force on Preventive Health Care. Personal communication, January 25, 2017.
[792] Anderson T, Gregiore J, Pearson G et al. 2016 Canadian Cardiovascular Society guidelines for the management of dyslipidemia for the prevention of cardiovascular disease in then adult. *Canadian Journal of Cardiology.* 2016; 32: 1263-82.

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB and CE associated with universal screening for and initiating use of low- to moderate-dose statins in adults aged 40 to 75 years without a history of CVD, who have 1 or more CVD risk factors, and a calculated 10-year CVD event risk of 10% or greater.

In estimating CPB, we made the following assumptions:

- Based on BC life tables for 2018 to 2020, there are a total of 1,281,822 life years lived and 7,719 deaths between the ages of 40 and 74 in a BC birth cohort of 40,000 (see Table 1).

Table 1: Deaths and Years of Life Lived and Lost Between the Ages of 40 and 74
in a British Columbia Birth Cohort of 40,000

Age Group	*Life Years Lived*	*Deaths in Birth Cohort*	*Deaths due to* Cardiovascular Disease		Cerebrovascular Disease		*Life Years Lost*			
			%	#	%	#	Life Expectancy	All Deaths	Cardio	Cerebro
40-44	194,020	307	4.20%	13	1.46%	4	42.1	12,926	543	189
45-49	192,260	404	12.11%	49	2.44%	10	37.4	15,134	1,833	369
50-54	189,873	562	12.11%	68	2.44%	14	32.8	18,473	2,237	451
55-59	186,494	807	12.11%	98	2.44%	20	28.4	22,887	2,772	558
60-64	181,582	1,185	12.11%	143	2.44%	29	24.0	28,475	3,448	695
65-69	174,288	1,774	14.50%	257	4.57%	81	19.9	35,274	5,115	1,612
70-74	163,305	2,679	14.50%	388	4.57%	122	16.0	42,798	6,206	1,956
Total	**1,281,822**	**7,719**	**13.17%**	**1,017**	**3.63%**	**280**		**175,967**	**22,153**	**5,830**

- Based on BC vital statistics data, 46 of 1,094 (4.20%) deaths in 25-44 year olds in 2015 were due to cardiovascular disease (ICD-10 codes I00-I51) and 16 of 1,094 (1.46%) deaths were due to cerebrovascular disease (ICD-10 codes I60-I69). In 45-64 year olds, 645 of 5,324 (12.11%) deaths were due to cardiovascular disease, and 130 of 5,324 (2.44%) deaths were due to cerebrovascular disease. In 65-79 year olds, 1,397 of 9,636 (14.50%) deaths were due to cardiovascular disease while 440 of 9,636 (4.57%) deaths were due to cerebrovascular disease.[793] This data was used to estimate that approximately 1,017 (13.17%) of the 7,719 deaths in the birth cohort would be due to cardiovascular disease and 280 (3.63%) due to cerebrovascular disease (see Table 1 and Table 3, rows *f*, *g*, *h* & *i*).
- We are not aware of any information which indicates the proportion of adults aged 40 to 74 years in BC who have had a cardiovascular risk assessment within the past five years. Nor are we aware of BC-specific data on the proportion of adults at intermediate or higher risk of CVD who are taking statins over the longer term for primary prevention purposes. Research suggests that 54.8% of Canadians between the ages of 40 and 79 are at low risk (defined as a mean 10-year risk of a CVD event of less than 10%), 14.4% are at intermediate risk (mean 10-year risk of a CVD event of 10%-19%) and 30.9% are at high risk (mean 10-year risk of a CVD event of ≥20%)[794] (see Table 2 below and Table 3, row *b*).

[793] British Columbia Vital Statistics Agency. *Selected Vital Statistics and Health Status Indicators: One Hundred and Forty-Fourth Annual Report.* 2015. British Columbia Ministry of Health. Available at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2015/pdf/annual-report-2015.pdf. Accessed March 2023.
[794] Hennessy D, Tanuseputro P, Tuna M et al. Population health impact of statin treatment in Canada. *Health Reports*. 2016; 27(1): 20-8.

Table 2: Estimated Number of Canadian Adults Ages 40-79 By CVD Risk Status, 2007 to 2011

Age Group	Population	Estimated # by CVD Risk Status			Estimated % by CVD Risk Status		
		Low	Int.	High	Low	Int.	High
20-39	8,983,467	8,893,999	4,335	85,133	99.0%	0.05%	0.95%
40-59	9,863,690	7,231,730	1,014,437	1,617,523	73.3%	10.3%	16.4%
60-79	5,186,843	1,011,071	1,148,828	3,026,944	19.5%	22.1%	58.4%
Total	**24,034,000**	**17,136,800**	**2,167,600**	**4,729,600**	**71.3%**	**9.0%**	**19.7%**
40-79	15,050,533	8,242,801	2,163,265	4,644,467	54.8%	14.4%	30.9%

- In a systematic review for the USPSTF, Chou et al included 19 randomized control trials (RCTs) with 71,344 participants with a mean age between 51 and 66 years and an average of 4.1 years of follow-up. They conclude that statin therapy is associated with a decreased risk of the following: [795]
  - All-cause mortality (RR, 0.86 [95% CI, 0.80 to 0.93]) (Table 3, row *y*)
  - Cardiovascular mortality (RR, 0.69 [95% CI, 0.54 to 0.88])
  - Myocardial infarction (RR, 0.64 [95% CI, 0.57 to 0.71]) (Table 3, row *ab*)
  - Stroke (RR, 0.71 [95% CI, 0.62 to 0.82]) (Table 3, row *ae*)
- Based on the review for the USPSTF, statin therapy (when compared with a placebo) is not associated with an increased risk of withdrawal due to adverse events, serious adverse events, any cancer, fatal cancer, myalgias or elevated aminotransferase levels, rhabdomyolysis or myopathy, renal dysfunction, cognitive harms or new-onset diabetes following initiation of statin therapy.[796]
- The review for the USPSTF by Chou et al has been criticized on several fronts. Redberg and Katz note that the review did not exclude studies that included patients taking statins for secondary prevention.[797] A 2010 review by Ray and colleagues, which included only studies of patients receiving statins for primary prevention, did not find a benefit of statin use and all-cause mortality (RR, 0.91; 95% CI of 0.83 to 1.01).[798] In addition, Redberg and Katz note that the most commonly reported side effect of muscle weakness and pain is not included in the review by Chou et al. Clinical trials suggest that statin myopathy occurs in 1-5% of patients while it may range as high as 20-30% based on observations in clinical practice.[799,800]

[795] Chou R, Dana T, Blazina I et al. Statins for prevention of cardiovascular disease in adults: evidence report and systematic review for the US Preventive Services Task Force. *Journal of the American Medical Association*. 2016; 316(19): 2008-24.
[796] Ibid.
[797] Redberg R and Katz M. Statins for primary prevention: the debate is intense, but the data are weak. *Journal of the American Medical Association*. 2016; 316(19): 1979-81.
[798] Ray K, Seshasai S, Erqou S et al. Statins and all-cause mortality in high-risk primary prevention: a meta-analysis of 11 randomized controlled trials involving 65 229 participants. *Archives of Internal Medicine*. 2010; 170(12): 1024-31.
[799] Magni P, Macchi C, Morlotti B et al. Risk identification and possible countermeasures for muscle adverse effects during statin therapy. *European Journal of Internal Medicine*. 2015; 26(2): 82-8.
[800] Thompson P. What to believe and do about statin-associated adverse effects. *Journal of the American Medical Association*. 2016; 316(19): 1969-70.

- In a 2016 review of the available evidence on the safety of statin therapy, Collins and colleagues note that "(t)he only serious adverse events that have been shown to be caused by long-term statin therapy - i.e., adverse effects of the statin, are myopathy (defined as muscle pain or weakness combined with large increases in blood concentrations of creatine kinase), new-onset diabetes mellitus, and, probably, haemorrhagic stroke. Typically, treatment of 10 000 patients for 5 years with an effective regimen (e.g., atorvastatin 40 mg daily) would cause about 5 cases of myopathy (one of which might progress, if the statin therapy is not stopped, to the more severe condition of rhabdomyolysis), 50–100 new cases of diabetes, and 5–10 haemorrhagic strokes. However, any adverse impact of these side-effects on major vascular events has already been taken into account in the estimates of the absolute benefits. Statin therapy may cause symptomatic adverse events (e.g., muscle pain or weakness) in up to about 50–100 patients (i.e., 0.5–1.0% absolute harm) per 10 000 treated for 5 years. However, placebo-controlled randomised trials have shown definitively that almost all of the symptomatic adverse events that are attributed to statin therapy in routine practice are not actually caused by it (i.e., they represent misattribution)….It is, therefore, of concern that exaggerated claims about side-effect rates with statin therapy may be responsible for its under-use among individuals at increased risk of cardiovascular events. For, whereas the rare cases of myopathy and any muscle-related symptoms that are attributed to statin therapy generally resolve rapidly when treatment is stopped, the heart attacks or strokes that may occur if statin therapy is stopped unnecessarily can be devastating."[801]
- The controversy over side-effects continues, especially regarding muscle problems, as evidenced by the series of letters in the March 18, 2017 issue of *The Lancet* responding to the Collins et al review. In our sensitivity analysis, we have included an assumption that 5%[802,803] of patients taking statins would develop muscle problems and that their QoL would be reduced by 53%[804] during the estimated 3 months it would take for the statin withdrawal and rechallenge process[805,806] to determine that the muscle problem is associated with the use of statins.
- Other assumptions used in assessing the clinically preventable burden are detailed in the Reference Document.

Based on these assumptions, the CPB associated with universal CVD risk-factor screening and initiating use of low- to moderate-dose statins in adults aged 40 to 74 years without a history of CVD who have 1 or more CVD risk factors and a calculated 10-year CVD event risk of 10% or greater is 7,102 QALYs (see Table 3, row *ap*). This is based on the assumption of moving from no statin use in this intermediate or high risk cohort, to 30% of this cohort initiating and sustaining statin use.

[801] Collins R, Reith C, Emberson J et al. Interpretation of the evidence for the efficacy and safety of statin therapy. *The Lancet*. 2016; 388(10059): 2532-61.
[802] Parker B, Capizzi J, Grimaldi A et al. The effect of statins on skeletal muscle function. *Circulation*. 2013; 127(1): 96-103.
[803] Ganga H, Slim H and Thompson P. A systematic review of statin-induced muscle problems in clinical trials. *American Heart Journal*. 2014; 168(1): 6-15.
[804] Cham S, Evans M, Denenberg J et al. Statin-associated muscle-related adverse effects: a case series of 354 patients. *Pharmacotherapy: The Journal of Human Pharmacology and Drug Therapy*. 2010; 30(6): 541-53.
[805] Jacobson T. Toward "pain-free" statin prescribing: clinical algorithm for diagnosis and management of myalgia. *Mayo Clinic Proceedings*. 2008; 83(6): 687-700.
[806] Ahmad Z. Statin intolerance. *American Journal of Cardiology*. 2014; 113(10): 1765-71.

Table 3: CPB of Universal Screening for and Initiating Use of Statins in Adults Aged 40 to 74 Years with an Intermediate or High Risk of CVD in a Birth Cohort of 40,000			
Label	**Variable**	**Base Case**	**Data Source**
	Estimated current status		
a	# of life years lived between the ages of 40-74 in birth cohort	1,281,822	Table 1
b	% of life years at intermediate or high risk	45.2%	Table 2
c	# of life years at intermediate or high risk	579,800	= (a * b)
d	% of life years at intermediate or high risk on statins	30.0%	See Ref Doc
e	# of life years at intermediate or high risk on statins	173,940	= (c * d)
f	Total deaths in birth cohort between the ages of 40-74	7,719	Table 1
g	Cardiovascular deaths in birth cohort between the ages of 40-74	1,017	Table 1
h	Cerebrovascular deaths in birth cohort between the ages of 40-74	280	Table 1
i	**Life years lost due to total deaths**	**175,967**	Table 1
j	Life years lost per death	22.8	= (i / f)
k	# of nonfatal cardiovascular events per fatal event	5.09	See Ref Doc
l	# of nonfatal cardiovascular events	5,176	= (g * k)
m	Average age of individual with a cardiovascular event	68.0	See Ref Doc
n	Life years lived with a nonfatal cardiovascular event	12.1	See Ref Doc
o	Life years lost due to a nonfatal cardiovascular event	6.3	See Ref Doc
p	QoL reduction living with a nonfatal cardiovascular event (for 1 month)	0.098	See Ref Doc
q	**QALYs lost due to nonfatal cardiovascular events**	**507**	= l * p
r	Ratio of nonfatal cerebrovascular events per fatal event	4.58	See Ref Doc
s	# of nonfatal cerebrovascular events	1,283	= (r * h)
t	Average age of individual with a cerebrovascular event	72.8	See Ref Doc
u	Life years lived with a nonfatal cerebrovascular event	9.3	See Ref Doc
v	Life years lost due to a nonfatal cerebrovascular event	5.5	See Ref Doc
w	QoL reduction living with a nonfatal cerebrovascular event	0.200	See Ref Doc
x	**QALYs lost due to nonfatal cerebrovascular events**	**2,387**	= (s * u * w)
	Benefits **if 30% of intermediate or high risk individuals were on statins**		
y	% reduction in all cause mortality associated with statin use	14%	√
z	Deaths avoided with statin usage	324	= (f * d * y)
aa	**QALYs gained due to a reduction in all cause mortality**	**7,391**	= (z * j)
ab	% reduction in cardiovascular events associated with statin use	36%	√
ac	Cardiovascular events avoided with 30% statin usage	559	= (l * d *ab)
ad	**QALYs gained due to a reduction in nonfatal cardiovascular events associated with statin use**	**55**	= (q * d * ab)
ae	% reduction in cerebrovascular events associated with statin use	29%	√
af	Cerebrovascular events avoided with 30% statin usage	112	= (s * d * ae)
ag	**QALYs gained due to a reduction in nonfatal cerebrovascular events associated with statin use**	**208**	= (af * t * u)
ah	**Total QALYs gained if 30% of intermediate or high risk individuals were on statins**	**7,653**	= (aa + ad + ag)
	Harms **if 30% of intermediate or high risk individuals were on statins**		
ai	Disutility per year associated with taking pills for cardiovascular prevention	-0.0032	See Ref Doc
aj	**Disutility associated with taking pills for cardiovascular prevention**	**-551**	= (e * ai)
ak	Proportion of individuals taking statins who experience muscle problems	0.0%	√
al	Length of time for muscle problems to be indentified and resolved (in years)	0.25	√
am	Disutilty per year associated with muscle problems	-0.53	√
an	**Disutility associated with muscle problems**	**0**	Table 1 * b * ak * al * am
ao	**QALYs lost if 30% of intermediate or high risk individuals were on statins**	**-551**	= (aj + an)
ap	**Potential QALYs gained, Screening & Intervention from 0% to 30%**	**7,102**	= (ah + ao)

√ = Estimates from the literature

For our sensitivity analysis, we modified a number of major assumptions and recalculated the CPB as follows:

- Assume that decreased risk of all-cause mortality associated with statin therapy is reduced from 14% to 7% (Table 3, row *y*), the decreased risk of a myocardial infarction is reduced from 36% to 29% (Table 3, row *ab*) and the decreased risk of stroke is reduced from 29% to 18% (Table 3, row *ae*): **CPB = 3,317**.
- Assume that decreased risk of all-cause mortality associated with statin therapy is increased from 14% to 20% (Table 3, row *y*), the decreased risk of a myocardial infarction is increased from 36% to 43% (Table 3, row *ab*) and the decreased risk of stroke is increased from 29% to 38% (Table 3, row *ae*): **CPB = 10,344**.
- Assume that the disutility per year associated with taking pills for cardiovascular prevention is reduced from -0.0032 to 0.0 (Table 3, row *ai*): CPB = 7,653.
- Assume that the disutility per year associated with taking pills for cardiovascular prevention is increased from -0.0032 to -0.0044 (Table 3, row *ai*): CPB = 6,895.
- Assume that the percent of life years at intermediate risk on statins is reduced from 30% to 25% (Table 3, row *d*): CPB = 5,918.
- Assume that the percent of life years at intermediate risk on statins is increased from 30% to 40% (Table 3, row *d*): CPB = 9,469.
- Assume that statin use is associated with muscle problems in 5% of users (Table 3, row *ak*): CPB = 5,949.

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with universal screening for and initiating use of low- to moderate-dose statins in adults aged 40 to 74 years without a history of CVD, who have 1 or more CVD risk factors, and a calculated 10-year CVD event risk of 10% or greater.

In estimating CE, we made the following assumptions:

Cost of Screening for CVD Risk

- The USPSTF recommends using the ACC/AHA Pooled Cohort Equations to calculate the 10-year risk of CVD events.[807]
- The *2013 ACC/AHA Guideline on the Assessment of Cardiovascular Risk* indicate that "it is reasonable to …estimate 10-year ASCVD risk every 4-6 years in adults 40-79 years of age who are free from ASCVD."[808]
- The ACC-AHA-ASCVD score, however, overestimates the 10-year ASCVD risk. The USPSTF recognizes this. "The reasons for this possible overestimation are still unclear. The Pooled Cohort Equations were derived from prospective cohorts of volunteers from studies conducted in the 1990s and may not be generalizable to a

[807] Bibbins-Domingo K, Grossman D, Curry S et al. Statin use for the primary prevention of cardiovascular disease in adults: US Preventive Services Task Force recommendation statement. *Journal of the American Medical Association*. 2016; 316(19): 1997-2007.
[808] Goff D, Lloyd-Jones D, Bennett G et al. 2013 ACC/AHA guideline on the assessment of cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on practice guidelines. *Circulation*. 2014; 135(2): S49-S74.

more contemporary and diverse patient population seen in current clinical practice."[809]

- Cook and Ridker, using the Women's Health Study, found that the ACC-AHA-ASCVD score overestimated the actual 10-year ASCVD risk in women by 43% to 90% in women, depending on their baseline risk.[810] DeFilippis and colleagues compared the performance of five risk assessment tools in a community-based, sex-balanced, multiethnic cohort. The ACC-AHA-ASCVD score overestimated the 10-year ASCVD risk by 78%. They found that the best risk assessment tool was the Reynolds Risk Score.[811] Rana and co-authors used a large contemporary, multi-ethnic population to assess the ACC-AHA-ASCVD score. They found that the ACC-AHA-ASCVD score substantially overestimated the actual 5-year ASCVD risk and that this overestimation was similar in both males and females and in four major ethnic groups (black, Asian/Pacific Islander, Hispanic and white).[812] In a commentary, Nissen notes that "the extent of miscalibration is substantial…. This is not a trivial problem…. Overestimation by the guideline risk equations would likely add millions of Americans to the roles of patients for whom statins are recommended."[813]
- The USPSTF notes that "because the Pooled Cohort Equations lack precision, the risk estimation tool should be used as a starting point to discuss with patients their desire for lifelong statin therapy."[814]
- For screening purposes, we have assumed that 54.8% of the BC population ages 40-75 is at a low risk for CVD (Table 4, row *b*), 14.4% is at an intermediate risk (Table 4, row *d*) and 30.9% is at a high risk (Table 4, row *f*) (see also Table 2).
- We have assumed that the CVD screening would take place once every five years and modified this to once every two years in the sensitivity analysis (Table 4, row *h*).
- Completion of a risk assessment includes a clinician visit and a full lipid profile (total cholesterol [TC]; high density lipoprotein cholesterol [HDL-C]; low-density lipoprotein cholesterol [LDL-C], non-HDL-C; and triglycerides [TG]). The full lipid profile costs $21.31 (Table 4, row *o*).[815]
- We assumed that a 10-minute office visit would be required for the initial screening. If the results indicate a low risk of CVD, then the follow-up would consist of a phone call to the patient. If the results indicate an intermediate or high risk of CVD, then a

[809] Bibbins-Domingo K, Grossman D, Curry S et al. Statin use for the primary prevention of cardiovascular disease in adults: US Preventive Services Task Force recommendation statement. *Journal of the American Medical Association*. 2016; 316(19): 1997-2007.
[810] Cook NR and Ridker PM. Further insight into the cardiovascular risk calculator: the roles of statins, revascularizations, and underascertainment in the Women's Health Study. *Journal of the American Medical Association Internal Medicine*. 2014; 174(12): 1964-71.
[811] DeFilippis A, Young R, Carrubba C et al. An analysis of calibration and discrimination among multiple cardiovascular risk scores in a modern multiethnic cohort. *Annals of Internal Medicine*. 2015; 162(4): 266-75.
[812] Rana J, Tabada G, Solomon M et al. Accuracy of the atherosclerotic cardiovascular risk equation in a large contemporary, multiethnic population. *Journal of the American College of Cardiology*. 2016; 67(18): 2118-30.
[813] Nissen SE. Prevention guidelines: bad process, bad outcome. *Journal of the American Medical Association Internal Medicine*. 2014; 174(12): 1972-3.
[814] Bibbins-Domingo K, Grossman D, Curry S et al. Statin use for the primary prevention of cardiovascular disease in adults: US Preventive Services Task Force recommendation statement. *Journal of the American Medical Association*. 2016; 316(19): 1997-2007.
[815] Ministry of Health. *Cardiovascular Disease – Primary Prevention* 2021. Available online at https://www2.gov.bc.ca/gov/content/health/practitioner-professional-resources/bc-guidelines/cardiovascular-disease. Accessed March 2023.

follow-up visit would be required to discuss the results and the possibility of taking statins (Table 4, row *l*).

Costs of the Intervention

- Adherence with statin therapy in the real world is relatively poor. Benner and colleagues found that early and frequent follow-up by physicians (including cholesterol retesting) improves long-term adherence by approximately 45% (OR 1.45; 95% CI of 1.34 – 1.55).[816]
- Brookhart et al., in a study based on BC data, found that a return to adherence after a period of nonadherence was associated with a return visit to the physician who initially prescribed the statin and a retest of cholesterol. "Our results suggest that continuity of care combined with increased follow-up and cholesterol testing could promote long-term adherence."[817]
- Pandya and colleagues estimated one additional physician visit per year for individuals in a disease-free state taking statins (i.e., for primary prevention).[818]
- The BC Guidelines for the primary prevention of cardiovascular disease suggest a follow-up physician visit 4-6 months after the initiation of statin which includes the measuring of lipid levels with a non-HDL-C or an apolipoprotein B (apoB) test, to assess patient adherence to statin therapy and any response to statin therapy, with further follow-ups as clinically indicated. The cost of a non-HDL-C test is $12.20 while that of an apoB test is $16.60.[819] For modelling purposes, we used the midpoint cost of these two tests (Table 4, row *ab*).
- For modelling purposes, we have assumed that 30% of intermediate and high risk patients would adhere to long-term statin therapy and modified this from 25% to 40% in the sensitivity analysis (Table 3, row *d*). We further assumed, based on expert input, that one annual follow-up office visit per year (Table 4, row *y*) is required for patients on statin therapy, that 100% of this office visit (Table 4, row *z*) is allocated to discussing the statin therapy and that a follow-up lipid test (non-HDL-C or apoB) would be required once every five years (Table 4, row *aa*).
- The BC Reference Drug Pricing program fully covers the costs of two statins, atorvastatin and rosuvastatin.[820] The cost of 10mg rosuvastatin, taken by the majority of patients, is $55 plus four dispensing fees of $10 each, for an annual cost of $95 (Table 4, row *w*).[821] The cost of 80mg atorvastatin is $99 plus four dispensing fees of $10 each, for an annual cost of $139. We have used this higher cost in the sensitivity analysis.[822]

[816] Benner J, Tierce J, Ballantyne C et al. Follow-up lipid tests and physician visits are associated with improved adherence to statin therapy. *PharmacoEconomics*. 2004; 22(3): 13-23.
[817] Brookhart M, Patrick A, Schneeweiss S et al. Physician follow-up and provider continuity are associated with long-term medication adherence: a study of the dynamics of statin use. *Archives of Internal Medicine*. 2007; 167(8): 847-52.
[818] Pandya A, Sy S, Cho S et al. Cost-effectiveness of 10-year risk thresholds for initiation of statin therapy for primary prevention of cardiovascular disease. *Journal of the American Medical Association*. 2015; 314(2): 142-50.
[819] Ministry of Health. *Cardiovascular Disease – Primary Prevention* 2014. Available at http://www2.gov.bc.ca/assets/gov/health/practitioner-pro/bc-guidelines/cvd.pdf. Accessed January 2017.
[820] See BC *Reference Drug Program*. Available online at https://www2.gov.bc.ca/gov/content/health/practitioner-professional-resources/pharmacare/prescribers/reference-drug-program/reference-drug-program-list-of-full-and-partial-benefits. Accessed March 2023.
[821] Pacific Blue Cross. *Pharmacy Compass*. Available online at https://www.pac.bluecross.ca/pharmacycompass. Accessed March 2023.
[822] Pacific Blue Cross. *Pharmacy Compass*. Available online at https://www.pac.bluecross.ca/pharmacycompass. Accessed March 2023.

Costs Avoided due to the Intervention

- For modelling purposes, we assumed that the acute care costs avoided per death avoided would be $10,260 (Table 4, row *ah*). This is based on the mix of cardiovascular and cerebrovascular deaths in the cohort (78% and 22%, respectively) (see Table 1) and the estimated cost of the acute care phase associated with a fatal myocardial infarction ($9,346) and a fatal stroke ($13,501).
- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the CE associated with universal screening for and initiating use of low- to moderate-dose statins in adults aged 40 to 74 years without a history of CVD, who have 1 or more CVD risk factors, and a calculated 10-year CVD event risk of 10% or greater is $4,487 / QALY (Table 4, row *ay*).

Table 4: CE of Universal Screening for and Initiating Use of Statins in Adults Aged 40 to 74 Years with an Intermediate or High Risk of CVD in a Birth Cohort of 40,000			
Row Label	**Variable**	**Base Case**	**Data Source**
a	# of life years lived between the ages of 40-74 in birth cohort	1,281,822	Table 1
b	% of life years at low risk	54.8%	Table 2
c	# of life years at low risk	702,022	= (a * b)
d	% of life years at intermediate risk	14.4%	Table 2
e	# of life years at intermediate risk	184,241	= (a * d)
f	% of life years at high risk	30.9%	Table 2
g	# of life years at high risk	395,560	= (a * f)
h	Annual frequency of screening	0.20	√
i	Adherence with offers to receive screening	48%	See Ref Doc
j	Total # of screens in birth cohort	123,055	= (a * h * i)
	Estimated cost of screening		
k	Number of office visits associated with screening - low risk	1.0	Expert Opinion
l	Number of office visits associated with screening - medium or high risk	2.0	Expert Opinion
m	Cost of 10-minute office visit	$35.97	See Ref Doc
n	Cost of a follow-up phone call	$20.00	See Ref Doc
o	Cost to measure cholesterol	$21.31	√
p	Health care costs of screening - low risk	$5,208,218	= (j * b) * k * (m + n + o)
q	Health care costs of screening - intermediate and high risk	$5,190,372	= ((d + f) * j * l)*(m + (o/2))
r	Patient time required / office visit (hours)	2.0	√
s	Value of patient time (per hour)	$37.16	√
t	Value of patient time and travel for screening	$9,145,444	= (j * r * s)
	Estimated cost of intervention		
u	Adherence with long-term statin therapy in intermediate and high risk cohort	30%	Table 3, row d
v	Years on statin therapy	173,940	= (e + g) * u
w	Cost of statin therapy / year	$95	√
x	Cost of statin therapy	$16,524,308	= (v * w)
y	# of follow-up office visits per year re: statin therapy	1.0	Expert Opinion
z	Portion of 10-minute office visit for follow-up re: statin therapy	100%	Expert Opinion
aa	# of lab tests (non-HDL-C or apoB) per year re: statin therapy	0.2	Expert Opinion
ab	Cost per lab test	$14.40	√
ac	Follow-up costs	$6,757,572	= (v * y * z * m) + (v * aa * ab)
ad	Value of patient time and travel for intervention	$12,927,227	= (v * y * s * r)
	Estimated costs avoided due to intervention		
ae	# of deaths avoided	324.2	Table 3, row z
af	# of nonfatal cardiovascular events avoided	559.0	Table 3, row ac
ag	# of nonfatal cerebrovascular events avoided	111.6	Table 3, row af
ah	Acute care costs avoided per avoided death	-$10,260	See Ref Doc
ai	First year costs avoided per nonfatal cardiovascular event avoided	-$25,500	See Ref Doc
aj	First year costs avoided per nonfatal cerebrovascular event avoided	-$30,252	See Ref Doc
ak	First-year acute care costs avoided	-$20,958,082	= (ae * ah) + (af * ai) + (ag * aj)
al	Post-first-year annual costs avoided for nonfatal cardiovascular events avoided	-$1,626	See Ref Doc
am	Number of years for which the costs are avoided	12.1	See Ref Doc
an	Post-first-year costs avoided for nonfatal cardiovascular events avoided	-$10,998,072	= (af * am * al)
ao	Post-first-year annual costs avoided for nonfatal cerebrovascular events avoided	-$8,524	See Ref Doc
ap	Number of years for which the costs are avoided	9.3	See Ref Doc
aq	Post-first-year costs avoided for nonfatal cerebrovascular events avoided	-$8,850,143	= (ag * ap * ao)
ar	Costs avoided due to intervention	-$40,806,297	= ak + an + aq
	CE Calculation		
as	Cost of intervention over lifetime of birth cohort	$55,753,142	= p + q + t + x + ac + ad
at	Costs avoided due to intervention over lifetime of birth cohort	-$40,806,297	= ar
au	QALYs saved	7,102	Table 3, row ap
av	Cost of intervention over lifetime of birth cohort (1.5% discount)	$43,968,362	Calculated
aw	Costs avoided due to intervention over lifetime of birth cohort (1.5% discount)	-$25,372,096	Calculated
ax	QALYs saved (1.5% discount)	4,144	Calculated
ay	**CE ($/QALY saved)**	**$4,487**	= (av + aw) / ax

√ = Estimates from the literature

For our sensitivity analysis, we modified a number of major assumptions and recalculated the CE as follows:

- Assume that decreased risk of all-cause mortality associated with statin therapy is reduced from 14% to 7% (Table 3, row *y*), the decreased risk of a myocardial infarction is reduced from 36% to 29% (Table 3, row *ab*) and the decreased risk of stroke is reduced from 29% to 18% (Table 3, row *ae*): **CE = $13,510**.
- Assume that decreased risk of all-cause mortality associated with statin therapy is increased from 14% to 20% (Table 3, row *y*), the decreased risk of a myocardial infarction is increased from 36% to 43% (Table 3, row *ab*) and the decreased risk of stroke is increased from 29% to 38% (Table 3, row *ae*): **CE = $2,027**.
- Assume that the disutility per year associated with taking pills for cardiovascular prevention is reduced from -0.0032 to 0.0 (Table 3, row *ai*): CE = $4,081.
- Assume that the disutility per year associated with taking pills for cardiovascular prevention is increased from -0.0032 to -0.0044 (Table 3, row *ai*): CE = $4,662.
- Assume that the percent of life years at intermediate risk on statins is reduced from 30% to 25% (Table 3, row *d*): CE = $5,231.
- Assume that the percent of life years at intermediate risk on statins is increased from 30% to 40% (Table 3, row *d*): CE = $3,558.
- Assume that statin use is associated with muscle problems in 5% of users (Table 3, row *ak*): CE = $5,667.
- Assume that the annual frequency of screening is increased from once every five years to once every two years (Table 4, row *i*): CE = $10,066.
- Assume that the cost of statin therapy in increased from $95 per year to $139 per year (Table 4, row *w*): CE = $5,944.

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with universal screening for and initiating use of low- to moderate-dose statins in adults aged 40 to 74 years without a history of CVD, who have 1 or more CVD risk factors, and a calculated 10-year CVD event risk of 10% or greater is estimated to be 4,144 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $4,487 per QALY (see Table 5).

Table 5: Universal Screening for and Initiating Use of Statins in Adults aged 40 to 74 years with an Intermediate or High Risk of CVD in a Birth Cohort of 40,000

Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Gap between No Service and 'Best in the World' (30%)			
1.5% Discount Rate	***4,144***	1,890	6,075
3% Discount Rate	2,337	1,025	3,462
0% Discount Rate	7,102	3,317	10,344
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	***$4,487***	$2,027	$13,510
3% Discount Rate	$8,448	$4,597	$23,397
0% Discount Rate	$2,105	$466	$7,886
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$287	Cost-saving	$4,302
3% Discount Rate	$2,477	$565	$9,774
0% Discount Rate	Cost-saving	Cost-saving	$1,232

United States Preventive Services Task Force Recommendations (2021) [823]

> *The USPSTF recommends screening for prediabetes and type 2 diabetes in (nonpregnant) adults aged 35 to 70 years who have overweight or obesity. Clinicians should offer or refer patients with prediabetes to effective preventive interventions. (B Recommendation)*

Canadian Task Force on Preventive Health Care (2012) [824]

The CTFPHC suggests a two-phase approach to screening. First, it recommends screening all adults ages 18 and older using a validated risk calculator such as FINDRISC (Finnish Diabetes Risk Score) or CANRISK (Canadian Diabetes Risk Assessment Questionnaire). This first level of screening should be completed once every 3-5 years. Those with a FINDRISC score of 15 to 20 are considered to be at high risk of diabetes (an individual's risk of developing type 2 diabetes within 10 years is between 33% and 49%) and those with a score greater than 21 are at very high risk (an individual's risk of developing diabetes within 10 years is 50% or higher). The second phase of screening involves either an A1C, fasting glucose or oral glucose tolerance test. The CTFPHC recommends the use of the A1C test given its "convenience for patients." Individuals at high risk are to be screened every 3-5 years while individuals at very high risk are to be screened every year. The CTFPHC considers these recommendations to be "weak" based on "low-quality evidence".

Best in the World

Screening

- "Prediabetes and type 2 diabetes can be detected by measuring fasting plasma glucose or HbA1c level, or with an oral glucose tolerance test… Because HbA1c measurements do not require fasting, they are more convenient than using a fasting plasma glucose level or an oral glucose tolerance test… The diagnosis of type 2 diabetes should be confirmed with repeat testing."[825]
- In Ontario, 74% of the adult population aged 20 years or older were screened with a fasting blood glucose test within a 5 year period after 2000/01.[826]
- In the Anglo-Danish-Dutch Study of Intensive Treatment in People with Screen-detected Diabetes in Primary Care (ADDITION-Europe study), 73% of individuals ages 40-69 identified as high risk for diabetes participated in blood glucose testing.[827] The highest rate was observed in Denmark were 95.1% of patients identified as high risk participated in blood glucose testing if the testing occurred immediately following their general practitioner appointment. If the patient was invited to return

[823] US Preventive Service Task Force. US Preventive Services Task Force Recommendation Statement. Screening for prediabetes and type 2 diabetes: US Preventive Services Task Force recommendation statement. *JAMA*. 2021; 326(8): 736-43.
[824] Canadian Task Force on Preventive Health Care. Recommendations on screening for type 2 diabetes in adults. *Canadian Medical Association Journal*. 2012; 184(15): 1687-96.
[825] US Preventive Service Task Force. US Preventive Services Task Force Recommendation Statement. Screening for prediabetes and type 2 diabetes: US Preventive Services Task Force recommendation statement. *JAMA*. 2021; 326(8): 736-43.
[826] Wilson SE, Rosella LC, Lipscombe LL et al. The effectiveness and efficiency of diabetes screening in Ontario, Canada: a population-based cohort study. *BMC Public Health*. 2010; 10(1): 506.
[827] Simmons R, Echouffo-Tcheugui J, Sharp S et al. Screening for type 2 diabetes and population mortality over 10 years (ADDITION-Cambridge): a cluster-randomised controlled trial. *The Lancet*. 2012; 380(9855): 1741-8.

for a fasting blood glucose test on another occasion, then 80.7% participated. Ongoing attendance for blood glucose testing declines over time.[828]

- In Ontario, up-to-date glucose testing (at least 1 glycosylated hemoglobin, plasma or serum glucose or oral glucose tolerance test in the previous 3 years) in 2017 varied by age and sex, as follows:[829]

Age	Males	Females
40-49	57%	70%
50-59	69%	77%
60-69	79%	84%

- For the purposes of this project, we have assumed that the best ongoing screening rate in the world for individuals identified as high risk for diabetes would be 80.7%, based on rates observed in Denmark and adjusted this rate by age and sex based on the data from Ontario.

Modelling the Clinically Preventable Burden

In this section, we model the CPB associated with screening for prediabetes and type 2 diabetes in asymptomatic non-pregnant adults aged 35 to 70 years who have overweight or obesity.

"Screening asymptomatic adults for type 2 diabetes may allow earlier detection, diagnosis, and treatment, with the ultimate goal of improving health outcomes. Earlier detection of prediabetes may allow for interventions to prevent progression to diabetes and a shorter exposure to the hyperglycemic states associated with adverse outcomes. When screening results in a diagnosis of diabetes, treatment to prevent or reduce the risk of diabetic complications can be initiated." [830]

Definitions and Diagnosis

- Prediabetes and type 2 diabetes can be detected by measuring fasting plasma glucose or HbA_{1c} levels, or with an oral glucose tolerance test (OGTT).
- A fasting plasma glucose level of 6.99 mmol/L (126 mg/dL) or greater, an HbA_{1c} level of 6.5% or greater, or a 2-hour post load glucose level of 11.1 mmol/L (200 mg/dL) or greater are consistent with the diagnosis of **type 2 diabetes**.[831]
- The Diabetes Canada Clinical Practice Guidelines note that any of these three tests are valid in diagnosing type 2 diabetes in non-pregnant adults. In the absence of symptoms, however, a second confirmatory test (ideally using the same test as the

[828] Van den Donk M, Sandbaek A, Borch-Johnsen K et al. Screening for Type 2 diabetes. Lessons from the ADDITION-Europe study. *Diabetic Medicine*. 2011; 28(11): 1416-24.
[829] Chu A, Shah B, Rashid M et al. Trends in glucose testing among individuals without diabetes in Ontario between 2010 and 2017: A population-based cohort study. *CMAJ Open*. 2022; 10(3):
[830] Jonas E, Crotty K, Yun J et al. *Screening for Prediabetes and Type 2 Diabetes Mellitus: An Evidence Review for the U.S. Preventive Services Task Force. Evidence Synthesis No. 207*. AHRQ Publication No. 21-05276-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; 2021.
[831] US Preventive Service Task Force. US Preventive Services Task Force Recommendation Statement. Screening for prediabetes and type 2 diabetes: US Preventive Services Task Force recommendation statement. *JAMA*. 2021; 326(8): 736-43.

original) should be repeated (in a timely fashion). Positive results on both tests would yield a diagnosis of type 2 diabetes.[832]

- According to the USPSTF, a fasting plasma glucose level of 5.55-6.94 mmol/L (100 to 125 mg/dL), an HbA_{1c} level of 5.7% to 6.4%, or a 2-hour post load glucose level of 7.77-11.04 mmol/L (140 to 199 mg/dL) are consistent with **prediabetes**.[833]
- The Diabetes Canada Clinical Practice Guidelines suggest a slightly more restrictive range of test results in diagnosing **prediabetes**: A fasting plasma glucose level of 6.1-6.9 mmol/L, an HbA_{1c} level of 6.0% to 6.4%, or a 2-hour post load glucose level of 7.8-11.0 mmol/L.[834]
- While Diabetes Canada highlights the validity of these three tests, they note the variability between tests in identifying undiagnosed diabetes and prediabetes. For screening purposes, they suggest that "while fasting plasma glucose (FPG) and/or A1C are the recommended screening tests, a 75 g oral glucose tolerance test (OGTT) may be considered when the FPG is 6.1 to 6.9 mmol/L and/or A1C is 6.0% to 6.4%."[835]
- A Canadian analysis by Rosella and colleagues found that using an FPG level of ≥7.0 mmol/L identified 1.3% of non-pregnant adults ≥20 years of age as having **undiagnosed diabetes**. If an HbA_{1c} level of ≥6.5 was used, 3.09% were identified as having undiagnosed diabetes. The results were even more discordant when assessing **prediabetes**, 4.3% with FPG and 12.5% with HbA_{1c} (6.4% / 11.8% in males and 2.2% and 13.3% in females, respectively).[836]
- Similar variation has been identified in the US.[837,838,839] One author concludes that "when employed as lone tests, the odds of false negative outcomes are very high when using the FPG or A1c….Although more difficult to administer and more costly, use of the OGTT leads to far fewer diagnostic errors."[840]

Probability of Diabetes Developing Based on HbA_{1c} and BMI

- Based on an analysis by Glauber et al, the 2-year risk of diabetes diagnosis varies widely by HbA_{1C} and body mass index (BMI) (see Table 1). In their observational study of more than 77,000 adult members (age 18-75 years), 5.2% had a very high risk (black shading in Table 1) of T2DM developing within 2 years while another

[832] Punthakee Z, Goldenberg R, Katz P. 2018 Clinical Practice Guidelines: Definition, classification and diagnosis of diabetes, prediabetes and metabolic syndrome. *Canadian Journal of Diabetes*. 2018; 42: S10-S15.
[833] US Preventive Service Task Force. US Preventive Services Task Force recommendation statement. Screening for prediabetes and type 2 diabetes: US Preventive Services Task Force recommendation statement. *JAMA*. 2021; 326(8): 736-43.
[834] Punthakee Z, Goldenberg R, Katz P. 2018 Clinical Practice Guidelines: Definition, classification and diagnosis of diabetes, prediabetes and metabolic syndrome. *Canadian Journal of Diabetes*. 2018; 42: S10-S15.
[835] Ekoe J, Goldenberg R, Katz P. Clinical Practice Guidelines: Screening for diabetes in adults. *Canadian Journal of Diabetes*. 2018; 42: S16-S19.
[836] Rosella L, Lebenbaum M, Fitzpatrick T et al. Prevalence of prediabetes and undiagnosed diabetes in Canada (2007 - 2011) according to fasting plasma glucose and HbA_{1c} screening criteria. *Diabetes Care*. 2015; 38: 1299-1305.
[837] Blum J, Aeschbacher S, Schoen T et al. Prevalence of prediabetes according to hemoglobin A1c versus fasting plasma glucose criteria in health adults. *Acta Diabetologica*. 2015; 52: 631-2.
[838] White K, Daneshvari S, Lilyquist J et al. Prediabetes: Variation between HbA1c and fasting plasma glucose. *International Journal of Diabetology & Vascular Disease Research*. 2015; S2(001):1-7.
[839] Tucker L. Limited agreement between classifications of diabetes and prediabetes resulting from the OGTT, hemoglobin A1c, and fasting glucose tests in 7412 U.S. adults. *Journal of Clinical Medicine*. 2020; 9: 2207.
[840] Tucker L. Limited agreement between classifications of diabetes and prediabetes resulting from the OGTT, hemoglobin A1c, and fasting glucose tests in 7412 U.S. adults. *Journal of Clinical Medicine*. 2020; 9: 2207.

13.3% had a moderate 2-year risk (grey shading) of T2DM, whereas most (81.5%) of the population was at much lower risk (no shading).[841]

Table 1: Two-Year Probability of Diabetes Developing
Based on HbA1c and Body Mass Index

	Body Mass Index (BMI)				
HbA1c	< 25	25 - 30	31-35	≥36	Total
5.7 - 5.8	0.4%	5.0%	1.1%	2.1%	
5.9 - 6.0	0.8%	1.4%	2.3%	4.1%	
6.1 - 6.2	2.5%	3.8%	**6.3%**	**8.8%**	
6.3 - 6.4	**7.9%**	**10.8%**	**15.6%**	**20.7%**	
	Population in Each Cell *				
5.7 - 5.8	6,599	11,844	6,496	5,794	**30,733**
5.9 - 6.0	4,190	8,573	5,279	5,162	**23,204**
6.1 - 6.2	1,935	4,664	**3,329**	**3,367**	**13,295**
6.3 - 6.4	**743**	**2,210**	**1,630**	**2,028**	**6,611**
Total	**13,467**	**27,291**	**16,734**	**16,351**	**73,843**
	% of Population in Each Cell				
5.7 - 5.8	8.9%	16.0%	8.8%	7.8%	**41.6%**
5.9 - 6.0	5.7%	11.6%	7.1%	7.0%	**31.4%**
6.1 - 6.2	2.6%	6.3%	**4.5%**	**4.6%**	**18.0%**
6.3 - 6.4	**1.0%**	**3.0%**	**2.2%**	**2.7%**	**9.0%**
Total	**18.2%**	**37.0%**	**22.7%**	**22.1%**	**100.0%**

** The BMI is missing for 3,264 individuals*

Defining and Estimating the Population at Risk

Incidence of Pregnancy in BC

- The USPSTF recommendation excludes females who are pregnant.
- In 2022 in BC, 10,704 females ages 35-39 gave birth[842] out of a population of 192,658.[843] That is, approximately 5.56% of the female population age 35-39 would have been pregnant that year. Likewise, 2,425 females ages 40-44 gave birth out of a population of 176,880 (1.37%).

[841] Glauber H, Vollmer W, Nichols G. A simple model for predicting two-year risk of diabetes development in individuals with prediabetes. *The Permanente Journal*. 2018; 22: 4-9.
[842] Statistics Canada. *Live Births, By Age of Mother.* Available online at https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=1310041601. Accessed November 2023.
[843] Statistics Canada. *Population Estimates on July 1, By Age and Sex*. Available online at https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710000501. Accessed November 2023.

Prevalence of Overweight and Obesity

- The USPSTF recommendation includes adults who have overweight or obesity.
- Between 2019 and 2021, the mean prevalence of overweight and obesity in BC was as follows (see Table 2):[844]

Table 2: Prevalence of Overweight and Obesity in BC
By Age and Sex for 2019 - 2021 (Mean)

	Overweight (BMI 25.0 - 29.9)			Obese (BMI ≥ 30)		
Age Group	Females	Males	Total	Females	Males	Total
35-49	31.9%	41.4%	36.7%	25.1%	27.1%	26.1%
50-64	31.4%	43.1%	37.1%	24.0%	29.6%	26.8%
≥ 65	35.6%	42.5%	38.8%	23.2%	24.6%	23.9%

Statistics Canada. Table 13-10-0096-01 Health characteristics, annual estimates. Available online at https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310009601.
Body Mass Index (BMI) calculations based on adjusted self-reported height and weight.

Prevalence of Diagnosed Diabetes

- Individuals with diagnosed diabetes would not need to be screened.
- Depending on the age group, the proportion of the **female** population in BC living with diagnosed diabetes in 2020/21 ranges between 1.2% and 28.3%. Between 2000/01 and 2020/21, the total increase in prevalence by female age group ranges between 67% and 148% (see Table 3).[845] Note that the increase in the 35-49 year age group at 122% is second only to the increase of 148% in the ≥80 year age group.
- Depending on the age group, the proportion of the **male** population in BC living with diagnosed diabetes in 2020/21 ranges between 1.2% and 35.2%. Between 2000/01 and 2020/21, the total increase in prevalence by male age group ranges between 74% and 129% (see Table 3). Note that the increase in the 35-49 year age group at 107% is second only to the increase of 129% in the ≥80 year age group.

[844] Statistics Canada. Table 13-10-0096-01. Health Characteristics, Annual Estimates. Available online at https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310009601. Accessed October 2023.
[845] Public Health Agency of Canada. *Canadian Chronic Disease Surveillance System 2022*. Available online at https://health-infobase.canada.ca/ccdss/data-tool/. Accessed September 2023.

Table 3: Trends in the Prevalence of Diabetes in BC

By Age Group and Sex

Fiscal 2000/01 to 2020/21

	20-34		35-49		50-64		65-79		≥80	
Fiscal Year	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
2000/01	0.7%	0.7%	2.0%	2.4%	6.5%	8.8%	12.8%	16.2%	11.4%	15.4%
2001/02	0.8%	0.7%	2.2%	2.7%	6.9%	9.3%	13.7%	17.5%	12.3%	16.2%
2002/03	0.8%	0.7%	2.4%	2.9%	7.4%	9.9%	14.6%	18.6%	13.3%	17.3%
2003/04	0.8%	0.8%	2.6%	3.0%	7.8%	10.3%	15.5%	19.8%	14.4%	18.7%
2004/05	0.9%	0.8%	2.8%	3.2%	8.2%	10.8%	16.5%	21.0%	15.6%	20.1%
2005/06	0.9%	0.8%	3.0%	3.4%	8.6%	11.3%	17.4%	22.3%	16.8%	21.4%
2006/07	0.9%	0.9%	3.2%	3.7%	9.0%	11.8%	18.3%	23.5%	17.9%	22.8%
2007/08	0.9%	0.9%	3.3%	3.9%	9.3%	12.2%	19.0%	24.4%	19.2%	24.1%
2008/09	1.0%	0.9%	3.5%	4.1%	9.7%	12.7%	19.8%	25.4%	20.5%	25.6%
2009/10	1.0%	1.0%	3.7%	4.4%	10.2%	13.3%	20.5%	26.4%	21.5%	27.0%
2010/11	1.0%	1.0%	3.8%	4.7%	10.5%	13.8%	21.1%	27.1%	22.6%	28.1%
2011/12	1.1%	1.0%	4.0%	4.9%	10.8%	14.0%	21.6%	27.6%	23.5%	29.4%
2012/13	1.1%	1.1%	4.1%	5.0%	10.9%	14.2%	21.9%	27.8%	24.4%	30.5%
2013/14	1.1%	1.1%	4.2%	5.0%	11.1%	14.3%	22.0%	28.1%	25.2%	31.4%
2014/15	1.1%	1.1%	4.2%	5.0%	11.1%	14.4%	22.1%	28.2%	26.0%	32.2%
2015/16	1.1%	1.1%	4.3%	5.0%	11.2%	14.6%	22.0%	28.3%	26.5%	32.9%
2016/17	1.1%	1.1%	4.3%	5.0%	11.3%	14.7%	21.9%	28.3%	26.9%	33.5%
2017/18	1.1%	1.1%	4.3%	5.0%	11.4%	15.0%	21.9%	28.3%	27.4%	34.1%
2018/19	1.1%	1.1%	4.4%	5.0%	11.6%	15.3%	21.9%	28.5%	27.8%	34.6%
2019/20	1.1%	1.1%	4.4%	5.0%	11.8%	15.5%	22.0%	28.5%	28.0%	35.0%
2020/21	1.2%	1.2%	4.5%	5.1%	11.9%	15.7%	22.0%	28.6%	28.3%	35.2%
% Change 2000/01 to 2020/21	***67%***	***74%***	***122%***	***107%***	***83%***	***79%***	***72%***	***77%***	***148%***	***129%***

- To estimate the number of individuals with diagnosed diabetes in a BC birth cohort of 40,000 we began with the age- and sex-specific proportion of the BC population with diagnosed diabetes in 2020/21 (see Table 3). We assumed a linear distribution when assigning these proportions to a specific age and only included diagnosed diabetes between the ages of 35 and 70.

Prevalence of Undiagnosed Diabetes

- Based on the analysis by Wilson et al, 24.0% of Ontario males and 16.8% of Ontario females were not aware that they had diabetes. This proportion varies substantially by age group (see Table 4).[846]

Table 4: Diagnosed and Undiagnosed Diabetes
Ontario By Sex and Age

	Males				***Females***			
Age		*Diagnosed Diabetes*				*Diagnosed Diabetes*		
Group	Total	Yes	No	Ratio	Total	Yes	No	Ratio
< 30	770,046	3,775	4,813	1.27	724,622	9,258	3,389	0.37
30-40	932,346	17,516	12,211	0.70	878,512	23,993	7,079	0.30
40-50	895,685	37,893	16,668	0.44	915,611	26,571	6,355	0.24
50-60	592,437	54,358	11,617	0.21	605,545	33,802	4,990	0.15
60-70	352,317	34,063	5,728	0.17	425,580	24,965	3,910	0.16
70-80	237,503	27,067	5,023	0.19	326,074	24,579	3,563	0.14
≥80	80,671	6,076	963	0.16	140,307	6,682	958	0.14
Total	**3,861,005**	**180,748**	**57,023**	**0.32**	**4,016,251**	**149,850**	**30,244**	**0.20**
Ages 30-70	2,772,785	143,830	46,224	0.32	2,825,248	109,331	22,334	0.20

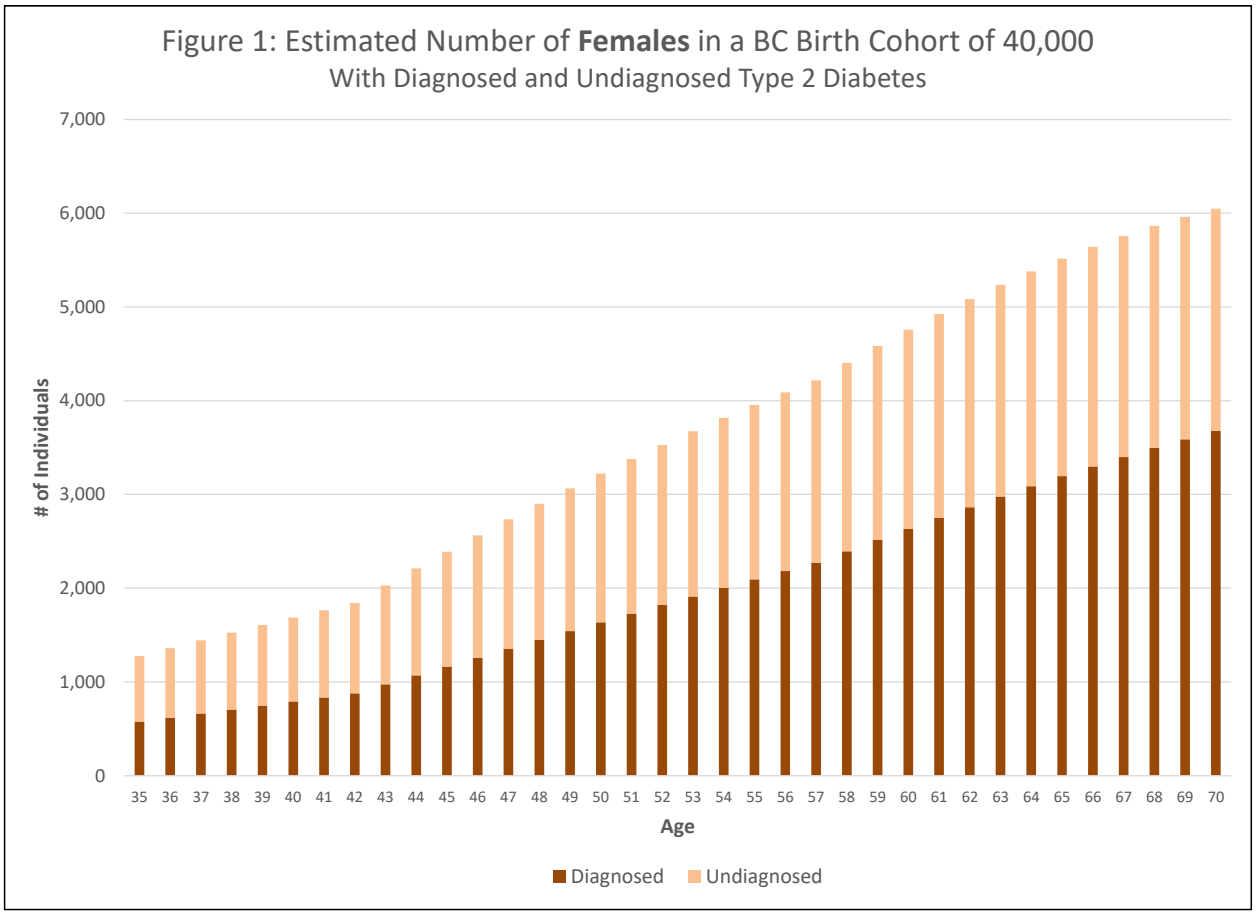
- The analyses by Wilson et al noted above were based on fasting plasma glucose (FPG) diagnostic criteria. Research by Rosella and colleagues indicates that using HbA1c as the diagnostic criteria results in a higher level of undiagnosed diabetes in Canadians than using FPG. When using FPG as the diagnostic criterion, they found that 20.1% of type 2 diabetes was undiagnosed. This increased to 40.9%, however, when using HbA1c as the diagnostic criteria (see Table 5).[847]

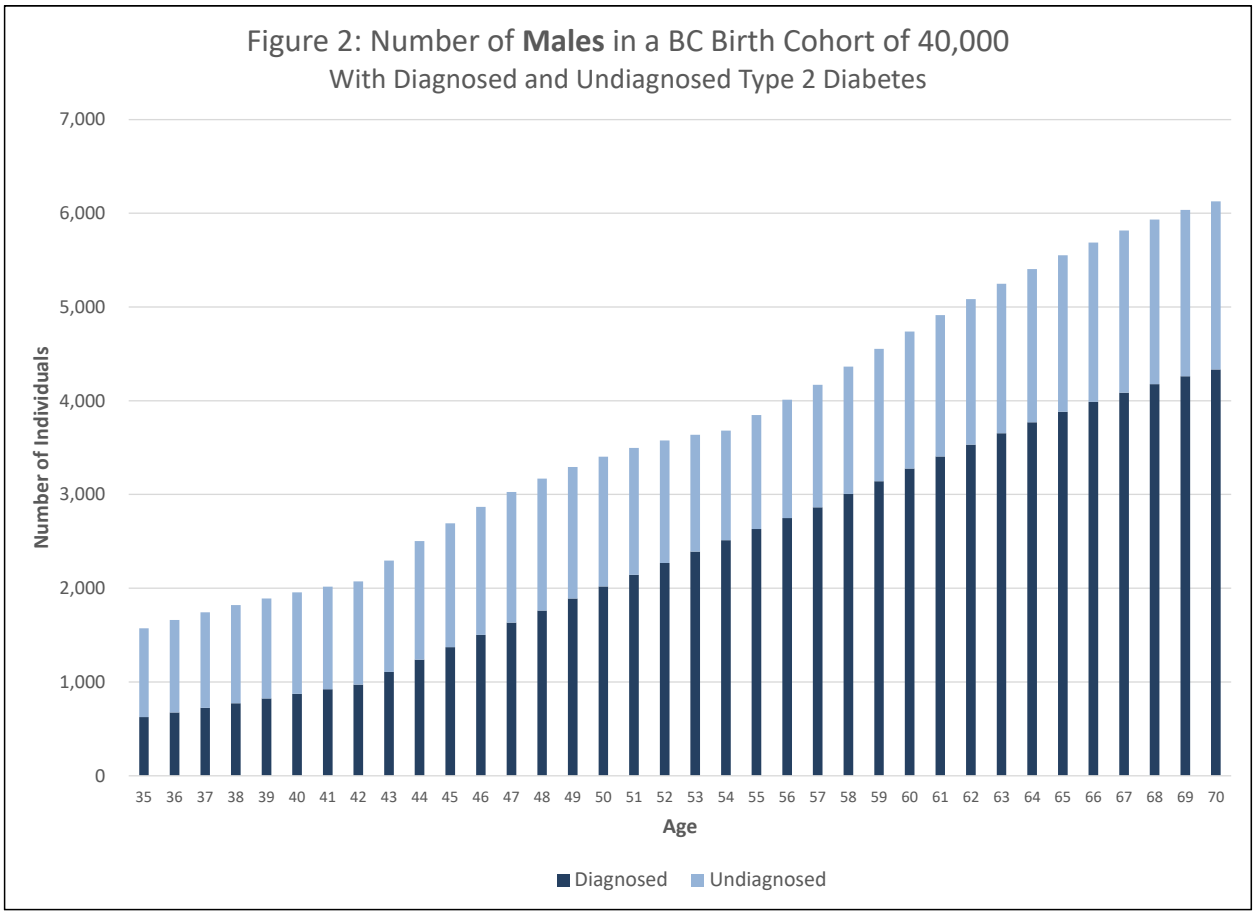
Table 5: Diagnosed and Undiagnosed Diabetes
Percent of Canadians Age 20+ by Diagnostic Criteria

	Females	***Males***	***Total***
Diagnosed Type 2 Diabetes			
FPG (≥ 7.0 mmo/L)	3.87%	5.09%	4.49%
HbA1c (≥ 6.5%)	3.83%	5.10%	4.46%
Undiagnosed Type 2 Diabetes			
FPG (≥ 7.0 mmo/L)	0.87%	1.40%	1.13%
HbA1c (≥ 6.5%)	3.24%	2.94%	3.09%
Total Type 2 Diabetes			
FPG (≥ 7.0 mmo/L)	4.74%	6.49%	5.62%
HbA1c (≥ 6.5%)	7.07%	8.04%	7.55%
Proportion of Type 2 Diabetes that is Undiagnosed			
FPG (≥ 7.0 mmo/L)	18.4%	21.6%	20.1%
HbA1c (≥ 6.5%)	45.8%	36.6%	40.9%

[846] Wislon S, Rosella L, Lipscombe L et al. The effectiveness and efficiency of diabetes screening in Ontario, Canada: A population-based cohort study. *BMC Public Health*. 2010; 10(506):
[847] Rosella L, Lebenbaum M, Fitzpatrick T et al. Prevalence of prediabetes and undiagnosed diabetes in Canada (2007 - 2011) according to fasting plasma glucose and HbA_{1c} screening criteria. *Diabetes Care*. 2015; 38: 1299-1305.

- To adjust for the lower proportion of undiagnosed diabetes observed in Table 4 compared with Table 5 we increased the age-and sex-specific ratios calculated from Table 4 systematically until 45.8% of life years lived with diabetes in females between the ages of 35 and 70 were life years lived with undiagnosed diabetes. Similarly, we increased the age-and sex-specific ratios calculated from Table 4 systematically until 36.6% of life years lived with diabetes in males between the ages of 35 and 70 were life years lived with undiagnosed diabetes. The results for females and males are shown in Figures 1 and 2.





Prevalence of Prediabetes

- Research by Rosella et al suggests that 4.3% of Canadians 20+ years of age have prediabetes when measured by FPG and based on the more restrictive Canadian diagnostic criteria (see *Definitions and Diagnosis* section above). This increases to 12.5% when measured by HbA1c and to 15.2% (15.8% in males and 14.6% in females) when combining both approaches to measurement.[848]
- Using the American diagnostic criteria, Rosella et al found that 38.3% of Canadians 20+ years of age would have prediabetes.[849]
- Research by Hosseini and co-authors found that 12.4% of Canadians ages 20-79 had prediabetes, when diagnosed using HbA1c and Canadian diagnostic criteria.[850] The results by age group were as follows:
    - 20 to 39 – 5.1% (95% CI of 2.4% to 7.9%)
    - 40 to 59 – 13.8% (95% CI of 8.9% to 18.6%)

[848] Rosella L, Lebenbaum M, Fitzpatrick T et al. Prevalence of prediabetes and undiagnosed diabetes in Canada (2007 - 2011) according to fasting plasma glucose and HbA_{1c} screening criteria. *Diabetes Care*. 2015; 38: 1299-1305.
[849] Rosella L, Lebenbaum M, Fitzpatrick T et al. Prevalence of prediabetes and undiagnosed diabetes in Canada (2007 - 2011) according to fasting plasma glucose and HbA_{1c} screening criteria. *Diabetes Care*. 2015; 38: 1299-1305.
[850] Hosseini Z, Whiting S, Vatanparast H. Type 2 diabetes prevalence among Canadian adults - dietary habits and sociodemographic risk factors. *Applied Physiology, Nutrition, and Metabolism*. 2019; 44(10): https://doi.org/10.1139/apnm-2018-0567.

- 60 to 79 – 22.2% (95% CI of 16.2% to 28.2%)

- In the US, based on US diagnostic criteria, 36.5% of adults ages 18 and older have prediabetes, 41.0% of males and 32.0% of females.[851]

Prevalence of Undiagnosed Prediabetes

- In the US, just 17.4% of people with prediabetes are aware that they have prediabetes, 15.9% of males and 19.4% of females.[852]
- To estimate the number of individuals with prediabetes in a BC birth cohort of 40,000 we began with the estimated age-specific proportion of the Canadian population with prediabetes as calculated by Hosseini and co-authors.[853] We assumed a linear distribution when assigning these proportions to a specific age and only included estimated prediabetes between the ages of 35 and 70.
- We then assumed that the ratio of female to male prediabetes would be 0.78 to 1, based on evidence from the US.[854]
- Finally, we assumed that 15.9% of males and 19.4% of females would be aware of their prediabetes, again based on estimates from the US.[855]
- The estimated number of females and males between the ages of 35 and 70 in a BC birth cohort of 40,000 with diagnosed and undiagnosed prediabetes are shown in Figures 3 and 4.

[851] US Centers for Disease Control and Prevention. *National Diabetes Statistics Report: Estimates of Diabetes and Its Burden in the United States.* Available online at https://www.cdc.gov/diabetes/data/statistics-report/index.html. Accessed February 2024.
[852] US Centers for Disease Control and Prevention. *National Diabetes Statistics Report: Estimates of Diabetes and Its Burden in the United States.* Available online at https://www.cdc.gov/diabetes/data/statistics-report/index.html. Accessed February 2024.
[853] Hosseini Z, Whiting S, Vatanparast H. Type 2 diabetes prevalence among Canadian adults - dietary habits and sociodemographic risk factors. *Applied Physiology, Nutrition, and Metabolism*. 2019; 44(10): https://doi.org/10.1139/apnm-2018-0567.
[854] US Centers for Disease Control and Prevention. *National Diabetes Statistics Report: Estimates of Diabetes and Its Burden in the United States.* Available online at https://www.cdc.gov/diabetes/data/statistics-report/index.html. Accessed February 2024.
[855] US Centers for Disease Control and Prevention. *National Diabetes Statistics Report: Estimates of Diabetes and Its Burden in the United States.* Available online at https://www.cdc.gov/diabetes/data/statistics-report/index.html. Accessed February 2024.

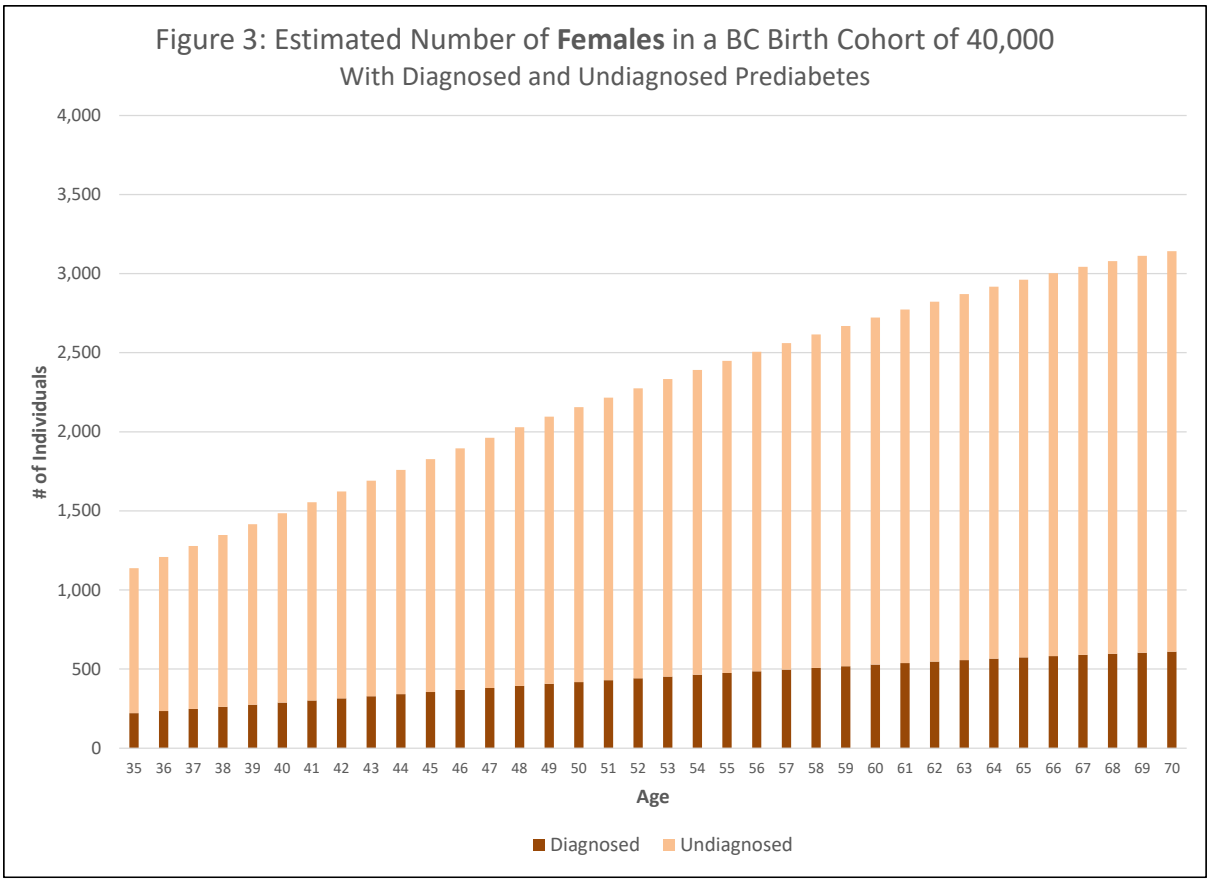


Figure 3: Estimated Number of **Females** in a BC Birth Cohort of 40,000
With Diagnosed and Undiagnosed Prediabetes
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
# of Individuals
35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70
Age
Diagnosed
Undiagnosed

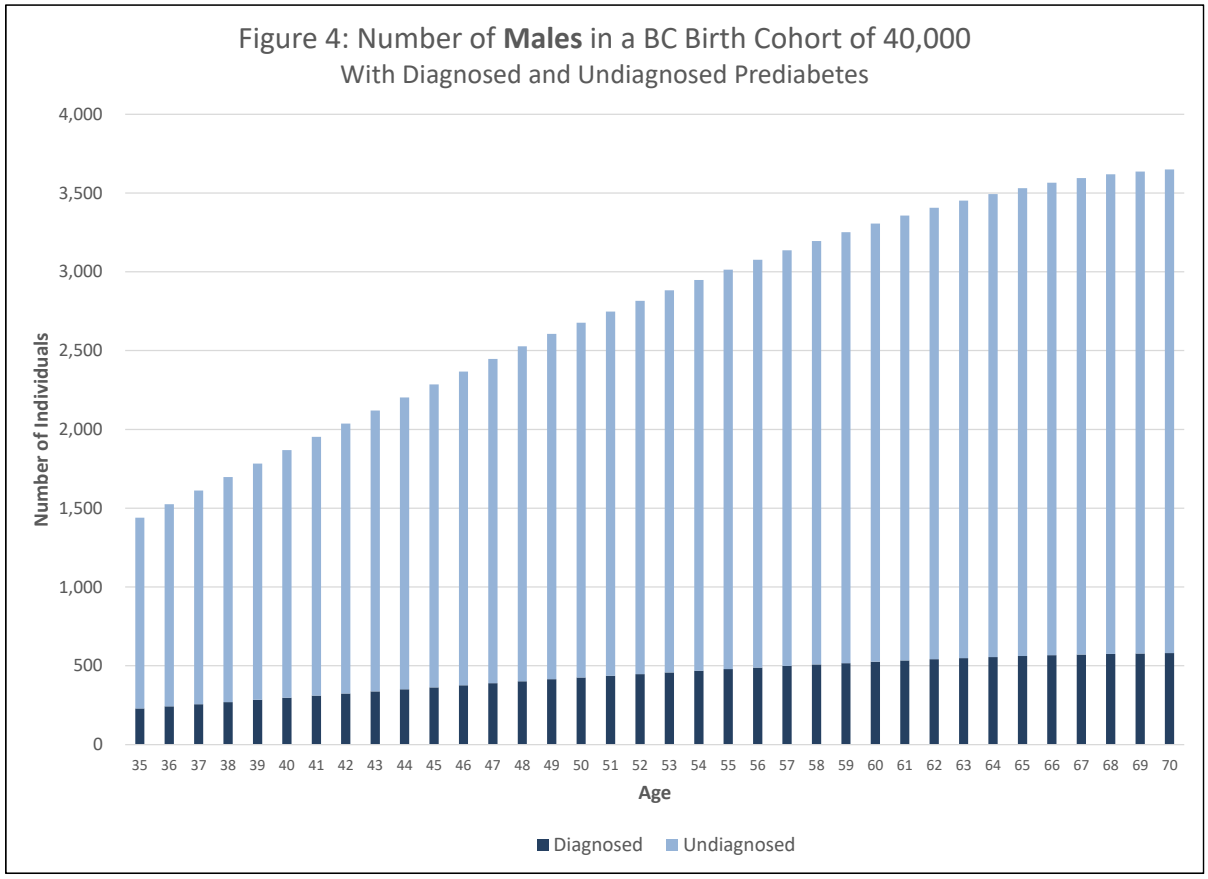


Figure 4: Number of **Males** in a BC Birth Cohort of 40,000
With Diagnosed and Undiagnosed Prediabetes
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Number of Individuals
35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70
Age
Diagnosed
Undiagnosed

Summary of Population at Risk

- At age 35, an estimated 2,414 (12.2%) of the **females** in the BC birth cohort of 40,000 would have prediabetes or diabetes, with 1,617 (67%) being undiagnosed. This would increase to 9,189 (51.6%) by age 70, with 4,904 (53%) undiagnosed (see Table 6).
- At age 35, an estimated 3,011 (15.5%) of the **males** in the BC birth cohort of 40,000 would have prediabetes or diabetes, with 2,158 (72%) being undiagnosed. This would increase to 9,776 (60.6%) by age 70, with 4,862 (50%) undiagnosed (see Table 7).

Table 6: *Females* with Diagnosed and Undiagnosed Prediabetes and Diabetes

In a BC Birth Cohort of 40,000

Ages 35 to 70

		Prediabetes						***Diabetes***						***Prediabetes and Diabetes***					
	# in	Undiagnosed		Diagnosed		**Total**		Undiagnosed		Diagnosed		Total		Undiagnosed		Diagnosed		Total	
Age	Birth	%	#	%	#	**%**	**#**	%	#	%	#	%	#	%	#	%	#	%	#
35	19,736	4.6%	917	1.1%	221	5.8%	1,138	3.5%	699	2.9%	576	6.5%	1,275	8.2%	1,617	4.0%	797	**12.2%**	**2,414**
36	19,722	4.9%	974	1.2%	234	6.1%	1,208	3.8%	741	3.1%	619	6.9%	1,360	8.7%	1,715	4.3%	853	**13.0%**	**2,568**
37	19,708	5.2%	1,030	1.3%	248	6.5%	1,278	4.0%	782	3.4%	662	7.3%	1,444	9.2%	1,812	4.6%	910	**13.8%**	**2,722**
38	19,693	5.5%	1,086	1.3%	261	6.8%	1,347	4.2%	821	3.6%	705	7.8%	1,527	9.7%	1,907	4.9%	966	**14.6%**	**2,874**
39	19,677	5.8%	1,141	1.4%	275	7.2%	1,416	4.4%	859	3.8%	748	8.2%	1,608	10.2%	2,001	5.2%	1,023	**15.4%**	**3,024**
40	19,661	6.1%	1,197	1.5%	288	7.6%	1,485	4.6%	896	4.0%	791	8.6%	1,687	10.6%	2,093	5.5%	1,079	**16.1%**	**3,172**
41	19,643	6.4%	1,253	1.5%	301	7.9%	1,554	4.7%	931	4.2%	834	9.0%	1,765	11.1%	2,184	5.8%	1,136	**16.9%**	**3,319**
42	19,625	6.7%	1,308	1.6%	315	8.3%	1,623	4.9%	965	4.5%	877	9.4%	1,842	11.6%	2,273	6.1%	1,192	**17.7%**	**3,465**
43	19,605	7.0%	1,363	1.7%	328	8.6%	1,691	5.4%	1,055	5.0%	973	10.3%	2,028	12.3%	2,418	6.6%	1,301	**19.0%**	**3,719**
44	19,584	7.2%	1,418	1.7%	341	9.0%	1,759	5.8%	1,141	5.5%	1,069	11.3%	2,210	13.1%	2,559	7.2%	1,410	**20.3%**	**3,969**
45	19,561	7.5%	1,473	1.8%	354	9.3%	1,827	6.3%	1,224	6.0%	1,164	12.2%	2,388	13.8%	2,697	7.8%	1,519	**21.5%**	**4,215**
46	19,537	7.8%	1,527	1.9%	368	9.7%	1,895	6.7%	1,303	6.4%	1,259	13.1%	2,563	14.5%	2,831	8.3%	1,627	**22.8%**	**4,458**
47	19,511	8.1%	1,581	2.0%	381	10.1%	1,962	7.1%	1,379	6.9%	1,354	14.0%	2,733	15.2%	2,961	8.9%	1,735	**24.1%**	**4,695**
48	19,484	8.4%	1,635	2.0%	394	10.4%	2,029	7.5%	1,452	7.4%	1,448	14.9%	2,900	15.8%	3,087	9.5%	1,842	**25.3%**	**4,929**
49	19,454	8.7%	1,689	2.1%	406	10.8%	2,095	7.8%	1,521	7.9%	1,542	15.7%	3,063	16.5%	3,210	10.0%	1,949	**26.5%**	**5,159**
50	19,422	8.9%	1,737	2.2%	418	11.1%	2,156	8.2%	1,587	8.4%	1,636	16.6%	3,222	17.1%	3,324	10.6%	2,054	**27.7%**	**5,378**
51	19,388	9.2%	1,786	2.2%	430	11.4%	2,215	8.5%	1,649	8.9%	1,729	17.4%	3,377	17.7%	3,434	11.1%	2,158	**28.8%**	**5,593**
52	19,352	9.5%	1,833	2.3%	441	11.8%	2,275	8.8%	1,707	9.4%	1,821	18.2%	3,528	18.3%	3,540	11.7%	2,262	**30.0%**	**5,803**
53	19,312	9.7%	1,881	2.3%	453	12.1%	2,333	9.1%	1,762	9.9%	1,913	19.0%	3,675	18.9%	3,643	12.2%	2,365	**31.1%**	**6,008**
54	19,270	10.0%	1,927	2.4%	464	12.4%	2,391	9.4%	1,813	10.4%	2,004	19.8%	3,817	19.4%	3,741	12.8%	2,468	**32.2%**	**6,208**
55	19,224	10.3%	1,974	2.5%	475	12.7%	2,449	9.7%	1,861	10.9%	2,094	20.6%	3,955	19.9%	3,834	13.4%	2,569	**33.3%**	**6,403**
56	19,174	10.5%	2,019	2.5%	486	13.1%	2,505	9.9%	1,905	11.4%	2,183	21.3%	4,088	20.5%	3,924	13.9%	2,669	**34.4%**	**6,593**
57	19,121	10.8%	2,064	2.6%	497	13.4%	2,561	10.2%	1,945	11.9%	2,272	22.1%	4,217	21.0%	4,009	14.5%	2,768	**35.4%**	**6,777**
58	19,063	11.1%	2,108	2.7%	507	13.7%	2,616	10.5%	2,010	12.6%	2,393	23.1%	4,404	21.6%	4,119	15.2%	2,901	**36.8%**	**7,019**
59	19,000	11.3%	2,151	2.7%	518	14.0%	2,669	10.9%	2,071	13.2%	2,514	24.1%	4,584	22.2%	4,222	16.0%	3,031	**38.2%**	**7,253**
60	18,932	11.6%	2,194	2.8%	528	14.4%	2,722	11.2%	2,126	13.9%	2,632	25.1%	4,758	22.8%	4,319	16.7%	3,160	**39.5%**	**7,480**
61	18,858	11.9%	2,235	2.9%	538	14.7%	2,773	11.5%	2,175	14.6%	2,749	26.1%	4,925	23.4%	4,410	17.4%	3,287	**40.8%**	**7,697**
62	18,777	12.1%	2,275	2.9%	548	15.0%	2,823	11.8%	2,220	15.3%	2,864	27.1%	5,084	23.9%	4,495	18.2%	3,412	**42.1%**	**7,906**
63	18,689	12.4%	2,314	3.0%	557	15.4%	2,871	12.1%	2,259	15.9%	2,977	28.0%	5,235	24.5%	4,572	18.9%	3,534	**43.4%**	**8,106**
64	18,593	12.6%	2,351	3.0%	566	15.7%	2,917	12.3%	2,292	16.6%	3,087	28.9%	5,379	25.0%	4,643	19.6%	3,653	**44.6%**	**8,296**
65	18,489	12.9%	2,387	3.1%	574	16.0%	2,961	12.5%	2,320	17.3%	3,194	29.8%	5,514	25.5%	4,707	20.4%	3,769	**45.8%**	**8,475**
66	18,375	13.2%	2,420	3.2%	583	16.3%	3,003	12.7%	2,342	18.0%	3,299	30.7%	5,641	25.9%	4,762	21.1%	3,881	**47.0%**	**8,644**
67	18,250	13.4%	2,452	3.2%	590	16.7%	3,042	12.9%	2,358	18.6%	3,399	31.5%	5,758	26.4%	4,810	21.9%	3,990	**48.2%**	**8,800**
68	18,113	13.7%	2,482	3.3%	597	17.0%	3,079	13.1%	2,369	19.3%	3,496	32.4%	5,865	26.8%	4,850	22.6%	4,093	**49.4%**	**8,944**
69	17,963	14.0%	2,509	3.4%	604	17.3%	3,112	13.2%	2,373	20.0%	3,588	33.2%	5,961	27.2%	4,881	23.3%	4,192	**50.5%**	**9,074**
70	17,799	14.2%	2,533	3.4%	610	17.7%	3,142	13.3%	2,371	20.7%	3,676	34.0%	6,046	27.5%	4,904	24.1%	4,285	**51.6%**	**9,189**
Life Years Lived			**65,224**		**15,699**		**80,923**		**59,283**		**70,143**		**129,426**		**124,507**		**85,842**		**210,349**

Table 7: *Males* with Diagnosed and Undiagnosed Prediabetes and Diabetes

In a BC Birth Cohort of 40,000

Ages 35 to 70

		Prediabetes						***Diabetes***						***Prediabetes and Diabetes***					
	# in	Undiagnosed		Diagnosed		**Total**		Undiagnosed		Diagnosed		Total		Undiagnosed		Diagnosed		Total	
Age	Birth	%	#	%	#	**%**	**#**	%	#	%	#	%	#	%	#	%	#	%	#
35	19,474	6.2%	1,210	1.2%	229	7.4%	1,439	4.9%	948	3.2%	625	8.1%	1,572	11.1%	2,158	4.4%	853	**15.5%**	**3,011**
36	19,442	6.6%	1,283	1.2%	243	7.8%	1,526	5.1%	986	3.5%	674	8.5%	1,660	11.7%	2,269	4.7%	917	**16.4%**	**3,186**
37	19,409	7.0%	1,356	1.3%	256	8.3%	1,612	5.2%	1,019	3.7%	724	9.0%	1,743	12.2%	2,374	5.1%	980	**17.3%**	**3,355**
38	19,375	7.4%	1,428	1.4%	270	8.8%	1,698	5.4%	1,046	4.0%	774	9.4%	1,820	12.8%	2,474	5.4%	1,044	**18.2%**	**3,517**
39	19,339	7.8%	1,500	1.5%	284	9.2%	1,783	5.5%	1,067	4.3%	824	9.8%	1,891	13.3%	2,567	5.7%	1,107	**19.0%**	**3,674**
40	19,303	8.1%	1,571	1.5%	297	9.7%	1,868	5.6%	1,084	4.5%	873	10.1%	1,957	13.8%	2,655	6.1%	1,170	**19.8%**	**3,825**
41	19,264	8.5%	1,642	1.6%	310	10.1%	1,953	5.7%	1,094	4.8%	923	10.5%	2,017	14.2%	2,736	6.4%	1,234	**20.6%**	**3,970**
42	19,225	8.9%	1,713	1.7%	324	10.6%	2,037	5.7%	1,099	5.1%	973	10.8%	2,072	14.6%	2,812	6.7%	1,297	**21.4%**	**4,109**
43	19,183	9.3%	1,783	1.8%	337	11.1%	2,120	6.2%	1,189	5.8%	1,106	12.0%	2,295	15.5%	2,972	7.5%	1,443	**23.0%**	**4,416**
44	19,140	9.7%	1,853	1.8%	350	11.5%	2,203	6.6%	1,263	6.5%	1,239	13.1%	2,502	16.3%	3,116	8.3%	1,590	**24.6%**	**4,705**
45	19,094	10.1%	1,922	1.9%	363	12.0%	2,285	6.9%	1,322	7.2%	1,371	14.1%	2,693	17.0%	3,244	9.1%	1,735	**26.1%**	**4,978**
46	19,047	10.5%	1,990	2.0%	376	12.4%	2,367	7.2%	1,365	7.9%	1,503	15.1%	2,868	17.6%	3,356	9.9%	1,879	**27.5%**	**5,234**
47	18,996	10.8%	2,058	2.0%	389	12.9%	2,448	7.3%	1,393	8.6%	1,633	15.9%	3,026	18.2%	3,451	10.6%	2,022	**28.8%**	**5,474**
48	18,943	11.2%	2,126	2.1%	402	13.3%	2,527	7.4%	1,406	9.3%	1,762	16.7%	3,168	18.6%	3,531	11.4%	2,164	**30.1%**	**5,696**
49	18,887	11.6%	2,192	2.2%	414	13.8%	2,606	7.4%	1,403	10.0%	1,891	17.4%	3,294	19.0%	3,595	12.2%	2,305	**31.2%**	**5,901**
50	18,827	12.0%	2,252	2.3%	426	14.2%	2,677	7.4%	1,386	10.7%	2,018	18.1%	3,404	19.3%	3,638	13.0%	2,444	**32.3%**	**6,081**
51	18,763	12.3%	2,310	2.3%	437	14.6%	2,747	7.2%	1,354	11.4%	2,144	18.6%	3,498	19.5%	3,664	13.8%	2,581	**33.3%**	**6,245**
52	18,695	12.7%	2,368	2.4%	448	15.1%	2,815	7.0%	1,307	12.1%	2,268	19.1%	3,575	19.7%	3,674	14.5%	2,716	**34.2%**	**6,390**
53	18,622	13.0%	2,424	2.5%	458	15.5%	2,883	6.7%	1,245	12.8%	2,391	19.5%	3,636	19.7%	3,669	15.3%	2,850	**35.0%**	**6,519**
54	18,545	13.4%	2,480	2.5%	469	15.9%	2,949	6.3%	1,169	13.5%	2,512	19.9%	3,681	19.7%	3,649	16.1%	2,981	**35.8%**	**6,630**
55	18,461	13.7%	2,534	2.6%	479	16.3%	3,013	6.6%	1,216	14.3%	2,632	20.8%	3,848	20.3%	3,750	16.9%	3,111	**37.2%**	**6,861**
56	18,372	14.1%	2,587	2.7%	489	16.7%	3,076	6.9%	1,261	15.0%	2,749	21.8%	4,010	20.9%	3,848	17.6%	3,238	**38.6%**	**7,086**
57	18,277	14.4%	2,638	2.7%	499	17.2%	3,136	7.1%	1,305	15.7%	2,864	22.8%	4,169	21.6%	3,943	18.4%	3,363	**40.0%**	**7,305**
58	18,175	14.8%	2,687	2.8%	508	17.6%	3,195	7.5%	1,359	16.5%	3,005	24.0%	4,364	22.3%	4,046	19.3%	3,513	**41.6%**	**7,559**
59	18,065	15.1%	2,735	2.9%	517	18.0%	3,252	7.8%	1,411	17.4%	3,142	25.2%	4,553	23.0%	4,146	20.3%	3,659	**43.2%**	**7,805**
60	17,947	15.5%	2,780	2.9%	526	18.4%	3,306	8.1%	1,461	18.3%	3,276	26.4%	4,737	23.6%	4,241	21.2%	3,802	**44.8%**	**8,043**
61	17,820	15.8%	2,824	3.0%	534	18.8%	3,357	8.5%	1,508	19.1%	3,406	27.6%	4,914	24.3%	4,332	22.1%	3,940	**46.4%**	**8,272**
62	17,684	16.2%	2,864	3.1%	542	19.3%	3,406	8.8%	1,553	20.0%	3,533	28.8%	5,085	25.0%	4,417	23.0%	4,074	**48.0%**	**8,491**
63	17,537	16.6%	2,902	3.1%	549	19.7%	3,451	9.1%	1,594	20.8%	3,654	29.9%	5,249	25.6%	4,497	24.0%	4,203	**49.6%**	**8,700**
64	17,379	16.9%	2,938	3.2%	555	20.1%	3,493	9.4%	1,633	21.7%	3,771	31.1%	5,404	26.3%	4,571	24.9%	4,326	**51.2%**	**8,897**
65	17,208	17.3%	2,970	3.3%	561	20.5%	3,531	9.7%	1,669	22.6%	3,882	32.3%	5,551	27.0%	4,638	25.8%	4,444	**52.8%**	**9,082**
66	17,024	17.6%	2,998	3.3%	567	20.9%	3,565	10.0%	1,701	23.4%	3,987	33.4%	5,688	27.6%	4,699	26.8%	4,554	**54.4%**	**9,253**
67	16,826	18.0%	3,023	3.4%	571	21.4%	3,594	10.3%	1,730	24.3%	4,086	34.6%	5,816	28.2%	4,752	27.7%	4,657	**55.9%**	**9,410**
68	16,612	18.3%	3,043	3.5%	575	21.8%	3,618	10.6%	1,755	25.1%	4,177	35.7%	5,932	28.9%	4,798	28.6%	4,752	**57.5%**	**9,550**
69	16,381	18.7%	3,058	3.5%	578	22.2%	3,637	10.8%	1,776	26.0%	4,260	36.8%	6,036	29.5%	4,834	29.5%	4,838	**59.0%**	**9,673**
70	16,132	19.0%	3,069	3.6%	580	22.6%	3,649	11.1%	1,793	26.9%	4,334	38.0%	6,127	30.1%	4,862	30.5%	4,914	**60.6%**	**9,776**
	Life Years Lived		**83,109**		**15,713**		**98,822**		**48,869**		**84,987**		**133,857**		**131,978**		**100,700**		**232,678**

Harms Associated with Prediabetes and Diabetes

Prediabetes

- As noted in Table 1, individuals with prediabetes, especially those based on the Canadian diagnostic criteria of an HbA_{1c} level of 6.0-6.4, have an increased probability of developing diabetes within two years. This is especially so if the individual also has obesity. For example, an individual with a BMI of ≥36 and an HbA_{1c} level of 6.3-6.4 has a 20.7% two-year probability of developing diabetes. This compares to a 0.4% probability of developing diabetes within two years if the individual has a BMI of <25 and an HbA_{1c} level of 5.7-5.8 (see Table 1).

Diabetes

- Type 2 diabetes is associated with many adverse microvascular and macrovascular complications, including chronic kidney disease (CKD), end-stage renal disease (ESRD), proliferative neuropathy, lower extremity amputation, myocardial infarction (MI), unstable angina, stroke, heart failure, stable angina and peripheral vascular disease.[856]
- Advances in the management of diabetes and the consequent longer life expectancies has resulted in a group of emerging diabetes-related complications over and above the traditional ones, including cancers (liver, pancreas, colorectal, endometrial, breast and ovarian), infections (including post-operative and respiratory infections), non-alcoholic fatty liver disease / non-alcoholic steatohepatitis, affective disorders (depression, anxiety), obstructive sleep apnea, dementia and cognitive impairment.[857]
- In a Canadian study by Goeree et al including 610,852 individuals aged 35 and older, diabetes (at 10 years after diagnosis) was associated with a significant increase in the risk of death (RR of 1.42; 95% CI of 1.42 – 1.42), myocardial infarction (RR of 2.09; 95% CI of 2.09 – 2.10), stroke (RR of 1.88; 95% CI of 1.88 – 1.88), angina (RR of 1.53; 95% CI of 1.53 – 1.53), heart failure (RR of 2.52; 95% CI of 2.52 – 2.53), amputation (RR of 6.82; 95% CI of 6.82 – 6.82), nephropathy (RR of 2.90; 95% CI of 2.90 – 2.90), blindness (RR of 1.21; 95% CI of 1.21 – 1.22), and cataract (RR of 1.33; 95% CI of 1.32 – 1.33).[858]
- The study by Goeree et al also provides information on the excess risk of complications in individuals with and without diabetes based on the time since the diagnosis of diabetes (see Table 8).[859]

[856] An J, Nichols G, Qian L et al. Prevalence and incidence of microvascular and macrovascular complications over 15 years among patients with incident type 2 diabetes. *BMJ Open Diabetes Research & Care*. 2021; 9: e001847.
[857] Tomic D, Shaw J, Magliano D. The burden and risks of emerging complications of diabetes mellitus. *Nature Reviews: Endocrinology*. 2022; 18: 525-39.
[858] Goeree R, Lim M, Hopkins R et al. Excess risk of mortality and complications associated with newly diagnosed case of diabetes in Ontario, Canada. *Canadian Journal of Diabetes*. 2009; 33(2): 93-104.
[859] Goeree R, Lim M, Hopkins R et al. Excess risk of mortality and complications associated with newly diagnosed case of diabetes in Ontario, Canada. *Canadian Journal of Diabetes*. 2009; 33(2): 93-104.

Table 8: Excess Risk of Complications In Individuals With Diabetes

By Complication and Time Since Diagnosis

Complication	*Years Since Diagnosis* 0	1	2	3	4	5	6	7	8	9	10
Myocardial Infarction											
Diabetes CR	0.80%	1.57%	2.29%	2.99%	3.76%	4.52%	5.28%	6.06%	6.89%	7.70%	8.50%
Non-diabetes CR	0.00%	0.38%	0.77%	1.16%	1.55%	1.96%	2.38%	2.80%	3.21%	3.64%	4.06%
Excess CR	0.80%	1.19%	1.52%	1.83%	2.21%	2.56%	2.90%	3.26%	3.68%	4.06%	4.44%
Diabetes AR	0.80%	0.77%	0.72%	0.70%	0.77%	0.76%	0.76%	0.78%	0.83%	0.81%	0.80%
Non-diabetes AR	0.00%	0.38%	0.39%	0.39%	0.39%	0.41%	0.42%	0.42%	0.41%	0.43%	0.42%
Excess AR	0.80%	0.39%	0.33%	0.31%	0.38%	0.35%	0.34%	0.36%	0.42%	0.38%	0.38%
Stroke											
Diabetes CR	0.51%	1.07%	1.57%	2.05%	2.54%	3.05%	3.61%	4.17%	4.77%	5.34%	5.93%
Non-diabetes CR	0.00%	0.30%	0.58%	0.87%	1.19%	1.50%	1.81%	2.14%	2.47%	2.80%	3.16%
Excess CR	0.51%	0.77%	0.99%	1.18%	1.35%	1.55%	1.80%	2.03%	2.30%	2.54%	2.77%
Diabetes AR	0.51%	0.56%	0.50%	0.48%	0.49%	0.51%	0.56%	0.56%	0.60%	0.57%	0.59%
Non-diabetes AR	0.00%	0.30%	0.28%	0.29%	0.32%	0.31%	0.31%	0.33%	0.33%	0.33%	0.36%
Excess AR	0.51%	0.26%	0.22%	0.19%	0.17%	0.20%	0.25%	0.23%	0.27%	0.24%	0.23%
Angina											
Diabetes CR	1.71%	15.11%	20.62%	24.83%	28.48%	31.84%	34.90%	37.75%	40.47%	43.00%	45.40%
Non-diabetes CR	0.08%	8.03%	11.59%	14.51%	17.12%	19.52%	21.76%	23.91%	25.92%	27.86%	29.75%
Excess CR	1.63%	7.08%	9.03%	10.32%	11.36%	12.32%	13.14%	13.84%	14.55%	15.14%	15.65%
Diabetes AR	1.71%	13.40%	5.51%	4.21%	3.65%	3.36%	3.06%	2.85%	2.72%	2.53%	2.40%
Non-diabetes AR	0.08%	7.95%	3.56%	2.92%	2.61%	2.40%	2.24%	2.15%	2.01%	1.94%	1.89%
Excess AR	1.63%	5.45%	1.95%	1.29%	1.04%	0.96%	0.82%	0.70%	0.71%	0.59%	0.51%
Heart Failure											
Diabetes CR	0.46%	1.23%	1.82%	2.36%	2.89%	3.47%	4.08%	4.68%	5.35%	6.06%	6.78%
Non-diabetes CR	0.00%	0.29%	0.53%	0.79%	1.05%	1.31%	1.59%	1.87%	2.13%	2.40%	2.69%
Excess CR	0.46%	0.94%	1.29%	1.57%	1.84%	2.16%	2.49%	2.81%	3.22%	3.66%	4.09%
Diabetes AR	0.46%	0.77%	0.59%	0.54%	0.53%	0.58%	0.61%	0.60%	0.67%	0.71%	0.72%
Non-diabetes AR	0.00%	0.29%	0.24%	0.26%	0.26%	0.26%	0.28%	0.28%	0.26%	0.27%	0.29%
Excess AR	0.46%	0.48%	0.35%	0.28%	0.27%	0.32%	0.33%	0.32%	0.41%	0.44%	0.43%
Amputation											
Diabetes CR	0.09%	0.22%	0.29%	0.36%	0.44%	0.53%	0.63%	0.75%	0.87%	1.00%	1.16%
Non-diabetes CR	0.00%	0.02%	0.03%	0.05%	0.06%	0.08%	0.10%	0.12%	0.14%	0.15%	0.17%
Excess CR	0.09%	0.20%	0.26%	0.31%	0.38%	0.45%	0.53%	0.63%	0.73%	0.85%	0.99%
Diabetes AR	0.09%	0.13%	0.07%	0.07%	0.08%	0.09%	0.10%	0.12%	0.12%	0.13%	0.16%
Non-diabetes AR	0.00%	0.02%	0.01%	0.02%	0.01%	0.02%	0.02%	0.02%	0.02%	0.01%	0.02%
Excess AR	0.09%	0.11%	0.06%	0.05%	0.07%	0.07%	0.08%	0.10%	0.10%	0.12%	0.14%
Nephropathy											
Diabetes CR	0.08%	0.39%	0.52%	0.66%	0.79%	0.96%	1.12%	1.33%	1.52%	1.75%	2.02%
Non-diabetes CR	0.01%	0.13%	0.18%	0.23%	0.29%	0.35%	0.41%	0.48%	0.55%	0.62%	0.70%
Excess CR	0.07%	0.26%	0.34%	0.43%	0.50%	0.61%	0.71%	0.85%	0.97%	1.13%	1.32%
Diabetes AR	0.08%	0.31%	0.13%	0.14%	0.13%	0.17%	0.16%	0.21%	0.19%	0.23%	0.27%
Non-diabetes AR	0.01%	0.12%	0.05%	0.05%	0.06%	0.06%	0.06%	0.07%	0.07%	0.07%	0.08%
Excess AR	0.07%	0.19%	0.08%	0.09%	0.07%	0.11%	0.10%	0.14%	0.12%	0.16%	0.19%
Blindness											
Diabetes CR	0.00%	0.26%	0.47%	0.65%	0.83%	1.00%	1.15%	1.32%	1.51%	1.69%	1.89%
Non-diabetes CR	0.00%	0.19%	0.34%	0.49%	0.64%	0.78%	0.94%	1.11%	1.26%	1.41%	1.56%
Excess CR	0.00%	0.07%	0.13%	0.16%	0.19%	0.22%	0.21%	0.21%	0.25%	0.28%	0.33%
Diabetes AR	0.00%	0.26%	0.21%	0.18%	0.18%	0.17%	0.15%	0.17%	0.19%	0.18%	0.20%
Non-diabetes AR	0.00%	0.19%	0.15%	0.15%	0.15%	0.14%	0.16%	0.17%	0.15%	0.15%	0.15%
Excess AR	0.00%	0.07%	0.06%	0.03%	0.03%	0.03%	-0.01%	0.00%	0.04%	0.03%	0.05%
Cataract											
Diabetes CR	0.27%	2.62%	4.52%	6.28%	8.06%	9.80%	11.57%	13.52%	15.51%	17.50%	19.74%
Non-diabetes CR	0.01%	1.51%	2.89%	4.27%	5.68%	7.12%	8.56%	10.04%	11.60%	13.18%	14.89%
Excess CR	0.26%	1.11%	1.63%	2.01%	2.38%	2.68%	3.01%	3.48%	3.91%	4.32%	4.85%
Diabetes AR	0.27%	2.35%	1.90%	1.76%	1.78%	1.74%	1.77%	1.95%	1.99%	1.99%	2.24%
Non-diabetes AR	0.01%	1.50%	1.38%	1.38%	1.41%	1.44%	1.44%	1.48%	1.56%	1.58%	1.71%
Excess AR	0.26%	0.85%	0.52%	0.38%	0.37%	0.30%	0.33%	0.47%	0.43%	0.41%	0.53%

CR = cummulative risk; AR = annual risk

- In a population-based retrospective cohort study from Newfoundland/Labrador, 15,152 individuals with diabetes were compared with 58,631 individuals without diabetes on all-cause and cardiovascular mortality and cardiovascular hospitalizations over a period of 10 years.[860] This study also highlighted the benefits of early (no diabetes-related comorbidities at the time of diagnosis) vs late (comorbidities related to diabetes at the time of diagnosis) diagnosis of diabetes (see Table 9).

Table 9: Sex Differences in Mortality and Morbidity In Individuals With and Without Diabetes

	Males		Females	
	No Diabetes	Diabetes	No Diabetes	Diabetes
N=	30,039	7,751	28,592	7,401
Deceased at Study End	14.5%	23.8%	12.1%	23.1%
All-cause Hospitalizations	58.5%	72.3%	59.5%	74.6%
Mean Length of Hospital Stay (days)	5.6	6.4	5.5	7.0
CVD Hospitalizations	17.5%	28.9%	12.3%	22.9%
AMI Hospitalizations	3.5%	6.2%	2.0%	4.5%
Stroke Hospitalizations	2.3%	3.9%	1.8%	3.6%
	Males with Diabetes		**Females with Diabetes**	
Diabetes Diagnosis	Early	Late	Early	Late
N=	3,034	4,717	2,601	4,800
Deceased at Study End	13.2%	30.5%	11.7%	29.3%
All-cause Hospitalizations	64.6%	77.2%	69.1%	77.5%
Mean Length of Hospital Stay (days)	4.9	7.2	5.1	8.0
CVD Hospitalizations	17.7%	36.0%	13.8%	27.8%
AMI Hospitalizations	4.7%	7.1%	10.6%	4.3%
Stroke Hospitalizations	1.9%	5.2%	1.8%	4.6%

- In a meta-analysis of 35 studies with a mean follow-up of 10.7 years, type 2 diabetes was associated with an 85% increased risk of all-cause mortality (RR of 1.85; 95% CI of 1.79 – 1.92), 57% in males (RR of 1.57; 95% CI of 1.46 – 1.68) and 100% in females (RR of 2.00; 95% CI of 1.89 – 2.12).[861]
- In a study from Canada, males and females with diabetes at the age of 55 lost on average 5.0 and 6.0 life years, respectively, compared to those without diabetes.[862]

[860] Roche M, Wang P. Sex difference in all-cause and cardiovascular mortality, hospitalization for individuals with and without diabetes, and patients with diabetes diagnosed early and late. *Diabetes Care*. 2013; 36: 2582-90.
[861] Nwaneri C, Cooper H, Bowen-Jones D. Mortality in type 2 diabetes mellitus: Magnitude of the evidence from a systematic review and meta-analysis. *The British Journal of Diabetes & Vascular Disease*. 2013; 13(4):
[862] Loukine L, Waters C, Choi B et al. Impact of diabetes mellitus on life expectancy and health-adjusted life expectancy in Canada. *Population Health Metrics*. 2012; 10(7):

- Table 10 provides a summary of life years lost attributable to type 2 diabetes in the UK, by age and sex.[863]

Table 10: Estimated Life Expectancy
In Individuals With and Without Diabetes
By Age and Sex

	Males		Difference in LE		Females		Difference in LE	
Age	No Diabetes	Diabetes	Years	%	No Diabetes	Diabetes	Years	%
40-44	42.4	37.0	5.4	-12.7%	45.4	39.1	6.3	-13.9%
45-49	37.6	32.8	4.8	-12.8%	40.5	34.5	6.0	-14.8%
50-54	33.0	28.6	4.4	-13.3%	35.8	30.4	5.4	-15.1%
55-59	28.5	24.5	4.0	-14.0%	31.2	26.3	4.9	-15.7%
60-64	24.2	20.6	3.6	-14.9%	26.7	22.3	4.4	-16.5%
65-69	20.3	16.9	3.4	-16.7%	22.5	18.6	3.9	-17.3%
70-74	16.7	13.6	3.1	-18.6%	18.5	15.1	3.4	-18.4%
75-79	13.7	10.7	3.0	-21.9%	14.9	11.9	3.0	-20.1%
≥ 80	11.1	8.3	2.8	-25.2%	11.9	9.0	2.9	-24.4%

Quality of Life – Diabetes and Its Complications

- **Uncomplicated diabetes mellitus** reduces an individual's quality of life by 4.9% (95% CI of 3.1% to 7.2%). In this situation, the person has "a chronic disease that requires medication every day and causes some worry but minimal interference with daily activities".[864]
- A **myocardial infarction** reduces a person's quality of life by 9.8% for a period of one month (see Reference Document).
- On average, a **stroke** reduces a person's quality of life by 20% (95% CI of 13.4% to 26.5%) (see Reference Document).
- Moderate **angina** ("has chest pain that occurs with moderate physical activity, such as walking uphill or more than half a kilometer on level ground. After a brief rest, the pain goes away") reduces a person's quality of life by 8% (95% CI of 5.2% to 11.3%).[865]
- Moderate **heart failure** ("is short of breath and easily tires with minimal physical activity, such as walking only a short distance. The person feels comfortable at rest but avoids moderate activity") reduces a person's quality of life by 7.2% (95% CI of 4.7% to 10.3%).[866] Individuals with heart failure have a life expectancy of approximately 2.5 years.[867]

[863] Wright A, Kontopantelis E, Ermsley R et al. Life expectancy and cause-specific mortality in type 2 diabetes: A population-based cohort quantifying relationships in ethnic subgroups. *Diabetes Care*. 2017; 40: 338-45.
[864] Institute for Health Metrics and Evaluation. *GBD 2016 sequelae, health states, health state lay descriptions, and disability weights*. Available online at http://ghdx.healthdata.org/record/global-burden-disease-study-2016-gbd-2016-disability-weights. Accessed February 2024.
[865] GBD 2016
[866] GBD 2016
[867] Limpens M, Asllanaj E, Dommershuijsen L et al. Healthy lifestyle in older adults and life expectancy with and without heart failure. *European Journal of Epidemiology*. 2022; 37: 205-14.

- **Amputation** with treatment due to diabetes mellitus type 2 is associated with a reduction in quality of life of 16.7% (95% CI of 11.4% to 22.9%).[868]
- **Nephropathy** (chronic kidney disease) ("tires easily, has nausea, reduced appetite and difficulty sleeping") is associated with a reduction in quality of life of 10.4% (95% CI of 7.0% to 14.7%).[869]
- **Blindness** reduces a person's quality of life by 18.7% (95% CI of 12.4% to 26.0%).[870]
- Moderate vision impairment due to **cataract** ("has vision problems that make it difficult to recognize faces or objects across a room") reduces a person's quality of life by 3.1% (95% CI of 1.9% to 4.9%)[871] for a period of 16 weeks.[872]

No Screening / Intervention

In this section we estimate the type and number of complications, QALYs lost and LYL attributable to diagnosed and undiagnosed diabetes in a BC birth cohort of 40,000 between the ages of 35 and 70.

Complications

- To estimate the expected number of complications we used the excess annual risk of a specific complication as calculated in Table 8. Table 8 includes the annual risk out to 10 years after the diagnosis of diabetes. We assumed that the annual risk after 10 years would be stable (i.e. use the 10 year annual risk in year 11 and following years). This risk was applied to incident cases identified each year. For modelling purposes, we assumed that all cases of diabetes at the age of 35 would be incident cases.
- The number of excess complications attributable to diabetes in a BC birth cohort between the ages of 35 and 70 is as follows (see Table 11):
    - 1,033 cases of myocardial infarction
    - 635 cases of stroke
    - 2,523 cases of angina
    - 1,061 cases of heart failure
    - 307 amputations
    - 414 cases of nephropathy
    - 108 cases of blindness
    - 1,289 cases of cataracts

[868] GBD 2016
[869] GBD 2016
[870] GBD 2016
[871] GBD 2016
[872] 16 weeks is the benchmark wait time for cataract surgery in Canada. See Canadian Institute for Health Information. *Wait Times for Priority Procedures in Canada, 2022*. Available at https://www.cihi.ca/en/wait-times-for-priority-procedures-in-canada-2022. Accessed February 2024.

Table 11: Excess Complications In Individuals With Diabetes

By Age and Sex in a BC Birth Cohort of 40,000

	Myocardial Infarction			Stroke			Angina			Heart Failure			Amputation			Nephropathy			Blindness			Cataract		
Age	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T
35	10	13	23	6.5	8.0	15	21	26	47	5.9	7.2	13	1.1	1.4	2.6	0.9	1.1	2.0	0.0	0.0	0.0	3.3	4.1	7.4
36	5.7	6.8	12	3.8	4.5	8.3	71	87	158	6.5	8.0	14	1.5	1.8	3.3	2.5	3.0	5.5	0.9	1.1	2.0	11	14	25
37	5.2	6.2	11	3.5	4.1	7.6	31	37	68	5.3	6.3	12	0.9	1.1	2.0	1.2	1.5	2.7	0.8	1.0	1.8	7.6	9.1	17
38	5.2	6.1	11	3.2	3.8	7.0	24	28	52	4.6	5.5	10.1	0.9	1.0	1.9	1.4	1.7	3.1	0.5	0.6	1.1	6.2	7.3	14
39	6.4	7.4	14	3.1	3.6	6.7	22	24	46	4.7	5.5	10.2	1.1	1.3	2.5	1.2	1.4	2.7	0.5	0.6	1.1	6.4	7.4	14
40	6.3	7.2	13	3.7	4.1	7.8	22	24	45	5.6	6.4	12	1.2	1.4	2.6	1.8	2.1	3.9	0.5	0.6	1.2	5.8	6.5	12
41	6.4	7.2	14	4.4	5.0	9.5	20	22	42	6.0	6.8	13	1.4	1.6	3.0	1.8	2.0	3.8	0.1	0.0	0.1	6.4	7.1	14
42	6.9	7.7	15	4.4	4.8	9.2	19	20	39	6.1	6.8	13	1.7	1.9	3.6	2.4	2.7	5.1	0.2	0.1	0.3	8.4	9.5	18
43	8.8	10.1	19	5.6	6.5	12	22	23	44	8.0	9.1	17	1.9	2.2	4.0	2.3	2.6	4.9	0.7	0.8	1.4	8.6	9.6	18
44	9.0	10	19	5.7	6.5	12	27	30	56	9.2	11	20	2.3	2.7	5.0	3.1	3.6	6.7	0.7	0.7	1.4	10	11	20
45	10	11	21	6.0	6.7	13	28	31	59	10	11	21	2.7	3.2	5.9	3.7	4.3	8.0	1.0	1.2	2.2	12	14	26
46	10	11	22	6.3	7.0	13	29	32	61	10	12	22	2.9	3.3	6.2	3.9	4.5	8.4	1.1	1.2	2.3	13	14	27
47	11	12	23	6.6	7.3	14	30	32	63	11	12	23	3.1	3.5	6.5	4.1	4.7	8.8	1.1	1.3	2.4	13	15	28
48	11	12	24	7.0	7.5	14	31	32	64	12	13	24	3.2	3.6	6.8	4.4	4.9	9.3	1.2	1.4	2.6	14	15	30
49	12	13	25	7.4	7.8	15	32	32	64	12	13	25	3.4	3.8	7.2	4.6	5.1	9.7	1.2	1.3	2.6	15	16	31
50	13	13	26	7.7	8.0	16	33	31	64	13	13	26	3.6	3.9	7.5	4.9	5.3	10	1.3	1.3	2.6	16	17	32
51	13	13	27	8.1	8.3	16	33	30	64	13	14	27	3.8	4.1	7.9	5.1	5.5	11	1.3	1.4	2.7	16	17	33
52	14	14	27	8.5	8.4	17	34	29	63	14	14	28	4.0	4.2	8.2	5.4	5.7	11	1.4	1.4	2.8	17	17	34
53	14	14	28	8.8	8.5	17	34	28	62	15	15	29	4.2	4.4	8.6	5.7	5.9	12	1.5	1.5	3.0	18	18	36
54	15	14	29	9.1	8.6	18	35	27	61	15	15	30	4.5	4.5	9.0	6.0	6.1	12	1.5	1.6	3.1	19	18	37
55	15	15	31	9.4	9	19	35	27	62	16	16	32	4.7	4.8	9.5	6.3	6.4	13	1.6	1.6	3.2	19	19	38
56	16	16	32	9.7	10	19	35	33	69	17	17	33	4.9	5.1	10	6.6	6.8	13	1.7	1.7	3.4	20	20	40
57	16	16	33	10	10	20	35	35	71	17	17	35	5.1	5.3	10	6.9	7.1	14	1.8	1.9	3.6	21	21	42
58	17	17	34	11	11	21	37	37	74	18	18	36	5.4	5.5	11	7.2	7.4	15	1.8	1.9	3.8	22	22	44
59	18	18	36	11	11	22	40	40	80	19	19	38	5.6	5.7	11	7.6	7.7	15	2.0	2.1	4.0	23	23	46
60	19	19	37	11	11	23	41	42	83	20	20	39	5.8	5.9	12	7.9	7.9	16	2.1	2.2	4.2	24	24	48
61	19	19	38	12	12	23	42	43	85	20	20	40	6.0	6.0	12	8.2	8.2	16	2.1	2.2	4.3	25	25	49
62	20	20	39	12	12	24	43	43	86	21	21	42	6.2	6.2	12	8.4	8.4	17	2.2	2.2	4.4	25	26	51
63	20	20	41	12	12	25	43	44	87	21	21	43	6.4	6.4	13	8.7	8.7	17	2.3	2.3	4.6	26	26	52
64	21	21	42	13	13	25	43	44	87	22	22	44	6.6	6.6	13	9.0	8.9	18	2.3	2.3	4.7	27	27	54
65	21	21	43	13	13	26	43	44	88	23	23	45	6.8	6.8	14	9.3	9.2	18	2.4	2.4	4.8	28	28	55
66	22	22	44	13	13	27	43	44	88	23	23	47	7.0	7.0	14	9.5	9.5	19	2.5	2.5	4.9	28	28	57
67	22	22	45	14	14	27	43	44	87	24	24	48	7.2	7.3	14	10	10	20	2.5	2.5	5.1	29	29	58
68	23	23	45	14	14	28	43	44	86	24	24	49	7.4	7.5	15	10	10	20	2.6	2.6	5.2	30	30	59
69	23	23	46	14	14	28	42	43	85	25	25	50	7.6	7.7	15	10	10	21	2.7	2.7	5.3	30	30	61
70	23	23	47	14	14	28	41	43	84	25	25	51	7.8	7.8	16	11	11	21	2.7	2.7	5.5	31	31	62
Total	**508**	**525**	**1,033**	**312**	**322**	**635**	**1,247**	**1,276**	**2,523**	**521**	**540**	**1,061**	**150**	**156**	**307**	**203**	**211**	**414**	**53**	**55**	**108**	**633**	**656**	**1,289**

QALYs Lost

- To calculate the number of QALYs lost associated with living with the complications identified in Table 11, we multiplied an incident complication by the disutility attributable to that complication (see *Quality of Life – Diabetes and Its Complications* above) by the remaining life expectancy when the complication occurred. For a number of complications (e.g. myocardial infarction and cataract), the disutility was temporary. For incident heart failure, we assumed the individual would survive for 2.5 years.
- We also included the disutility associated with living with uncomplicated diagnosed diabetes for those who did not experience a complication.
- Based on these assumptions, a total of 26,752 QALYs are lost (13,450 in females and 13,302 in males) in the BC birth cohort (see Table 12).

Table 12: QALYs Lost due to Excess Complications In Individuals With Diabetes

By Age and Sex in a BC Birth Cohort of 40,000

	Myocardial Infarction			Stroke			Angina			Heart Failure			Amputation			Nephropathy			Blindness			Cataract			Uncomplicated Diagnosed Diabetes			Total QALYs Lost		
Age	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T
35	1.1	1.4	2.5	74	84	158	95	107	203	1.1	1.3	2.4	11	12	23	5.3	6.0	11	0.0	0.0	0.0	0.0	0.0	0.1	1,567	1,554	3,122	1,755	1,767	3,522
36	0.6	0.8	1.4	42	46	88	318	357	674	1.2	1.4	2.6	14	15	29	14	16	31	9.4	10.5	20	0.1	0.1	0.3	11	17	28	410	465	875
37	0.6	0.7	1.3	38	41	79	136	148	283	0.9	1.1	2.1	8.6	9.3	18	7.1	7.7	15	8.5	9.4	18	0.1	0.1	0.2	63	70	134	263	288	550
38	0.6	0.7	1.2	35	37	72	103	109	213	0.8	1.0	1.8	7.7	8.2	16	8.0	8.7	17	5.0	5.3	10.3	0.1	0.1	0.1	71	79	150	232	249	481
39	0.7	0.8	1.5	33	34	68	92	94	186	0.9	1.0	1.8	10	11	21	6.9	7.2	14	5.1	5.4	11	0.1	0.1	0.1	72	79	151	221	233	454
40	0.7	0.8	1.5	39	41	80	93	92	185	1.0	1.2	2.2	11	11	22	10	11	21	5.4	5.7	11	0.1	0.1	0.1	71	79	150	231	241	473
41	0.7	0.8	1.6	47	48	95	86	83	169	1.1	1.2	2.3	12	13	25	10	10	20	0.5	0.1	0.6	0.1	0.1	0.2	70	77	147	227	233	460
42	0.8	0.9	1.7	45	45	91	80	74	154	1.1	1.2	2.3	15	15	30	13	13	26	1.6	1.2	2.9	0.1	0.1	0.2	68	75	143	224	227	451
43	1.0	1.2	2.2	57	59	116	88	83	171	1.4	1.6	3.1	16	17	32	12	12	24	6.4	6.5	13	0.1	0.1	0.2	190	253	442	371	433	804
44	1.0	1.2	2.2	56	58	115	105	107	212	1.7	1.9	3.6	19	20	39	16	17	33	6.1	6.3	12	0.1	0.1	0.2	176	233	409	381	445	826
45	1.1	1.2	2.4	58	59	117	108	108	216	1.8	2.0	3.8	22	23	45	19	19	38	9.0	9.6	19	0.1	0.2	0.3	167	220	387	385	443	828
46	1.2	1.3	2.5	60	60	120	111	109	219	1.9	2.1	4.0	23	24	46	19	20	39	9.4	9.9	19	0.1	0.2	0.3	159	209	368	383	435	818
47	1.2	1.4	2.6	61	60	122	112	107	219	2.0	2.2	4.1	24	24	48	20	20	40	10	10	20	0.2	0.2	0.3	151	199	349	381	424	804
48	1.3	1.4	2.7	63	61	124	113	104	217	2.1	2.3	4.3	24	24	49	20	21	41	10	10	20	0.2	0.2	0.3	143	188	331	377	412	790
49	1.4	1.5	2.8	65	61	126	113	100	213	2.2	2.4	4.5	25	25	50	21	21	42	10	10	20	0.2	0.2	0.3	136	178	314	373	400	773
50	1.5	1.6	3.1	69	64	133	117	100	217	2.3	2.4	4.7	27	26	53	23	22	45	10	10	20	0.2	0.2	0.4	134	176	310	384	402	786
51	1.6	1.6	3.2	71	64	135	116	94	211	2.4	2.5	4.9	28	26	54	23	22	45	11	10	21	0.2	0.2	0.4	126	166	292	379	388	767
52	1.6	1.6	3.3	72	64	135	115	89	203	2.5	2.6	5.1	28	27	55	24	22	46	11	10	21	0.2	0.2	0.4	119	156	275	373	372	745
53	1.7	1.7	3.4	72	63	135	113	82	195	2.7	2.7	5.3	29	27	56	24	23	47	11	10	22	0.2	0.2	0.4	112	147	259	367	356	723
54	1.8	1.7	3.5	73	61	134	111	76	186	2.8	2.7	5.5	30	27	57	25	23	48	12	10	22	0.2	0.2	0.4	105	138	243	360	339	699
55	1.8	1.8	3.7	73	64	138	108	76	184	2.9	2.9	5.7	30	28	58	26	23	49	12	10	22	0.2	0.2	0.4	98	127	225	352	333	685
56	1.9	1.9	3.8	73	65	139	106	90	196	3.0	3.0	6.0	31	28	59	26	24	50	12	11	23	0.2	0.2	0.5	91	110	201	345	334	678
57	2.0	2.0	3.9	73	66	139	103	92	195	3.1	3.1	6.2	31	29	60	26	24	50	12	11	23	0.2	0.2	0.5	85	99	184	336	326	662
58	2.1	2.1	4.1	75	67	142	104	94	197	3.2	3.3	6.5	32	29	60	27	24	51	12	11	24	0.3	0.3	0.5	137	131	268	392	361	753
59	2.1	2.1	4.3	76	67	142	110	98	208	3.4	3.4	6.8	32	29	61	27	24	51	13	12	24	0.3	0.3	0.5	124	117	241	388	352	740
60	2.3	2.3	4.6	78	68	146	113	101	214	3.5	3.5	7.0	33	30	63	28	25	53	13	12	25	0.3	0.3	0.6	117	108	225	388	350	738
61	2.3	2.3	4.7	78	68	146	111	100	211	3.6	3.6	7.3	33	29	63	28	25	53	13	12	25	0.3	0.3	0.6	108	96	204	377	336	714
62	2.4	2.4	4.8	77	68	145	109	98	206	3.8	3.7	7.5	33	29	63	28	25	53	13	12	25	0.3	0.3	0.6	99	85	183	365	322	688
63	2.5	2.5	5.0	76	67	144	106	96	201	3.9	3.9	7.7	33	29	62	28	24	52	13	12	25	0.3	0.3	0.6	89	74	163	352	308	661
64	2.5	2.6	5.1	75	67	142	102	93	195	4.0	4.0	7.9	33	29	62	28	24	52	13	11	24	0.3	0.3	0.6	80	63	143	339	293	632
65	2.6	2.6	5.2	74	66	140	99	89	188	4.1	4.1	8.2	33	29	61	28	24	52	13	11	24	0.3	0.3	0.7	72	52	124	325	278	603
66	2.7	2.7	5.4	73	65	138	95	86	181	4.2	4.2	8.4	32	28	61	27	24	51	13	11	24	0.3	0.3	0.7	63	41	104	311	262	573
67	2.7	2.7	5.5	72	63	135	91	82	173	4.3	4.3	8.6	32	28	60	27	24	51	13	11	23	0.3	0.3	0.7	54	31	85	296	246	542
68	2.8	2.8	5.6	70	62	132	87	78	165	4.4	4.4	8.8	32	28	59	27	23	50	12	11	23	0.4	0.4	0.7	46	21	67	280	230	510
69	2.8	2.8	5.6	68	60	128	82	74	156	4.4	4.5	8.9	31	27	58	26	23	49	12	11	23	0.4	0.4	0.7	37	11	48	264	213	477
70	3.0	3.0	6.0	70	61	131	82	73	155	4.5	4.6	9.1	32	28	60	27	24	51	13	11	24	0.4	0.4	0.8	31	1	32	262	206	468
Total	**61**	**63**	**124**	**2,312**	**2,156**	**4,467**	**3,931**	**3,641**	**7,571**	**94**	**97**	**191**	**898**	**841**	**1,739**	**753**	**706**	**1,459**	**353**	**331**	**684**	**7**	**8**	**15**	**5,042**	**5,459**	**10,501**	**13,450**	**13,302**	**26,752**

Life Years Lost

- As noted in Table 10, diabetes is associated with a significant reduction in life expectancy.
- Diabetes is estimated to be associated with 60,950 LYL in the BC birth cohort, 33,189 in females and 27,761 in males (see Table 13). This is equivalent to 5.5 LYL per female with diabetes and 4.5 LYL per male with diabetes.

Table 13: Life Years Lost due Diabetes
By Age and Sex in a BC Birth Cohort of 40,000

	Incident Diabetes			Life Expectancy in BC		% Reduction in LE with Diabetes		Total LYL		
Age	F	M	T	F	M	F	M	F	M	T
35	1,275	1,572	2,848	50.8	46.5	-13.9%	-12.7%	8,993	9,310	**18,304**
36	85	88	173	49.9	45.6	-13.9%	-12.7%	589	510	**1,099**
37	84	82	166	48.9	44.7	-13.9%	-12.7%	568	468	**1,037**
38	82	77	159	47.9	43.7	-13.9%	-12.7%	548	428	**976**
39	81	71	152	47.0	42.8	-13.9%	-12.7%	528	389	**917**
40	80	66	145	46.0	41.9	-13.9%	-12.7%	508	351	**859**
41	78	60	139	45.1	41.0	-13.9%	-12.7%	489	315	**804**
42	77	55	132	44.1	40.1	-13.9%	-12.7%	470	280	**749**
43	186	223	409	43.1	39.1	-13.9%	-12.7%	1,111	1,113	**2,224**
44	182	207	389	42.2	38.2	-13.9%	-12.7%	1,065	1,008	**2,073**
45	178	191	369	41.2	37.3	-14.8%	-12.8%	1,089	909	**1,998**
46	175	175	349	40.3	36.4	-14.8%	-12.8%	1,042	812	**1,853**
47	171	158	329	39.3	35.5	-14.8%	-12.8%	995	718	**1,713**
48	167	142	309	38.4	34.6	-14.8%	-12.8%	949	628	**1,577**
49	163	126	289	37.4	33.7	-14.8%	-12.8%	904	542	**1,446**
50	159	110	269	36.5	32.8	-15.1%	-13.3%	875	480	**1,356**
51	155	94	249	35.6	31.9	-15.1%	-13.3%	831	398	**1,230**
52	151	77	228	34.6	31.0	-15.1%	-13.3%	788	320	**1,108**
53	147	61	208	33.7	30.2	-15.1%	-13.3%	745	246	**991**
54	142	45	187	32.8	29.3	-15.1%	-13.3%	703	176	**879**
55	138	166	304	31.9	28.4	-15.7%	-14.0%	689	663	**1,352**
56	133	163	296	30.9	27.5	-15.7%	-14.0%	647	628	**1,276**
57	129	159	287	30.0	26.7	-15.7%	-14.0%	606	594	**1,200**
58	187	195	382	29.1	25.8	-15.7%	-14.0%	855	706	**1,562**
59	181	189	370	28.2	25.0	-15.7%	-14.0%	799	664	**1,464**
60	174	184	357	27.3	24.1	-16.5%	-14.9%	782	660	**1,441**
61	167	177	344	26.4	23.3	-16.5%	-14.9%	725	615	**1,341**
62	159	171	330	25.5	22.5	-16.5%	-14.9%	670	571	**1,241**
63	152	163	315	24.6	21.7	-16.5%	-14.9%	616	527	**1,142**
64	144	155	299	23.8	20.9	-16.5%	-14.9%	562	482	**1,045**
65	135	147	282	22.9	20.1	-17.3%	-16.7%	536	494	**1,030**
66	126	137	264	22.0	19.3	-17.3%	-16.7%	482	444	**926**
67	117	127	244	21.2	18.5	-17.3%	-16.7%	429	395	**824**
68	107	116	223	20.3	17.7	-17.3%	-16.7%	377	345	**722**
69	97	104	201	19.5	17.0	-17.3%	-16.7%	326	296	**622**
70	85	91	176	18.7	16.2	-18.4%	-18.6%	293	274	**567**
Total	**6,046**	**6,127**	**12,174**	**5.5**	**4.5**			**33,189**	**27,761**	**60,950**

The Intervention(s)

Frequency of Screening

- The USPSTF suggests that screening adults with normal blood glucose levels every 3 years would be a reasonable approach while annual screening is typically recommended for those with prediabetes. [873,874]

Effectiveness of the Intervention(s)

- "Intensive lifestyle interventions to achieve weight loss and increase physical activity are the first-line therapies for preventing progression of prediabetes to diabetes. The U.S. Food and Drug Administration (FDA) has not approved any medications specifically to prevent progression of prediabetes to diabetes, nor has the Canadian Medicare System."[875]
- The onset of diabetes occurs 4-7 years prior to its clinical diagnosis.[876] Screening can reduce the lag time in identifying diabetes by an average of 3.3 years.[877]

Prediabetes - Intensive Lifestyle Interventions

- The Diabetes Prevention Program (DPP) study is an RCT which followed 3,234 individuals at high risk of diabetes for an average of 2.8 years. Persons were randomly assigned to three groups; placebo, metformin (850 mg twice daily) and intensive lifestyle intervention. After 2.8 years, the incidence of diabetes was 11.0, 7.8 and 4.8 cases per 100 person-years in the placebo, metformin and intensive lifestyle groups. To prevent one case of diabetes, during a period of three years, 6.9 persons would have to participate in the lifestyle intervention, and 13.9 would have to receive metformin.[878]
- The intensive lifestyle intervention in the DPP has become the 'gold standard' in the US for preventing diabetes in high risk individuals.[879] The goals for the lifestyle intervention were to achieve and maintain a weight reduction of at least 7% of initial body weight through healthy eating and physical activity, and to achieve and maintain a level of physical activity of at least 150 min/week through moderate intensity activity.[880]

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[873] US Preventive Service Task Force. US Preventive Services Task Force Recommendation Statement. Screening for prediabetes and type 2 diabetes: US Preventive Services Task Force recommendation statement. *JAMA*. 2021; 326(8): 736-43.
[874] Jonas E, Crotty K, Yun J et al. *Screening for Prediabetes and Type 2 Diabetes Mellitus: An Evidence Review for the U.S. Preventive Services Task Force. Evidence Synthesis No. 207*. AHRQ Publication No. 21-05276-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; 2021.
[875] Jonas E, Crotty K, Yun J et al. *Screening for Prediabetes and Type 2 Diabetes Mellitus: An Evidence Review for the U.S. Preventive Services Task Force. Evidence Synthesis No. 207*. AHRQ Publication No. 21-05276-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; 2021.
[876] Ekoe J, Goldenberg R, Katz P. Clinical Practice Guidelines: Screening for diabetes in adults. *Canadian Journal of Diabetes*. 2018; 42: S16-S19.
[877] Rahman M, Simmons R, Hennings S et al. How much does screening bring forward the diagnosis of type 2 diabetes and reduce complications? Twelve year follow-up of the Ely cohort. *Diabetologia*. 2012; 55(6): 1651-9.
[878] Diabetes Prevention Program Research Group. Reduction in the incidence or type 2 diabetes with lifestyle intervention or metformin. *The New England Journal of Medicine*. 2002; 346(6): 393-403.
[879] US Preventive Service Task Force. US Preventive Services Task Force Recommendation Statement. Screening for prediabetes and type 2 diabetes: US Preventive Services Task Force recommendation statement. *JAMA*. 2021; 326(8): 736-43.
[880] The Diabetes Prevention Program Research Group. The Diabetes Prevention Program: Design and methods for a clinical trial in the prevention of type 2 diabetes. *Diabetes Care*. 1999; 22(4): 623-34.

- The DPP intensive lifestyle intervention is conducted by case managers with training in nutrition, exercise, or behavior modification who meet with an individual participant for at least 16 sessions in the first 24 weeks and contact the participant at least monthly thereafter (with in-person contacts at least every 2 months throughout the remainder of the program). The initial 16 sessions represent a core curriculum, with general information about diet and exercise and behavior strategies such as self-monitoring, goal setting, stimulus control, problem solving, and relapse prevention training. Individualization is facilitated by use of several different approaches to self-monitoring and flexibility in deciding how to achieve the changes in diet and exercise. Two supervised group exercise sessions per week are provided to help participants achieve their exercise goal. For individuals having difficulty achieving or maintaining the weight-loss or exercise goal, a "tool box" approach is used to add new strategies for the participant. Strategies may include incentives such as items of nominal value. Additional tool box approaches may include loaning aerobic exercise tapes or other home exercise equipment, enrolling the participant in a class at an exercise facility, and use of more structured eating plans, liquid formula diets, or home visits. Group courses are also offered quarterly during maintenance, with each course lasting 4 - 6 weeks and focusing on topics related to exercise, weight loss, or behavioral issues. These courses are designed to help participants achieve and maintain the weight-loss and exercise goals.[881]
- The China Da Qing Diabetes Prevention Outcomes Study, which began in 1986, evaluated a 6 year lifestyle intervention with 30 years of follow-up among people with prediabetes living in China.[882] The results indicate that an absolute decrease in diabetes incidence of about 24% over 6 years (43.6% vs. 67.7% of participants for lifestyle intervention vs. control) was associated with 10% fewer deaths (46% vs. 56%), 8% fewer cardiovascular deaths (22% vs. 30%), 11% fewer cardiovascular events (48% vs. 59%), and 5% fewer microvascular events (19% vs. 24%) over 30 years. The intervention delayed the onset of diabetes by a median of 3.96 years, CVD events by 4.64 years, microvascular disease outcomes by 5.17 years, death due to CVD by 7.25 years and all-cause mortality by 4.82 years. This study was assessed to be at medium risk of bias by the USPSTF and involved relatively few participants (577).[883]
- In the Da Qing study, those in the lifestyle intervention arms (diet only, exercise only, diet and exercise) initially received individual counselling by a physician followed by small group counselling sessions weekly for the first month, monthly for three months and then every three months for the duration of the 6 years.[884]
- The review for the USPSTF found 23 RCTs which included lifestyle interventions meant to delay or prevent diabetes in persons with obese or overweight. These lifestyle interventions were associated with a 22% reduction (RR 0.78 95% CI 0.69 to 0.88) in the incidence of subsequent diabetes.[885] Interventions with a high level of

[881] The Diabetes Prevention Program Research Group. The Diabetes Prevention Program: Design and methods for a clinical trial in the prevention of type 2 diabetes. *Diabetes Care*. 1999; 22(4): 623-34.
[882] Gong Q, Zhang P, Wang J, et al. Morbidity and mortality after lifestyle intervention for people with impaired glucose tolerance: 30-year results of the Da Qing Diabetes Prevention Outcome Study. *The Lancet: Diabetes and Endocrinology*. 2019; 7(6): 452-61.
[883] Jonas E, Crotty K, Yun J et al. *Screening for Prediabetes and Type 2 Diabetes Mellitus: An Evidence Review for the U.S. Preventive Services Task Force. Evidence Synthesis No. 207*. AHRQ Publication No. 21-05276-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; 2021.
[884] Pan X, Li G, Hu Y et al. Effect of diet and exercise in preventing NIDDM in people with impaired glucose tolerance: The Da Qing IGT and Diabetes Study. *Diabetes Care*. 1997; 20(4): 537-44.
[885] Jonas D, Crotty K, Yun J et al. Screening for prediabetes and type 2 diabetes: Updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2021; 326(8): 744-60.

contact (>360 minutes) were most effective when delivered to individuals with a BMI ≥30.[886]

- Key targets associated with intensive lifestyle interventions include: weight loss >5%, intake of fat <30% energy, intake of saturated fats <10% energy, increase of dietary fiber to ≥15 g/1,000 kcal, and increase of physical activity to at least four hours per week.[887]

Prediabetes - Pharmaceutical Interventions

- Based on three studies, the review for the USPSTF found that metformin was associated with a 27% reduction (RR 0.73 95% CI 0.64 to 0.83) in the incidence of subsequent diabetes.[888]

Diabetes – Screen Detected

- The USPSTF review found two RCTs that addressed whether screening for type 2 diabetes in asymptomatic adults improves health outcomes. Neither study found a significant benefit in terms of a reduction in mortality or morbidity. While the follow-up was for 10 years, the USPSTF notes that 10 years of follow-up "may have been too short to detect an effect on health outcomes."[889]

Diabetes – Recently Diagnosed

- The USPSTF review found 3 studies that assessed the effect of interventions for newly diagnosed (not screen detected) diabetes on health outcomes. One study (the UK Prospective Diabetes Study - UKPDS) found a benefit of sulfonylureas or insulin over 20 years of follow-up but not at shorter follow-up. For example, for persons with overweight in the UKPDS, intensive glucose control with metformin decreased all-cause mortality (RR 0.64: 95% CI 0.45 to 0.91), diabetes-related mortality (RR 0.58: 95% CI 0.37 to 0.91), and myocardial infarction (RR 0.61: 95% CI 0.41 to 0.89) at the 10-year follow-up and benefits were maintained during the subsequent 10 years of post-trail; follow-up. The other two studies found no benefits but only had follow-up periods of 3 and 7 years.[890]
- The USPSTF notes that "it is uncertain whether results from trials of persons with recently diagnosed diabetes are applicable to those with screen-detected diabetes. Recently diagnosed diabetes was generally clinically detected (e.g., because of symptoms) and may represent a different subset of the diabetes spectrum, possibly with greater condition severity. The evidence of benefits for persons with recently diagnosed (not screen-detected) diabetes comes primarily from the UKPDS, conducted among predominantly White participants from 1977 through 1997, when

[886] Jonas E, Crotty K, Yun J et al. *Screening for Prediabetes and Type 2 Diabetes Mellitus: An Evidence Review for the U.S. Preventive Services Task Force. Evidence Synthesis No. 207*. AHRQ Publication No. 21-05276-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; 2021.
[887] Tuomilehto J, Schwarz P, Lindström J. Long-term benefits from lifestyle interventions for type 2 diabetes prevention: Time to expand the efforts. *Diabetes Care*. 2011; 34(Suppl 2): S210-14.
[888] Jonas E, Crotty K, Yun J et al. *Screening for Prediabetes and Type 2 Diabetes Mellitus: An Evidence Review for the U.S. Preventive Services Task Force. Evidence Synthesis No. 207*. AHRQ Publication No. 21-05276-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; 2021.
[889] US Preventive Service Task Force. US Preventive Services Task Force Recommendation Statement. Screening for prediabetes and type 2 diabetes: US Preventive Services Task Force recommendation statement. *JAMA*. 2021; 326(8): 736-43.
[890] US Preventive Service Task Force. US Preventive Services Task Force Recommendation Statement. Screening for prediabetes and type 2 diabetes: US Preventive Services Task Force recommendation statement. *JAMA*. 2021; 326(8): 736-43.

routine care for CVD prevention would not have included treatments now considered to be current standard medical therapy (e.g., statins, lower blood pressure targets)."[891]

Summary

The preponderance of the evidence reviewed for the USPSTF indicates that interventions are effective in delaying the progression from prediabetes to diabetes in individuals ages 35-70 with overweight or obesity. While both intensive lifestyle and pharmaceutical (metformin) interventions appear to be effective, medications specifically to prevent progression of prediabetes to diabetes are currently not approved for use in the US or Canada. The evidence suggesting any potential benefits with intensive treatment following screen-detected diabetes is very limited. It is not surprising then that the USPSTF recommends that clinicians should focus on referring "patients with ***prediabetes*** (emphasis added) to effective preventive interventions".[892] ***In the following modelling we will focus on the benefits of intensive lifestyle interventions in delaying the progression from prediabetes to diabetes in individuals ages 35-70 with overweight or obesity.***

Real-World Effectiveness of Intensive Lifestyle Interventions

- As noted above, based on research evidence, intensive lifestyle interventions for individuals with prediabetes are associated with a 22% reduction in the incidence of subsequent diabetes.[893] This success has resulted in a number of countries implementing national diabetes prevention programs, including Finland (in 2003),[894] Australia (in 2007),[895] the US (in 2012)[896] and the UK (in 2016).[897] A key question is whether, when implemented outside of the research environment, the effectiveness of these national programs approaches that of the interventions as implemented within research trials.

Finland's National Diabetes Prevention Program

- The Finnish program (FIN-D2D) consists of 4-8 group sessions either once a week or every other week, with a follow-up session one month after the final intervention session. "The program, its content and the methods used are planned together with the members and the manager of the group according to patient empowerment principles."[898]
- Between 2003 and 2008, a total of 10,149 individuals were identified as high risk, based primarily on a score of ≥15 on the FINDRISC. Of these 10,149, a total of 8,353

[891] Jonas D, Crotty K, Yun J et al. Screening for prediabetes and type 2 diabetes: Updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2021; 326(8): 744-60.
[892] US Preventive Service Task Force. US Preventive Services Task Force Recommendation Statement. Screening for prediabetes and type 2 diabetes: US Preventive Services Task Force recommendation statement. *JAMA*. 2021; 326(8): 736-43.
[893] Jonas D, Crotty K, Yun J et al. Screening for prediabetes and type 2 diabetes: Updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2021; 326(8): 744-60.
[894] Saaristo T, Peltonen M, Keinänen-Kiukaanniemi S et al. National type 2 diabetes prevention programme in Finland: FIN-D2D. *International Journal of Circumpolar Health*. 2007; 66(2): 101-12.
[895] Laatikainen T, Dunbar J, Chapman A et al. Prevention of Type 2 Diabetes by lifestyle intervention in an Australian primary health care setting: Greater Green Triangle (GGT) Diabetes Prevention Project. *BMC Public Health*. 2007; 7: 249-55.
[896] Albright A, Gregg E. Preventing type 2 diabetes in communities across the U.S.: The National Diabetes Prevention Program. *American Journal of Preventive Medicine*. 2013; 44 (Suppl. 4): S346-51.
[897] Penn L, Rodrigues A, Haste A et al. NHS Diabetes Prevention Programme in England: Formative evaluation of the programme in early phase implementation. *BMJ Open*. 2018; 8: e019467
[898] Saaristo T, Peltonen M, Keinänen-Kiukaanniemi S et al. National type 2 diabetes prevention programme in Finland: FIN-D2D. *International Journal of Circumpolar Health*. 2007; 66(2): 101-12.

went on to receive a confirmatory oral glucose tolerance test and 5,523 had any follow-up data with 3,880 having follow-up data at one-year post intervention.[899]

- Of those with follow-up data at one-year post intervention, 17.5% had a weight loss of ≥5%, 16.8% had a weight loss of between 2.5-4.9%, the weight remained stable for 46.1% and 19.5% gained ≥2.5% weight.[900]
- At seven years of follow-up, individuals who lost 5% or more of their weight during the first year had a 29% (HR of 0.71; 95% CI of 0.56 to 0.90) lower risk of diabetes, compared to those with stable weight.[901]

Australia's Life! Taking Action on Diabetes Program

- The Australian program (*Life! Taking Action on Diabetes* [*Life!*]) consists of a group-course six session intensive intervention for 8–15 people. The first five sessions occurred every fortnight for 9 weeks. The sixth intervention session was scheduled for 8 months after the first session. The objective of session six is to follow up with participants and observe maintenance of their newly learned lifestyles.[902]
- A review of the results indicates that 14,819 individuals were referred to the program between October of 2007 and June of 2011, with 8,412 commencing the program. Of the 8,412, a total of 6,632 attended session five and 3,114 attended session six. Those completing sessions one through five had a weight loss of 1.4kg while those attending session six had a weight loss of 2.4kg.[903]
- *Life!* was estimated to cost $400 (in 2010 Australian dollars) per participant[904] or $446 in 2022 CDN.

US National Diabetes Prevention Program

- The US program (National DPP) consists of 16 hourly sessions held at approximately weekly intervals during the first 6 months, followed by a minimum of six sessions held at approximately monthly intervals during months 7–12. The second 6 months is intended to reinforce and build on content delivered in the first half of the program.[905]
- An analysis of 14,747 participants who attended at least one of the 22 sessions found that 12,775 attended at least four sessions. Median weight loss was 3.6% for those attending at least four sessions vs. 0.4% for those who did not. Median weight loss

[899] Saaristo T, Moilanen L, Korpi-Hyov E et al .Lifestyle intervention for prevention of type 2 diabetes in primary health care: One-year follow-up of the Finnish National Diabetes Prevention Program. *Diabetes Care*. 2010; 33(10): 2146-51.
[900] Saaristo T, Moilanen L, Korpi-Hyov E et al .Lifestyle intervention for prevention of type 2 diabetes in primary health care: One-year follow-up of the Finnish National Diabetes Prevention Program. *Diabetes Care*. 2010; 33(10): 2146-51.
[901] Rintamäki R, Rautio N, Peltonend M et al. Long-term outcomes of lifestyle intervention to prevent type 2 diabetes in people at high risk in primary health care. *Primary Care Diabetes*. 2021; 15: 444-50.
[902] Dunbar J, Jayawardena A, Johnson G et al. Scaling up diabetes prevention in Victoria, Australia: Policy development, implementation, and evaluation. *Diabetes Care*. 2014; 37: 934-42.
[903] Dunbar J, Jayawardena A, Johnson G et al. Scaling up diabetes prevention in Victoria, Australia: Policy development, implementation, and evaluation. *Diabetes Care*. 2014; 37: 934-42.
[904] Dunbar J, Jayawardena A, Johnson G et al. Scaling up diabetes prevention in Victoria, Australia: Policy development, implementation, and evaluation. *Diabetes Care*. 2014; 37: 934-42.
[905] Ely E, Gruss S, Luman E et al. A national effort to prevent type 2 diabetes: Participant level evaluation of CDC's National Diabetes Prevention Program. *Diabetes Care*. 2017; 40: 1331-41.

for those attending at least 17 sessions was 6.0%.[906] The authors note that 43% completed 16 sessions, compared with 95% in the original DPP.[907]

- A review of the first 41,203 attendees of the National DPP found that 63% of participants were retained in the program through week 18 and 31.9% completed the entire program.[908]

UK's Healthier You: National Health Service Diabetes Prevention Programme

- The UK program (NHS DPP) involves groups of 15–20 adults attending at least 13 sessions (totalling 16 hours) with a minimum of 9 months' duration.[909]
- A total of 99,473 individuals were referred to the NHS DPP during 2016 and 2017. Of those referred, 55,275 started the program (attended at least the initial assessment), 37,871 attended at least one intervention session, 18,562 attended at least 60% of the intervention sessions and 12,127 completed the full course.[910]
- An evaluation of early outcomes noted a clear dose-response with individuals who attended more sessions experiencing greater reductions in both weight and HbA_{1c}. Those who attended at least 60% of sessions had a mean weight loss of > 3 kg and a reduction of between 2.0 and 3.0 mmol/mol in HbA_{1c}.[911]
- Initial research suggests that the implementation of the NHS DPP has reduced rates of type 2 diabetes incidence at the population level during 2018 and 2019, with an estimated 13,776 (6.2%) fewer cases than would be expected in the absence of the NHS DPP.[912]
- Providing the NHS DPP digitally also appears to be effective.[913,914]
- The average cost of the NHS DPP has been estimated at £143 (in 2020 or $262 in 2022 CDN) per referral and £342 (in 2020 or $626 in 2022 CDN) per referral that completed at least 60% of the program.[915]

[906] Ely E, Gruss S, Luman E et al. A national effort to prevent type 2 diabetes: Participant level evaluation of CDC's National Diabetes Prevention Program. *Diabetes Care*. 2017; 40: 1331-41.
[907] Wing R, Hamman R, Bray G et al. Achieving weight and activity goals among Diabetes Prevention Program lifestyle participants. *Obesity Research*. 2004; 12: 1426-34.
[908] Cannon M, Masalovich S, Ng B et al. Retention among participants in the National Diabetes Prevention Program lifestyle change program. *Diabetes Care*. 2020; 43: 2042-9.
[909] Penn L, Rodrigues A, Haste A et al. NHS Diabetes Prevention Programme in England: Formative evaluation of the programme in early phase implementation. *BMJ Open*. 2018; 8: e019467
[910] Howarth E, Bower P, Kontopantelis E et al. 'Going the distance': An independent cohort study of engagement and dropout among the first 100 000 referrals into a large-scale diabetes prevention program. *BMJ Open Diabetes Research & Care*. 2020; 8: e001835
[911] Valabhji J, Barron E, Bradley D et al. Early outcomes from the English National Health Service Diabetes Prevention Programme. *Diabetes Care*. 2020; 43: 152-60.
[912] McManus E, Meacock R, Parkinson P et al. Population level impact of the NHS Diabetes Prevention Programme on incidence of type 2 diabetes in England: An observational study. *The Lancet Regional Health – Europe*. 2022; 19: 100429.
[913] Ross J, Barron E, McGough B et al. Uptake and impact of the English National Health Service digital diabetes prevention programme: Observational study. *BMJ Open Diabetes Research & Care*. 2022; 10: e002736.
[914] Barron E, Bradley D, Safazadeh S et al. Effectiveness of digital and remote provision of the Healthier You: NHS Diabetes Prevention Programme during the COVID-19 pandemic. *Diabetic Medicine*. 2023; 40: e15028.
[915] McManus E, Meacock R, Parkinson P et al. Evaluating the short-term costs and benefits of a nationwide Diabetes Prevention Programme in England: Retrospective observational study. *Applied Health Economics and Health Policy*. 2023; 21: 891-903.

BC-Based Diabetes Prevention Programmes

Small Steps for Big Changes

- Small Steps for Big Changes (SSBC) "is a brief motivational interviewing-informed diabetes prevention program designed to empower clients to make diet and exercise changes that suit their lives."[916] In addition to a focus on client autonomy, the program has a focus on improving equitable access and inclusive care to everyone.[917]
- SSBC involves a training phase which includes a free 1-month gym membership, six sessions of 1-on-1 exercise and dietary change counselling with a trained coach over three weeks, the completion of two to four independent exercise sessions each week and tracking diet and exercise with a health app and fitness watch.[918]
- SSBC is currently being offered at eight centres in the interior and north of BC.[919]
- An effectiveness evaluation based on 123 participants who completed both the training phase and attended the six-month check in, indicated a weight loss of 3.9% (3.35kg), a decrease in waist circumference of 4.0% (4.2 cm) and a 6.0% improvement in the 6-minute walk test at six-months post intervention.[920]
- The six 1-on-1 sessions are each estimated to take an average of 60 minutes of a coaches time.[921] YMCA frontline staff, fitness managers and volunteers are trained to be SSBC coaches.[922] We have used the average B.C. hourly wage rate in 2022 ($31.49[923]) to value their time. Furthermore, we have assumed an additional 18% for benefits and 16% for paid, non-working days.[924] The estimated cost per coaches hour would thus be $42.20 ($31.49 + (31.49*0.18) + ($31.49 * 0.16)). The estimated labour cost per participant would therefore be estimated at $253 (6.0 hours * $42.20).
- In addition, approximately $150 per participant is required to cover costs such as coaches training, materials (marketing, workbook, scales, tablet, etc.) and a dedicated website for coaches.[925]

[916] Dineen T, Bean C, Jung M. Successes and challenges from a motivational interviewing-informed diabetes prevention program situated in the community. *Health Promotion Practice*. 2024; 25(2): 274-84.
[917] Cranston K, MacPherson M, Sim J, Jung M. Small steps towards an inclusive diabetes prevention program: How Small Steps for Big Changes is improving program equity and inclusion. *Community Health Equity Research & Policy*. 2023; 0(0). doi:10.1177/2752535X231189932
[918] The University of British Columbia. *Small Steps for Big Changes*. Available online at https://ok-smallsteps.sites.olt.ubc.ca/. Accessed April 2024.
[919] The University of British Columbia. *Small Steps for Big Changes*. Available online at https://ok-smallsteps.sites.olt.ubc.ca/. Accessed April 2024.
[920] Bean C, Dineen T, Locke S et al. An evaluation of the reach and effectiveness of a diabetes prevention behaviour change program situated in a community site. *Canadian Journal of Diabetes*. 2021; 45(4): 360-8.
[921] Dr. Mary Jung. Personal Communication. May 2024.
[922] The University of British Columbia. *Small Steps for Big Changes*. Available online at https://ok-smallsteps.sites.olt.ubc.ca/. Accessed April 2024.
[923] BC Stats. *Earning & Employment Trends – August 2022*. Available at https://www2.gov.bc.ca/assets/gov/data/statistics/people-population-community/income/earnings_and_employment_trends_data_tables.pdf. Accessed September 2023.
[924] Of the 260 potential paid days in a year (52 weeks * 5 days / week), 20 days are paid vacation days, 12 days are paid statutory holidays, 5 are paid days for educational leave and 5 are paid days for sick time. Therefore, 16.2% (42/260) of paid days are non-working days.
[925] Dr. Mary Jung. Personal Communication. May 2024.

LifestyleRx

- *LifestyleRx* is a comprehensive, evidence-based approach to diabetes reversal, which individuals with provincial health coverage in British Columbia, Alberta and Ontario can attend for no charge (funded by MSP in BC).[926]
- A referral from a primary care provider (with a diagnosis of pre-diabetes or diabetes) is required to enter the program. The program begins with a full consultation with a physician followed by 12 weekly online physician-led sessions in groups of 15-30. Individuals also have access up to five appointments with a physician by video call over a 1 year period. Between sessions, individuals watch videos explaining core concepts, print out reference guides and cheat sheets, and complete ongoing learning exercises. Furthermore, they complete self-assessments and exercises to show where they are doing well and where they need to focus. Finally, individuals are provided with personal health reports that help them to understand what their lab results and other markers show about their current health and diabetic reversal path.
- Based on results to date, 61% of participants are female.[927]
- Results from the first 941 participants indicate an average reduction in HbA_{1c} from 7.8% to 6.7% over an average 141 day time period.[928]
- Program costs consist of an initial physician consult at $85, 12 group medical visits at $14.50 per person attending and up to 5 one-on-one physician follow-up consults at $45 each, for a total estimated program cost of $484 per participant.[929]

Male / Female Involvement in Diabetes Prevention Programmes

- Approximately 70-80% of those enrolled and participating in a diabetes prevention program are female.[930,931,932,933,934]
- The one exception appears to be the English NHS DPP in which the male / female participation is approximately 45% / 55%.[935]
- Offering a virtual program appears to increase male participation.[936] Note that 39% of participants in the online *Lifestyle Rx* program are male.

[926] *LifestyleRx*. Available online at https://lifestylerx.io/. Accessed April, 2024.
[927] Dr. Brendan Byrne. Personal Communication. April 2024.
[928] Dr. Brendan Byrne. Personal Communication. April 2024.
[929] Dr. Brendan Byrne. Personal Communication. April 2024.
[930] Ali M, Echouffo-Tcheugui J, Williamson D. How effective were lifestyle interventi9ons in real-world settings that were modeled on the Diabetes Prevention Program? *Health Affairs*. 2012; 31(1): 67-75.
[931] Ely E, Gruss S, Luman E et al. A national effort to prevent type 2 diabetes: Participant level evaluation of CDC's National Diabetes Prevention Program. *Diabetes Care*. 2017; 40: 1331-41.
[932] Gruss S, Nhim K, Gregg E et al. Public health approaches to type 2 diabetes prevention: The US National Diabetes Prevention Program and beyond. *Current Diabetes Reports*. 2019; 19: 78.
[933] Galavitz K, Weber M, Straus A et al. Global diabetes prevention interventions: A systematic review and network meta-analysis of the real-world impact on incidence, weight, and glucose. *Diabetes Care*. 2018; 41: 1526-34.
[934] Bean C, Dineen T, Locke S et al. An evaluation of the reach and effectiveness of a diabetes prevention behaviour change program situated in a community site. *Canadian Journal of Diabetes*. 2021; 45(4): 360-8.
[935] Valabhji J, Barron E, Bradley D et al. Early outcomes from the English National Health Service Diabetes Prevention Programme. *Diabetes Care*. 2020; 43: 152-60.
[936] Cannon M, Ng B, Lloyd K et al. Delivering the National Diabetes Prevention Program: Assessment of enrollment in in-person and virtual organizations. *Journal of Diabetes Research*. 2022; Article ID 2942918.

Retention in Diabetes Prevention Programmes

- Retention in a diabetes prevention program is critical to the effectiveness of the intervention in reducing the progression from prediabetes to diabetes. While retention is often high in research trials (suggesting a highly motivated cohort who enter the trials), retention in the real world setting is often suboptimal. While program completion is not necessarily required to achieve benefits, most programs suggest a minimum attendance at 4-6 sessions before benefits are realized (the effective dose). From the experience in Finland, Australia and the UK, the proportion of individuals referred to a diabetes prevention program who achieve an effective dose ranges between 18.7% and 44.8% (see Table 14).

Table 14: Retention in Diabetes Prevention Programmes

	Finland		Australia		UK	
Referred	10,149		14,819		99,473	
Started (e.g. initial assessment)	8,353	82.3%	8,412	56.8%	55,275	55.6%
Attend at least one session	5,523	54.4%	NA		37,871	38.1%
Effective dose	3,880	38.2%	6,632	44.8%	18,562	18.7%
Complete program	NA		3,114	21.0%	12,127	12.2%

- Once enrolled, the retention of males and females in a diabetes prevention program appears to be similar.[937]
- For modelling purposes we will assume that 44.8% of those referred to a diabetes prevention program will stay involved long enough to receive an 'effective dose' (as in Australia) and reduce this to 18.7% (as in the UK) in the sensitivity analysis.

With Intervention

Individuals Eligible for Screening

- To estimate the number of individuals eligible for screening, we calculated the percent of the population that had overweight and obesity (after first excluding pregnant females in the female cohort) and then excluded those with diagnosed diabetes from the cohort with overweight and obesity (essentially assuming that all individuals with type 2 diabetes would be in the overweight category). At age 35, this meant that 51% (10,048 of 19,736) of females and 65% (12,715 of 19,474) of males would be eligible for screening (see Table 15). By age 70, 38% of females and 40% of males would be eligible for screening.
- Because screening occurs just once every three years, we would expect 2,698 screens at age 35 in females and 2,780 in males (see Table 15).

[937] Cannon M, Masalovich S, Ng B et al. Retention among participants in the National Diabetes Prevention Program lifestyle change program, 2012-2017. *Diabetes Care*. 2020; 43: 2042-9.

Table 15: Number of Individuals Eligible for Screening

In a BC Birth Cohort of 40,000

Ages 35 to 70 by Sex

	Females											*Males*									
			OW or Obese		Diagnosed Diabetes		Eligible for Screening		Screening Up-to-		# of Annual		OW or Obese		Diagnosed Diabetes		Eligible for Screening		Screening Up-to-		# of Annual
Age	# in Birth	# Pregnant	%	#	%	#	%	#	%	#	Screens	Males	%	#	%	#	%	#	%	#	Screens
35	19,736	1,097	57%	10,624	2.9%	576	51%	10,048	81%	8,094	2,698	19,474	69%	13,340	3.2%	625	65%	12,715	66%	8,341	2,780
36	19,722	1,097	57%	10,617	3.1%	619	51%	9,997	81%	8,054	2,685	19,442	69%	13,318	3.5%	674	65%	12,643	66%	8,294	2,765
37	19,708	1,096	57%	10,609	3.4%	662	50%	9,947	81%	8,013	2,671	19,409	69%	13,295	3.7%	724	65%	12,571	66%	8,246	2,749
38	19,693	1,095	57%	10,601	3.6%	705	50%	9,896	81%	7,972	2,657	19,375	69%	13,272	4.0%	774	65%	12,498	66%	8,198	2,733
39	19,677	1,094	57%	10,593	3.8%	748	50%	9,844	81%	7,931	2,644	19,339	69%	13,247	4.3%	824	64%	12,424	66%	8,150	2,717
40	19,661	269	57%	11,053	4.0%	791	52%	10,262	81%	8,267	2,756	19,303	69%	13,222	4.5%	873	64%	12,349	66%	8,101	2,700
41	19,643	269	57%	11,043	4.2%	834	52%	10,209	81%	8,224	2,741	19,264	69%	13,196	4.8%	923	64%	12,273	66%	8,051	2,684
42	19,625	269	57%	11,033	4.5%	877	52%	10,156	81%	8,181	2,727	19,225	69%	13,169	5.1%	973	63%	12,196	66%	8,000	2,667
43	19,605	269	57%	11,022	5.0%	973	51%	10,049	81%	8,095	2,698	19,183	69%	13,140	5.8%	1,106	63%	12,034	66%	7,894	2,631
44	19,584	268	57%	11,010	5.5%	1,069	51%	9,941	81%	8,008	2,669	19,140	69%	13,111	6.5%	1,239	62%	11,872	66%	7,788	2,596
45	19,561		57%	11,150	6.0%	1,164	51%	9,986	81%	8,044	2,681	19,094	69%	13,080	7.2%	1,371	61%	11,708	66%	7,680	2,560
46	19,537		57%	11,136	6.4%	1,259	51%	9,877	81%	7,957	2,652	19,047	69%	13,047	7.9%	1,503	61%	11,544	66%	7,573	2,524
47	19,511		57%	11,121	6.9%	1,354	50%	9,767	81%	7,869	2,623	18,996	69%	13,013	8.6%	1,633	60%	11,379	66%	7,465	2,488
48	19,484		57%	11,106	7.4%	1,448	50%	9,657	81%	7,780	2,593	18,943	69%	12,976	9.3%	1,762	59%	11,213	66%	7,356	2,452
49	19,454		57%	11,089	7.9%	1,542	49%	9,546	81%	7,691	2,564	18,887	69%	12,937	10.0%	1,891	58%	11,047	66%	7,246	2,415
50	19,422		55%	10,760	8.4%	1,636	47%	9,124	89%	8,085	2,695	18,827	73%	13,687	10.7%	2,018	62%	11,669	79%	9,266	3,089
51	19,388		55%	10,741	8.9%	1,729	46%	9,012	89%	7,986	2,662	18,763	73%	13,641	11.4%	2,144	61%	11,497	79%	9,129	3,043
52	19,352		55%	10,721	9.4%	1,821	46%	8,900	89%	7,887	2,629	18,695	73%	13,591	12.1%	2,268	61%	11,323	79%	8,991	2,997
53	19,312		55%	10,699	9.9%	1,913	45%	8,786	89%	7,786	2,595	18,622	73%	13,538	12.8%	2,391	60%	11,147	79%	8,852	2,951
54	19,270		55%	10,675	10.4%	2,004	45%	8,672	89%	7,684	2,561	18,545	73%	13,482	13.5%	2,512	59%	10,970	79%	8,711	2,904
55	19,224		55%	10,650	10.9%	2,094	45%	8,556	89%	7,582	2,527	18,461	73%	13,421	14.3%	2,632	58%	10,790	79%	8,568	2,856
56	19,174		55%	10,623	11.4%	2,183	44%	8,439	89%	7,479	2,493	18,372	73%	13,357	15.0%	2,749	58%	10,608	79%	8,423	2,808
57	19,121		55%	10,593	11.9%	2,272	44%	8,321	89%	7,374	2,458	18,277	73%	13,287	15.7%	2,864	57%	10,423	79%	8,277	2,759
58	19,063		55%	10,561	12.6%	2,393	43%	8,168	89%	7,238	2,413	18,175	73%	13,213	16.5%	3,005	56%	10,209	79%	8,106	2,702
59	19,000		55%	10,526	13.2%	2,514	42%	8,013	89%	7,100	2,367	18,065	73%	13,133	17.4%	3,142	55%	9,991	79%	7,934	2,645
60	18,932		55%	10,488	13.9%	2,632	41%	7,856	97%	7,595	2,532	17,947	73%	13,047	18.3%	3,276	54%	9,771	91%	8,884	2,961
61	18,858		55%	10,447	14.6%	2,749	41%	7,698	97%	7,442	2,481	17,820	73%	12,955	19.1%	3,406	54%	9,549	91%	8,682	2,894
62	18,777		55%	10,403	15.3%	2,864	40%	7,538	97%	7,288	2,429	17,684	73%	12,856	20.0%	3,533	53%	9,323	91%	8,477	2,826
63	18,689		55%	10,354	15.9%	2,977	39%	7,377	97%	7,131	2,377	17,537	73%	12,749	20.8%	3,654	52%	9,095	91%	8,269	2,756
64	18,593		55%	10,301	16.6%	3,087	39%	7,214	97%	6,974	2,325	17,379	73%	12,634	21.7%	3,771	51%	8,863	91%	8,058	2,686
65	18,489		59%	10,871	17.3%	3,194	42%	7,677	97%	7,422	2,474	17,208	67%	11,547	22.6%	3,882	45%	7,664	91%	6,968	2,323
66	18,375		59%	10,804	18.0%	3,299	41%	7,506	97%	7,256	2,419	17,024	67%	11,423	23.4%	3,987	44%	7,436	91%	6,760	2,253
67	18,250		59%	10,731	18.6%	3,399	40%	7,331	97%	7,087	2,362	16,826	67%	11,290	24.3%	4,086	43%	7,204	91%	6,550	2,183
68	18,113		59%	10,650	19.3%	3,496	39%	7,154	97%	6,916	2,305	16,612	67%	11,147	25.1%	4,177	42%	6,970	91%	6,337	2,112
69	17,963		59%	10,562	20.0%	3,588	39%	6,974	97%	6,742	2,247	16,381	67%	10,992	26.0%	4,260	41%	6,732	91%	6,120	2,040
70	17,799		59%	10,466	20.7%	3,676	38%	6,790	97%	6,564	2,188	16,132	67%	10,824	26.9%	4,334	40%	6,490	91%	5,901	1,967

Undiagnosed Prediabetes Identified by Screening, Receipt of Treatment and Treatment Effectiveness

- To estimate the number of individuals with undiagnosed prediabetes who would be identified through screening we started with the estimated number of females (see Table 6) and males (see Table 7) with undiagnosed prediabetes by age in the birth cohort. We then used the proportion of the population by sex and age whose screening is up to date (see Table 15) to estimate the number of individuals with undiagnosed prediabetes who would be identified by screening (see Table 16). In doing so, we essentially assumed that all individuals with prediabetes would have overweight or obesity (see Table 1).
- We then assumed that all individuals with screen identified prediabetes would be referred to an intensive lifestyle intervention and that 44.8% of those referred would receive an effective dose. Attendance at the intervention would consist of a 70:30

female-to-male ratio. An equal proportion of females and males who attend would receive an effective dose. Of those who receive an effective dose, 22% would not progress from prediabetes to diabetes (see Table 16).

- Table 16 should be read as follows: at age 35, 917 females in the cohort have undiagnosed prediabetes. Of these, 739 (81%) would be identified by screening and referred to an intensive lifestyle intervention, 481 would participate in the intervention long enough to receive an effective dose and 106 (22%) would not progress from prediabetes to diabetes due to their change in lifestyle. At age 36, an additional 56 females would be diagnosed with prediabetes and so on.

Table 16: Individuals with Undiagnosed Prediabetes Identified by Screening Receiving an Effective Dose

In a BC Birth Cohort of 40,000

Ages 35 to 70

	Females						*Males*					
	# in Birth Cohort	**Undiagnosed Prediabetes**		Identified by Screening	# Receiving Effective Dose	# Not Progressing to Diabetes	**# in Birth Cohort**	**Undiagnosed Prediabetes**		Identified by Screening	# Receiving Effective Dose	# Not Progressing to Diabetes
Age		Prevalance	Incidence					Prevalance	Incidence			
35	19,736	917	917	739	481	105.8	19,474	1,210	1,210	794	206	45.3
36	19,722	974	56	45	29	6.4	19,442	1,283	73	48	13	2.8
37	19,708	1,030	56	45	29	6.4	19,409	1,356	73	48	12	2.7
38	19,693	1,086	56	45	29	6.4	19,375	1,428	72	47	12	2.7
39	19,677	1,141	56	45	29	6.4	19,339	1,500	72	47	12	2.7
40	19,661	1,197	56	45	29	6.3	19,303	1,571	71	47	12	2.7
41	19,643	1,253	56	45	29	6.3	19,264	1,642	71	47	12	2.7
42	19,625	1,308	55	45	29	6.3	19,225	1,713	71	46	12	2.7
43	19,605	1,363	55	44	28	6.2	19,183	1,783	70	46	12	2.7
44	19,584	1,418	55	44	28	6.2	19,140	1,853	70	46	12	2.7
45	19,561	1,473	55	44	28	6.2	19,094	1,922	69	45	12	2.6
46	19,537	1,527	54	44	28	6.1	19,047	1,990	69	45	12	2.6
47	19,511	1,581	54	44	28	6.1	18,996	2,058	68	45	12	2.6
48	19,484	1,635	54	43	27	6.0	18,943	2,126	67	44	12	2.6
49	19,454	1,689	54	43	27	6.0	18,887	2,192	66	44	12	2.6
50	19,422	1,737	49	43	28	6.2	18,827	2,252	60	47	12	2.7
51	19,388	1,786	48	43	28	6.2	18,763	2,310	59	47	12	2.6
52	19,352	1,833	48	42	28	6.1	18,695	2,368	58	46	12	2.6
53	19,312	1,881	47	42	27	6.0	18,622	2,424	57	45	12	2.6
54	19,270	1,927	47	41	27	5.9	18,545	2,480	55	44	11	2.5
55	19,224	1,974	46	41	26	5.8	18,461	2,534	54	43	11	2.5
56	19,174	2,019	46	40	26	5.7	18,372	2,587	53	42	11	2.4
57	19,121	2,064	45	40	25	5.5	18,277	2,638	51	41	11	2.4
58	19,063	2,108	44	39	25	5.4	18,175	2,687	49	39	11	2.3
59	19,000	2,151	43	38	24	5.3	18,065	2,735	48	38	10	2.3
60	18,932	2,194	42	41	26	5.7	17,947	2,780	46	41	11	2.4
61	18,858	2,235	41	40	25	5.5	17,820	2,824	43	39	11	2.3
62	18,777	2,275	40	39	24	5.2	17,684	2,864	41	37	10	2.2
63	18,689	2,314	39	37	23	5.0	17,537	2,902	38	35	10	2.1
64	18,593	2,351	37	36	21	4.7	17,379	2,938	35	32	9	2.0
65	18,489	2,387	36	34	20	4.4	17,208	2,970	32	29	9	1.9
66	18,375	2,420	34	33	18	4.0	17,024	2,998	28	26	8	1.7
67	18,250	2,452	32	31	17	3.7	16,826	3,023	25	22	7	1.6
68	18,113	2,482	29	28	15	3.2	16,612	3,043	20	18	6	1.4
69	17,963	2,509	27	26	13	2.8	16,381	3,058	16	14	5	1.2
70	17,799	2,533	24	23	10	2.3	16,132	3,069	10	10	4	1.0

- As calculated in Table 16, 298 females and 128 males in the BC birth cohort would not progress from prediabetes to diabetes due to screening and intervention. These individuals would also avoid the excess complications attributable to diabetes. In Table 17, we calculate that 42 cases of myocardial infarction, 26 cases of stroke, 97 cases of angina, 44 cases of heart failure, 13 amputations, 17 cases of nephropathy, 5 cases of blindness and 54 cases of cataracts would be avoided.

Table 17: Complications Avoided Due to Avoided Diabetes

By Age and Sex in a BC Birth Cohort of 40,000

	Myocardial Infarction			Stroke			Angina			Heart Failure			Amputation			Nephropathy			Blindness			Cataract		
Age	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T
35	0.8	0.4	1.2	0.5	0.2	0.8	1.7	0.7	2.5	0.5	0.2	0.7	0.1	0.0	0.1	0.1	0.0	0.1	0.00	0.00	0.00	0.3	0.1	0.4
36	0.5	0.2	0.7	0.3	0.1	0.4	5.9	2.5	8.4	0.5	0.2	0.8	0.1	0.1	0.2	0.2	0.1	0.3	0.07	0.03	0.11	0.9	0.4	1.3
37	0.4	0.2	0.6	0.3	0.1	0.4	2.5	1.1	3.6	0.4	0.2	0.6	0.1	0.0	0.1	0.1	0.0	0.1	0.07	0.03	0.10	0.6	0.3	0.9
38	0.4	0.2	0.6	0.3	0.1	0.4	1.9	0.8	2.8	0.4	0.2	0.5	0.1	0.0	0.1	0.1	0.1	0.2	0.04	0.02	0.06	0.5	0.2	0.7
39	0.5	0.2	0.7	0.3	0.1	0.4	1.8	0.8	2.5	0.4	0.2	0.6	0.1	0.0	0.1	0.1	0.0	0.1	0.04	0.02	0.06	0.5	0.2	0.7
40	0.5	0.2	0.7	0.3	0.1	0.4	1.7	0.7	2.5	0.5	0.2	0.7	0.1	0.0	0.1	0.1	0.1	0.2	0.04	0.02	0.06	0.5	0.2	0.7
41	0.5	0.2	0.7	0.4	0.2	0.5	1.6	0.7	2.4	0.5	0.2	0.7	0.1	0.0	0.2	0.1	0.1	0.2	0.00	0.00	0.00	0.5	0.2	0.7
42	0.6	0.2	0.8	0.4	0.2	0.5	1.6	0.7	2.2	0.5	0.2	0.7	0.1	0.1	0.2	0.2	0.1	0.3	0.01	0.01	0.02	0.7	0.3	1.0
43	0.7	0.3	0.9	0.4	0.2	0.6	1.6	0.7	2.3	0.6	0.3	0.9	0.1	0.1	0.2	0.2	0.1	0.3	0.06	0.02	0.08	0.7	0.3	1.0
44	0.6	0.3	0.9	0.4	0.2	0.6	1.5	0.7	2.2	0.7	0.3	1.0	0.2	0.1	0.2	0.2	0.1	0.3	0.05	0.02	0.07	0.7	0.3	1.0
45	0.7	0.3	0.9	0.4	0.2	0.6	1.5	0.6	2.1	0.7	0.3	1.0	0.2	0.1	0.3	0.3	0.1	0.4	0.07	0.03	0.10	0.8	0.4	1.2
46	0.7	0.3	1.0	0.4	0.2	0.6	1.5	0.6	2.2	0.7	0.3	1.0	0.2	0.1	0.3	0.3	0.1	0.4	0.07	0.03	0.11	0.9	0.4	1.2
47	0.7	0.3	1.0	0.4	0.2	0.6	1.5	0.7	2.2	0.7	0.3	1.1	0.2	0.1	0.3	0.3	0.1	0.4	0.08	0.03	0.11	0.9	0.4	1.3
48	0.7	0.3	1.0	0.4	0.2	0.6	1.6	0.7	2.2	0.8	0.3	1.1	0.2	0.1	0.3	0.3	0.1	0.4	0.08	0.03	0.11	0.9	0.4	1.3
49	0.7	0.3	1.1	0.5	0.2	0.7	1.6	0.7	2.3	0.8	0.3	1.1	0.2	0.1	0.3	0.3	0.1	0.5	0.08	0.04	0.12	1.0	0.4	1.4
50	0.8	0.3	1.1	0.5	0.2	0.7	1.6	0.7	2.3	0.8	0.4	1.2	0.2	0.1	0.4	0.3	0.1	0.5	0.09	0.04	0.12	1.0	0.4	1.4
51	0.8	0.3	1.1	0.5	0.2	0.7	1.7	0.7	2.4	0.8	0.4	1.2	0.3	0.1	0.4	0.3	0.1	0.5	0.09	0.04	0.13	1.0	0.4	1.5
52	0.8	0.4	1.2	0.5	0.2	0.7	1.7	0.7	2.4	0.9	0.4	1.2	0.3	0.1	0.4	0.4	0.2	0.5	0.09	0.04	0.13	1.1	0.5	1.5
53	0.8	0.4	1.2	0.5	0.2	0.7	1.7	0.7	2.5	0.9	0.4	1.3	0.3	0.1	0.4	0.4	0.2	0.5	0.10	0.04	0.14	1.1	0.5	1.6
54	0.9	0.4	1.2	0.5	0.2	0.8	1.7	0.7	2.5	0.9	0.4	1.3	0.3	0.1	0.4	0.4	0.2	0.5	0.10	0.04	0.14	1.1	0.5	1.6
55	0.9	0.4	1.3	0.5	0.2	0.8	1.8	0.8	2.5	0.9	0.4	1.4	0.3	0.1	0.4	0.4	0.2	0.6	0.10	0.04	0.14	1.2	0.5	1.7
56	0.9	0.4	1.3	0.6	0.2	0.8	1.8	0.8	2.6	1.0	0.4	1.4	0.3	0.1	0.4	0.4	0.2	0.6	0.10	0.04	0.15	1.2	0.5	1.7
57	0.9	0.4	1.3	0.6	0.2	0.8	1.8	0.8	2.6	1.0	0.4	1.4	0.3	0.1	0.4	0.4	0.2	0.6	0.11	0.05	0.15	1.2	0.5	1.7
58	0.9	0.4	1.4	0.6	0.2	0.8	1.8	0.8	2.6	1.0	0.4	1.5	0.3	0.1	0.4	0.4	0.2	0.6	0.11	0.05	0.16	1.2	0.5	1.8
59	1.0	0.4	1.4	0.6	0.3	0.8	1.8	0.8	2.6	1.0	0.4	1.5	0.3	0.1	0.5	0.4	0.2	0.6	0.11	0.05	0.16	1.3	0.5	1.8
60	1.0	0.4	1.4	0.6	0.3	0.9	1.9	0.8	2.7	1.1	0.5	1.5	0.3	0.1	0.5	0.4	0.2	0.6	0.12	0.05	0.16	1.3	0.6	1.9
61	1.0	0.4	1.4	0.6	0.3	0.9	1.9	0.8	2.7	1.1	0.5	1.6	0.3	0.1	0.5	0.5	0.2	0.7	0.12	0.05	0.17	1.3	0.6	1.9
62	1.0	0.4	1.5	0.6	0.3	0.9	1.9	0.8	2.7	1.1	0.5	1.6	0.3	0.1	0.5	0.5	0.2	0.7	0.12	0.05	0.17	1.4	0.6	1.9
63	1.0	0.4	1.5	0.6	0.3	0.9	1.9	0.8	2.7	1.1	0.5	1.6	0.4	0.2	0.5	0.5	0.2	0.7	0.12	0.05	0.18	1.4	0.6	2.0
64	1.1	0.5	1.5	0.6	0.3	0.9	1.9	0.8	2.8	1.2	0.5	1.7	0.4	0.2	0.5	0.5	0.2	0.7	0.13	0.05	0.18	1.4	0.6	2.0
65	1.1	0.5	1.5	0.7	0.3	0.9	1.9	0.8	2.8	1.2	0.5	1.7	0.4	0.2	0.5	0.5	0.2	0.7	0.13	0.06	0.18	1.4	0.6	2.1
66	1.1	0.5	1.6	0.7	0.3	1.0	1.9	0.8	2.7	1.2	0.5	1.7	0.4	0.2	0.5	0.5	0.2	0.7	0.13	0.06	0.19	1.5	0.6	2.1
67	1.1	0.5	1.6	0.7	0.3	1.0	1.9	0.8	2.7	1.2	0.5	1.7	0.4	0.2	0.5	0.5	0.2	0.7	0.13	0.06	0.19	1.5	0.6	2.1
68	1.1	0.5	1.6	0.7	0.3	1.0	1.9	0.8	2.7	1.2	0.5	1.8	0.4	0.2	0.5	0.5	0.2	0.7	0.14	0.06	0.19	1.5	0.6	2.1
69	1.1	0.5	1.6	0.7	0.3	1.0	1.9	0.8	2.7	1.2	0.5	1.8	0.4	0.2	0.6	0.5	0.2	0.8	0.14	0.06	0.20	1.5	0.7	2.2
70	1.1	0.5	1.6	0.7	0.3	1.0	1.8	0.8	2.6	1.3	0.5	1.8	0.4	0.2	0.6	0.5	0.2	0.8	0.14	0.06	0.20	1.5	0.7	2.2
Total	**30**	**13**	**42**	**18**	**8**	**26**	**68**	**29**	**97**	**31**	**13**	**44**	**9.1**	**3.9**	**13**	**12**	**5**	**17**	**3.2**	**1.4**	**4.5**	**37**	**16**	**54**

QALYs Gained due to Complications and Living with Diabetes Avoided

- As noted previously, each of the complications attributable to diabetes, as well as living with diagnosed diabetes, is associated with a reduction on QoL. We have calculated that by avoiding progressing from prediabetes to diabetes, the 298 females would gain 918 QALYs and the 128 males would gain 356 QALYs (see Table 18).

Table 18: QALYs Gained due to Excess Complications and Living with Diagnosed Diabetes Avoided

By Age and Sex in a BC Birth Cohort of 40,000

	Myocardial Infarction			Stroke			Angina			Heart Failure			Amputation			Nephropathy			Blindness			Cataract			Uncomplicated Diagnosed Diabetes			Total QALYs Gained		
Age	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T
35	0.1	0.0	0.1	6.2	2.4	8.6	7.9	3.1	11	0.1	0.0	0.1	0.9	0.4	1.3	0.4	0.2	0.6	0.0	0.0	0.0	0.00	0.00	0.00	288	113	401	303	119	422
36	0.1	0.0	0.1	3.4	1.4	4.8	26	10	37	0.1	0.0	0.1	1.1	0.4	1.6	1.2	0.5	1.7	0.8	0.3	1.1	0.01	0.00	0.01	-1.9	-0.7	-2.6	31	12	43
37	0.0	0.0	0.1	3.1	1.2	4.3	11.1	4.3	15	0.1	0.0	0.1	0.7	0.3	1.0	0.6	0.2	0.8	0.7	0.3	1.0	0.01	0.00	0.01	7.9	3.1	11	24	9	34
38	0.0	0.0	0.1	2.8	1.1	4.0	8.4	3.3	12	0.1	0.0	0.1	0.6	0.2	0.9	0.7	0.3	0.9	0.4	0.2	0.6	0.01	0.00	0.01	9.4	3.7	13	22	9	31
39	0.1	0.0	0.1	2.7	1.1	3.7	7.4	2.9	10	0.1	0.0	0.1	0.8	0.3	1.1	0.6	0.2	0.8	0.4	0.2	0.6	0.01	0.00	0.01	9.6	3.8	13	22	8	30
40	0.1	0.0	0.1	3.2	1.3	4.5	7.5	2.9	10	0.1	0.0	0.1	0.9	0.3	1.2	0.8	0.3	1.2	0.4	0.2	0.6	0.01	0.00	0.01	9.4	3.7	13	22	9	31
41	0.1	0.0	0.1	3.8	1.5	5.3	7.0	2.7	9.7	0.1	0.0	0.1	1.0	0.4	1.4	0.8	0.3	1.1	0.0	0.0	0.0	0.01	0.00	0.01	9.2	3.6	13	22	9	30
42	0.1	0.0	0.1	3.7	1.4	5.1	6.5	2.5	9.0	0.1	0.0	0.1	1.2	0.5	1.7	1.0	0.4	1.4	0.1	0.1	0.2	0.01	0.00	0.01	8.9	3.4	12	22	8	30
43	0.1	0.0	0.1	4.2	1.6	5.8	6.6	2.6	9.1	0.1	0.0	0.2	1.2	0.5	1.7	0.9	0.4	1.3	0.5	0.2	0.7	0.01	0.00	0.01	7.9	3.1	11	22	8	30
44	0.1	0.0	0.1	3.9	1.5	5.5	6.1	2.4	8.4	0.1	0.1	0.2	1.4	0.6	2.0	1.2	0.5	1.6	0.4	0.2	0.6	0.01	0.00	0.01	7.6	3.0	11	21	8	29
45	0.1	0.0	0.1	3.9	1.5	5.4	5.7	2.2	8.0	0.1	0.1	0.2	1.6	0.6	2.3	1.4	0.5	1.9	0.6	0.2	0.9	0.01	0.00	0.01	7.2	2.8	10	21	8	29
46	0.1	0.0	0.1	3.9	1.5	5.5	5.7	2.2	7.9	0.1	0.1	0.2	1.7	0.6	2.3	1.4	0.5	1.9	0.6	0.3	0.9	0.01	0.00	0.01	6.7	2.6	9.3	20	8	28
47	0.1	0.0	0.1	4.0	1.5	5.5	5.7	2.2	7.9	0.1	0.1	0.2	1.7	0.7	2.3	1.4	0.5	2.0	0.7	0.3	0.9	0.01	0.00	0.01	6.3	2.4	8.7	20	8	28
48	0.1	0.0	0.1	4.0	1.5	5.5	5.6	2.2	7.8	0.1	0.1	0.2	1.7	0.7	2.4	1.4	0.6	2.0	0.7	0.3	0.9	0.01	0.00	0.01	5.8	2.2	8.1	20	8	27
49	0.1	0.0	0.1	4.0	1.6	5.6	5.6	2.2	7.8	0.1	0.1	0.2	1.7	0.7	2.4	1.5	0.6	2.0	0.7	0.3	0.9	0.01	0.00	0.02	5.4	2.1	7.4	19	7	26
50	0.1	0.0	0.1	4.2	1.6	5.8	5.8	2.2	8.0	0.1	0.1	0.2	1.8	0.7	2.5	1.5	0.6	2.1	0.7	0.3	1.0	0.01	0.00	0.02	5.8	2.2	8.0	20	8	28
51	0.1	0.0	0.1	4.2	1.6	5.9	5.8	2.2	8.0	0.2	0.1	0.2	1.8	0.7	2.5	1.5	0.6	2.1	0.7	0.3	1.0	0.01	0.01	0.02	5.3	2.0	7.3	20	8	27
52	0.1	0.0	0.1	4.2	1.6	5.9	5.7	2.2	7.9	0.2	0.1	0.2	1.9	0.7	2.6	1.6	0.6	2.2	0.7	0.3	1.0	0.01	0.01	0.02	4.8	1.8	6.6	19	7	26
53	0.1	0.0	0.1	4.2	1.6	5.9	5.7	2.2	7.8	0.2	0.1	0.2	1.9	0.7	2.6	1.6	0.6	2.2	0.7	0.3	1.0	0.01	0.01	0.02	4.3	1.6	5.9	19	7	26
54	0.1	0.0	0.1	4.2	1.6	5.8	5.6	2.1	7.7	0.2	0.1	0.2	1.9	0.7	2.6	1.6	0.6	2.2	0.7	0.3	1.0	0.01	0.01	0.02	3.8	1.5	5.3	18	7	25
55	0.1	0.0	0.2	4.2	1.6	5.8	5.5	2.1	7.6	0.2	0.1	0.2	1.9	0.7	2.6	1.6	0.6	2.2	0.7	0.3	1.0	0.01	0.01	0.02	3.3	1.3	4.6	17	7	24
56	0.1	0.0	0.2	4.2	1.6	5.8	5.4	2.1	7.4	0.2	0.1	0.2	1.9	0.7	2.6	1.6	0.6	2.2	0.7	0.3	1.0	0.01	0.01	0.02	2.9	1.1	4.0	17	6	23
57	0.1	0.0	0.2	4.1	1.6	5.7	5.3	2.0	7.3	0.2	0.1	0.3	1.9	0.7	2.6	1.6	0.6	2.2	0.7	0.3	1.0	0.01	0.01	0.02	2.4	0.9	3.4	16	6	23
58	0.1	0.0	0.2	4.1	1.6	5.7	5.2	2.0	7.1	0.2	0.1	0.3	1.8	0.7	2.6	1.6	0.6	2.2	0.7	0.3	1.0	0.01	0.01	0.02	2.0	0.8	2.7	16	6	22
59	0.1	0.0	0.2	4.1	1.5	5.6	5.0	1.9	7.0	0.2	0.1	0.3	1.8	0.7	2.5	1.5	0.6	2.1	0.7	0.3	1.0	0.01	0.01	0.02	1.5	0.6	2.1	15	6	21
60	0.1	0.1	0.2	4.1	1.6	5.7	5.1	1.9	7.0	0.2	0.1	0.3	1.9	0.7	2.6	1.6	0.6	2.2	0.7	0.3	1.0	0.02	0.01	0.02	2.1	0.8	2.9	16	6	22
61	0.1	0.1	0.2	4.1	1.5	5.6	5.0	1.9	6.9	0.2	0.1	0.3	1.9	0.7	2.6	1.6	0.6	2.2	0.7	0.3	1.0	0.02	0.01	0.02	1.5	0.6	2.1	15	6	21
62	0.1	0.1	0.2	4.0	1.5	5.5	4.9	1.8	6.7	0.2	0.1	0.3	1.8	0.7	2.5	1.5	0.6	2.1	0.7	0.3	1.0	0.02	0.01	0.02	1.0	0.4	1.4	14	5	20
63	0.1	0.1	0.2	3.9	1.5	5.4	4.7	1.8	6.5	0.2	0.1	0.3	1.8	0.7	2.5	1.5	0.6	2.1	0.7	0.3	1.0	0.02	0.01	0.02	0.5	0.2	0.7	14	5	19
64	0.1	0.1	0.2	3.9	1.5	5.3	4.6	1.7	6.3	0.2	0.1	0.3	1.8	0.7	2.5	1.5	0.6	2.1	0.7	0.3	1.0	0.02	0.01	0.02	-0.0	-0.0	-0.0	13	5	18
65	0.1	0.1	0.2	3.8	1.4	5.2	4.4	1.7	6.1	0.2	0.1	0.3	1.7	0.7	2.4	1.5	0.6	2.0	0.7	0.3	1.0	0.02	0.01	0.02	-0.5	-0.2	-0.7	12	5	16
66	0.1	0.1	0.2	3.7	1.4	5.0	4.2	1.6	5.8	0.2	0.1	0.3	1.7	0.6	2.4	1.4	0.5	2.0	0.7	0.3	0.9	0.02	0.01	0.02	-1.0	-0.4	-1.4	11	4	15
67	0.1	0.1	0.2	3.6	1.3	4.9	4.0	1.5	5.6	0.2	0.1	0.3	1.7	0.6	2.3	1.4	0.5	1.9	0.7	0.2	0.9	0.02	0.01	0.03	-1.5	-0.6	-2.1	10	4	14
68	0.1	0.1	0.2	3.5	1.3	4.8	3.8	1.4	5.3	0.2	0.1	0.3	1.6	0.6	2.2	1.4	0.5	1.9	0.6	0.2	0.9	0.02	0.01	0.03	-2.0	-0.7	-2.7	9	4	13
69	0.1	0.1	0.2	3.3	1.2	4.6	3.6	1.4	5.0	0.2	0.1	0.3	1.6	0.6	2.2	1.3	0.5	1.8	0.6	0.2	0.9	0.02	0.01	0.03	-2.5	-0.9	-3.4	8	3	12
70	0.1	0.1	0.2	3.4	1.3	4.7	3.6	1.3	5.0	0.2	0.1	0.3	1.6	0.6	2.2	1.4	0.5	1.9	0.6	0.2	0.9	0.02	0.01	0.03	-3.1	-1.2	-4.3	8	3	11
Total	**3.5**	**1.5**	**5.0**	**140**	**54**	**194**	**226**	**87**	**313**	**5.5**	**2.4**	**7.9**	**56**	**21**	**77**	**47**	**18**	**65**	**22**	**8**	**30**	**0.44**	**0.19**	**0.62**	**418**	**163**	**581**	**918**	**356**	**1,274**

Life Years Gained with Diabetes Avoided

- As noted previously, diabetes is associated with a reduced life expectancy (see Table 10). We have calculated that by avoiding progressing from prediabetes to diabetes, the 298 females would gain 1,761 life years and the 128 males would gain 621 life years (see Table 19).

Table 19: Life Years Gained due to Diabetes Avoided
By Age and Sex in a BC Birth Cohort of 40,000

	Incident Diabetes Avoided			Life Expectancy in BC		% Reduction in LE with Diabetes		Total Life Years Gained		
Age	F	M	T	F	M	F	M	F	M	T
35	106	45	151	50.8	46.5	-13.9%	-12.7%	746	268	**1,014**
36	6.4	2.8	9.2	49.9	45.6	-13.9%	-12.7%	44	16	**60**
37	6.4	2.7	9.1	48.9	44.7	-13.9%	-12.7%	43	16	**59**
38	6.4	2.7	9.1	47.9	43.7	-13.9%	-12.7%	42	15	**58**
39	6.4	2.7	9.1	47.0	42.8	-13.9%	-12.7%	41	15	**56**
40	6.3	2.7	9.0	46.0	41.9	-13.9%	-12.7%	40	14	**55**
41	6.3	2.7	9.0	45.1	41.0	-13.9%	-12.7%	39	14	**53**
42	6.3	2.7	9.0	44.1	40.1	-13.9%	-12.7%	38	14	**52**
43	6.2	2.7	8.9	43.1	39.1	-13.9%	-12.7%	37	13	**51**
44	6.2	2.7	8.9	42.2	38.2	-13.9%	-12.7%	36	13	**49**
45	6.2	2.6	8.8	41.2	37.3	-14.8%	-12.8%	38	13	**50**
46	6.1	2.6	8.8	40.3	36.4	-14.8%	-12.8%	37	12	**49**
47	6.1	2.6	8.7	39.3	35.5	-14.8%	-12.8%	35	12	**47**
48	6.0	2.6	8.6	38.4	34.6	-14.8%	-12.8%	34	11	**46**
49	6.0	2.6	8.5	37.4	33.7	-14.8%	-12.8%	33	11	**44**
50	6.2	2.7	8.9	36.5	32.8	-15.1%	-13.3%	34	12	**46**
51	6.2	2.6	8.8	35.6	31.9	-15.1%	-13.3%	33	11	**44**
52	6.1	2.6	8.7	34.6	31.0	-15.1%	-13.3%	32	11	**43**
53	6.0	2.6	8.6	33.7	30.2	-15.1%	-13.3%	30	10	**41**
54	5.9	2.5	8.4	32.8	29.3	-15.1%	-13.3%	29	10	**39**
55	5.8	2.5	8.3	31.9	28.4	-15.7%	-14.0%	29	10	**39**
56	5.7	2.4	8.1	30.9	27.5	-15.7%	-14.0%	28	9	**37**
57	5.5	2.4	7.9	30.0	26.7	-15.7%	-14.0%	26	9	**35**
58	5.4	2.3	7.7	29.1	25.8	-15.7%	-14.0%	25	8	**33**
59	5.3	2.3	7.5	28.2	25.0	-15.7%	-14.0%	23	8	**31**
60	5.7	2.4	8.1	27.3	24.1	-16.5%	-14.9%	26	9	**34**
61	5.5	2.3	7.8	26.4	23.3	-16.5%	-14.9%	24	8	**32**
62	5.2	2.2	7.5	25.5	22.5	-16.5%	-14.9%	22	8	**30**
63	5.0	2.1	7.1	24.6	21.7	-16.5%	-14.9%	20	7	**27**
64	4.7	2.0	6.7	23.8	20.9	-16.5%	-14.9%	18	6	**25**
65	4.4	1.9	6.3	22.9	20.1	-17.3%	-16.7%	17	6	**24**
66	4.0	1.7	5.8	22.0	19.3	-17.3%	-16.7%	15	6	**21**
67	3.7	1.6	5.2	21.2	18.5	-17.3%	-16.7%	13	5	**18**
68	3.2	1.4	4.6	20.3	17.7	-17.3%	-16.7%	11	4	**16**
69	2.8	1.2	4.0	19.5	17.0	-17.3%	-16.7%	9	3	**13**
70	2.3	1.0	3.2	18.7	16.2	-18.4%	-18.6%	8	3	**11**
Total	**297**	**127**	**425**	**5.9**	**4.9**			**1,761**	**621**	**2,381**

Summary of CPB

Based on these assumptions, the CPB associated with screening for, and treatment of, prediabetes in adults aged 35 to 70 years who have overweight or obesity in a BC birth cohort of 40,000 is 3,655 QALYs (2,679 QALYs in females and 976 QALYs in males) (see Table 20).

Table 20: CPB of Screening for, and Treatment of, Prediabetes in Asymptomatic Non-Pregnant Adults Aged 35 to 70 Years Who Have Overweight or Obesity

Row Label	Variable	Base Case	Data Source
	In the Absence of Screening		
a	Life years lived with diagnosed prediabetes - Females	15,699	Table 6
b	Life years lived with undiagnosed prediabetes - Females	65,224	Table 6
c	Life years lived with diagnosed diabetes - Females	70,143	Table 6
d	Life years lived with undiagnosed diabetes - Females	59,283	Table 6
e	**Total life years lived with prediabetes/diabetes - Females**	**210,349**	=a+b+c+d
f	Life years lived with diagnosed prediabetes - Males	15,713	Table 7
g	Life years lived with undiagnosed prediabetes - Males	83,109	Table 7
h	Life years lived with diagnosed diabetes - Males	84,987	Table 7
i	Life years lived with undiagnosed diabetes - Males	48,869	Table 7
j	**Total life years lived with prediabetes/diabetes - Males**	**232,678**	=f+g+h+i
k	Expected # of Complications - Females	3,627	Table 11
l	Expected # of Complications - Males	3,742	Table 11
m	**Expected # of Complications - Total**	**7,369**	=k+l
n	QALYs lost due to complications and living with diagnosed diabetes - Females	13,450	Table 12
o	QALYs lost due to complications and living with diagnosed diabetes - Males	13,302	Table 12
p	**QALYs lost due to complications and living with diagnosed diabetes - Total**	**26,752**	=n+o
q	LYL attributable to diabetes - Females	33,189	Table 13
r	LYL attributable to diabetes - Males	27,761	Table 13
s	**LYL attributable to diabetes - Total**	**60,950**	=q+r
	With Screening / Intervention		
t	Incident diabetes avoided - Females	297	Table 16
u	Incident diabetes avoided - Males	127	Table 16
v	**Incident diabetes avoided - Total**	**425**	=t+u
w	Complications avoided due to diabetes avoided - Females	141	Table 17
x	Complications avoided due to diabetes avoided - Males	61	Table 17
y	**Complications avoided due to diabetes avoided - Total**	**202**	=w+x
z	QALYs gained due to complications and living with diabetes avoided - Females	918	Table 18
aa	QALYs gained due to complications and living with diabetes avoided - Males	356	Table 18
ab	**QALYs gained due to complications and living with diabetes avoided - Total**	**1,274**	=z+aa
ac	Life years gained due to diabetes avoided - Females	1,761	Table 19
ad	Life years gained due to diabetes avoided - Males	621	Table 19
ae	**Life years gained due to diabetes avoided - Total**	**2,381**	=ac+ad
af	Potential QALYs gained, Screening increasing from 0% to 80.7% - Females	2,679	=z+ac
ag	Potential QALYs gained, Screening increasing from 0% to 80.7% - Males	976	=aa+ad
ah	**Potential QALYs gained, Screening increasing from 0% to 80.7% - Total**	**3,655**	=af+ag

We also modified a number of major assumptions and recalculated the CPB as follows:

- Reduce the disutility associated with a stroke from 20.0% to 13.4%, angina from 8.0% to 5.2%, heart failure from 7.2% to 4.7%, amputation from 16.7% to 11.4%, nephropathy from 10.4% to 7.0%, blindness from 18.7% to 12.4%, cataract from 1.0% to 0.6% and living with diagnosed diabetes from 4.9% to 3.1%. CPB = 3,209 (2,357 in females and 852 in males).
- Increase the disutility associated with a stroke from 20.0% to 26.5%, angina from 8.0% to 11.3%, heart failure from 7.2% to 10.3%, amputation from 16.7% to 22.9%, nephropathy from 10.4% to 14.7%, blindness from 18.7% to 26.0%, cataract from 1.0% to 1.5% and living with diagnosed diabetes from 4.9% to 7.2%. CPB = 4,191 (3,065 in females and 1,126 in males).
- Decrease the proportion of those referred to an intensive lifestyle intervention who receive an effective dose from 44.8% to 18.7%. CPB = **1,526** (1,118 in females and 408 in males).
- Increase the effectiveness of the intensive lifestyle intervention in transitioning from prediabetes to diabetes from 22.0% to 31.0%. CPB = **5,151** (3,775 in females and 1,376 in males).
- Decrease the effectiveness of the intensive lifestyle intervention in transitioning from prediabetes to diabetes from 22.0% to 12.0%. CPB = 1,994 (1,461 in females and 533 in males).

Modelling Cost-Effectiveness

In this section, we model CE associated with screening for, and treatment of, prediabetes in non-pregnant adults aged 35 to 70 years who have overweight or obesity in a BC birth cohort of 40,000.

In calculating CE, we made the following assumptions:

Unit Costs

- The cost of an office visit to a General Practitioner (GP) in BC is estimated at $35.97.[938]
- Patient time costs resulting from receiving, as well as travelling to and from, a service are valued based on the average hourly wage rate in BC in 2022 ($31.49[939]) plus 18% benefits for an average cost per hour of $37.16. In the absence of specific data on the amount of time required, we assume two hours per service.

[938] Ministry of Health. *Medical Services Commission Payment Schedule*. 2021. Available at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msc-payment-schedule-may-2021.pdf. Accessed September 2023.
[939] BC Stats. *Earning & Employment Trends – August 2022*. Available at https://www2.gov.bc.ca/assets/gov/data/statistics/people-population-community/income/earnings_and_employment_trends_data_tables.pdf. Accessed September 2023.

- Laboratory screening tests - The cost of an A1C test (MSP fee item 91745) in BC is $5.30.[940,941]
- Cohen and colleagues estimated the *first year costs* associated with a **myocardial infarction** in Ontario to be $20,794 (in 2008 CAD).[942] We converted this to $25,500 in 2022 CAD. Cohen and colleagues estimated the *ongoing annual costs* following a myocardial infarct to be $1,325 (in 2008 CAD).[943] We converted this to $1,626 in 2022 CAD.
- Goeree et al estimated the *first year costs* associated with a **stroke** in Canada by age as follows:[944]
    - <55 years of age - $15,926 in 2004 CAD (converted to $22,196 in 2022 CAD)
    - 55-64 - $12,955 ($18,056)
    - 65-74 - $24,593 ($34,276)
    - 75-84 - $28,608 ($39,872)
    - ≥85 - $29,210 ($40,711)
- Gloede and coauthors in Australia estimated the *ongoing annual costs* (including informal care and out-of-pocket costs) associated with an ischemic **stroke** to be $7,996 (in 2010 AUD) while costs associated with a haemorrhagic stroke were $10,251.[945] Based on a mix of 85% ischemic strokes in Canada,[946] the weighted cost would be $8,335. We converted this to $8,524 in 2022 CAD.
- The typical event cost for **angina** is $3,183 with annual costs thereafter of $1,485 (in 2000 CAD)[947] or $5,328 and $2,486 respectively in 2022 CAD.

[940] BC Ministry of Health. Schedule of Fees for the Laboratory Services Outpatient Payment Schedule. February 29, 2024. Available online at http://www.phsa.ca/plms/Documents/Laboratory%20Services%20Outpatient%20Payment%20Schedule.pdf. Accessed March 2024.

[941] Approximately 73% of hemoglobin A1C testing in BC is conducted by LifeLabs, a private laboratory provider who is compensated through the Master Laboratory Services Agreement and not on a fee-for-service basis as with other providers in the province. This means that the fee amount included in the Outpatient Payment Schedule may not actually be reflective of the true cost of the testing to the system, as LifeLabs is compensated through a contract amount encompassing many different laboratory services. Jillian Hannah, Senior Policy Analyst, BC Ministry of Health. Personal Communication, March 19, 2024.

[942] Cohen D, Manuel D, Tugwell P et al. Direct healthcare costs of acute myocardial infarction in Canada's elderly across the continuum of care. *The Journal of Economics of Ageing*. 2014; 3: 44-49.

[943] Cohen D, Manuel D, Tugwell P et al. Direct healthcare costs of acute myocardial infarction in Canada's elderly across the continuum of care. *The Journal of Economics of Ageing*. 2014; 3: 44-49

[944] Goeree R, Blackhouse G, Petrovic R et al. Cost of stroke in Canada: A 1-year prospective study. *Journal of Medical Economics*. 2005; 8: 147-67.

[945] Gloede T, Halbach S, Thrift A et al. Long-term costs of stroke using 10-year longitudinal data from the North East Melbourne Stroke Incidence Study. *Stroke*. 2014: 1-8.

[946] Krueger H, Lindsay P, Cote R et al. Cost avoidance associated with optimal stroke care in Canada. *Stroke*. 2012; 43(8): 2198-206.

[947] O'Brien JA, Patrick AR and Caro JJ. Cost of managing complications resulting from type 2 diabetes mellitus in Canada. *BMC Health Services Research*. 2003; 3(1): 7.

- **Heart failure** is associated with annual costs of $7,100[948] (in 2020 CDN or $8,231 in 2022 CDN). Individuals with heart failure have a life expectancy of approximately 2.5 years.[949]
- The typical event cost for a lower extremity **amputation** is $24,583 with annual costs thereafter of $1,020 (in 2000 CAD)[950] or $37,600 and $1,560 respectively in 2022 CAD.
- **Nephropathy** (microalbuminuria) is associated with annual costs of $3,936[951] (in 2012 USD or $4,291 in 2022 CDN).
- In the US, **blindness** is associated with an annual increase in medical costs of $2,157 (in 2004 USD) or $2,606 in 2022 CAD, after adjusting for age, sex, marital status, education, income, self-reported health status, type of health insurance and family size.[952]
- The estimated cost of cataract surgery in BC is $350.[953]
- Harris and colleagues estimated patient out-of-pocket costs associated with type 2 diabetes to be $679 annually[954] (in 2005 CDN or $1,004 in 2022 CDN).

Costs of Screening and Intervention

- The original Diabetes Prevention Program intensive lifestyle intervention conducted within the RCT was conducted by case managers with training in nutrition, exercise, or behavior modification who met with an individual participant for at least 16 sessions in the first 24 weeks and contacted the participant at least monthly thereafter (with in-person contacts at least every 2 months throughout the remainder of the program).[955] The intensity of the intervention and the one-to-one relationship between the case manager and the participant meant that the intervention was expensive; an estimated $3,820 per participant[956] (in 2010 USD or $6,100 in 2022 CDN). The majority of national interventions established since the success of the original Diabetes Prevention Program have used group-based programs.
- The Australian group-based (8-15 per group) program *Life!* was estimated to cost $400 (in 2010 Australian dollars) per participant[957] or $446 in 2022 CDN.

[948] Levy A, Johnston K, Daoust A et al. Health expenditures after first hospital admission for heart failure in Nova Scotia, Canada: A retrospective cohort study. *CMAJ Open*. 2021; 9(3):
[949] Limpens M, Asllanaj E, Dommershuijsen L et al. Healthy lifestyle in older adults and life expectancy with and without heart failure. *European Journal of Epidemiology*. 2022; 37: 205-14.
[950] O'Brien JA, Patrick AR and Caro JJ. Cost of managing complications resulting from type 2 diabetes mellitus in Canada. *BMC Health Services Research*. 2003; 3(1): 7.
[951] Zhuo X, Zhang P, Hoerger T. Lifetime direct medical costs of treating type 2 diabetes and diabetic complications. *American Journal of Preventive Medicine*. 2013; 45(3): 253-61.
[952] Frick K, Gower E, Kempen J et al. Economic impact of visual impairment and blindness in the United States. *Archives of Ophthalmology*. 2007; 125(4): 544-50.
[953] CBC News. *Judge says B.C. can reduce fees for cataract surgery*. November 6, 2018.
[954] Harris S, Leiter L, Yale J et al. Out-of-pocket costs of managing hyperglycemia and hypoglycemia in patients with type 1 diabetes and insulin-treated type 2 diabetes. *Canadian Journal of Diabetes*. 2007; 31(1): 25-33.
[955] The Diabetes Prevention Program Research Group. The Diabetes Prevention Program: Design and methods for a clinical trial in the prevention of type 2 diabetes. *Diabetes Care*. 1999; 22(4): 623-34.
[956] The Diabetes Prevention Program Research Group. The 10-year cost-effectiveness of lifestyle intervention or metformin for diabetes prevention: An intent-to-treat analysis of the DPP/DPPOS. *Diabetes Care*. 2012; 35: 723-30.
[957] Dunbar J, Jayawardena A, Johnson G et al. Scaling up diabetes prevention in Victoria, Australia: Policy development, implementation, and evaluation. *Diabetes Care*. 2014; 37: 934-42.

- The average cost of the group-based (15-20 per group) NHS DPP has been estimated at £143 (in 2020 or $262 in 2022 CDN) per referral and £342 (in 2020 or $626 in 2022 CDN) per referral that completed at least 60% of the program.[958]
- For modelling purposes, we assumed that the HbA_{1C} test would be used for screening purposes. All individuals with overweight and obesity with an HbA_{1C} score of ≥ 6 but ≤ 6.5 would return for a confirmatory test. If prediabetes is confirmed, the individual would be referred to an intensive lifestyle intervention program. Of those referred, 44.8% would receive an effective dose. The program cost for those receiving an effective dose would be $626. The program cost for those referred but not receiving an effective dose would be $262.
- We have assumed that the intervention would include at least 13 sessions totalling 16 hours of contact time (i.e. each session lasts 1.23 hours), as per the intervention in the UK. Patient time costs for the intervention are based on those not receiving an effective dose attending an average of 3.4 sessions while those who received an effective dose would attend an average of 10.4 sessions.[959] We included 60 minutes of travel time to/from each session.
- Based on these assumptions, costs of screening and intervention would total $13.37 million in females and $12.98 million in males (see Table 21).

[958] McManus E, Meacock R, Parkinson P et al. Evaluating the short-term costs and benefits of a nationwide Diabetes Prevention Programme in England: Retrospective observational study. *Applied Health Economics and Health Policy.* 2023; 21: 891-903.
[959] Valabhji J, Barron E, Bradley D et al. Early outcomes from the English National Health Service Diabetes Prevention Programme. *Diabetes Care*. 2020; 43: 152-60.

Table 21: Cost of Screening and Intervention

In a BC Birth Cohort of 40,000

Ages 35 to 70 by Sex

	Females								***Males***							
					Intervention								*Intervention*			
Age	# in Birth	# of Annual Screens	System $	Patient $	# Referred	# Effective	System $	Patient $	Males	# of Annual Screens	System $	Patient $	# Referred	# Effective	System $	Patient $
35	19,736	2,698	$141,855	$255,455	739	481	$368,624	$485,048	19,474	2,780	$147,506	$265,632	794	206	$282,991	$340,508
36	19,722	2,685	$112,663	$202,886	45	29	$22,480	$29,555	19,442	2,765	$116,069	$209,019	48	13	$17,079	$20,564
37	19,708	2,671	$112,098	$201,869	45	29	$22,424	$29,476	19,409	2,749	$115,407	$207,828	48	12	$17,010	$20,483
38	19,693	2,657	$111,528	$200,842	45	29	$22,360	$29,389	19,375	2,733	$114,738	$206,622	47	12	$16,935	$20,395
39	19,677	2,644	$110,954	$199,808	45	29	$22,296	$29,301	19,339	2,717	$114,060	$205,402	47	12	$16,857	$20,305
40	19,661	2,756	$115,578	$208,136	45	29	$22,227	$29,205	19,303	2,700	$113,375	$204,169	47	12	$16,776	$20,209
41	19,643	2,741	$114,986	$207,070	45	29	$22,143	$29,092	19,264	2,684	$112,679	$202,914	47	12	$16,684	$20,101
42	19,625	2,727	$114,388	$205,993	45	29	$22,060	$28,977	19,225	2,667	$111,972	$201,642	46	12	$16,589	$19,988
43	19,605	2,698	$113,195	$203,844	44	28	$21,968	$28,852	19,183	2,631	$110,498	$198,988	46	12	$16,488	$19,870
44	19,584	2,669	$111,995	$201,684	44	28	$21,866	$28,713	19,140	2,596	$109,018	$196,323	46	12	$16,379	$19,741
45	19,561	2,681	$112,482	$202,561	44	28	$21,754	$28,560	19,094	2,560	$107,529	$193,641	45	12	$16,253	$19,593
46	19,537	2,652	$111,267	$200,373	44	28	$21,633	$28,396	19,047	2,524	$106,033	$190,947	45	12	$16,125	$19,441
47	19,511	2,623	$110,046	$198,173	44	28	$21,504	$28,221	18,996	2,488	$104,529	$188,238	45	12	$15,986	$19,277
48	19,484	2,593	$108,816	$195,959	43	27	$21,358	$28,020	18,943	2,452	$103,011	$185,504	44	12	$15,822	$19,084
49	19,454	2,564	$107,577	$193,728	43	27	$21,200	$27,806	18,887	2,415	$101,483	$182,754	44	12	$15,654	$18,886
50	19,422	2,695	$113,004	$203,501	43	28	$21,584	$28,435	18,827	3,089	$129,425	$233,072	47	12	$16,810	$20,207
51	19,388	2,662	$111,628	$201,023	43	28	$21,377	$28,151	18,763	3,043	$127,513	$229,629	47	12	$16,568	$19,923
52	19,352	2,629	$110,240	$198,523	42	28	$21,144	$27,832	18,695	2,997	$125,579	$226,146	46	12	$16,301	$19,608
53	19,312	2,595	$108,839	$196,000	42	27	$20,893	$27,489	18,622	2,951	$123,625	$222,628	45	12	$16,020	$19,278
54	19,270	2,561	$107,423	$193,450	41	27	$20,610	$27,102	18,545	2,904	$121,646	$219,064	44	11	$15,706	$18,907
55	19,224	2,527	$105,994	$190,876	41	26	$20,306	$26,685	18,461	2,856	$119,639	$215,449	43	11	$15,357	$18,496
56	19,174	2,493	$104,548	$188,273	40	26	$19,971	$26,229	18,372	2,808	$117,605	$211,786	42	11	$14,983	$18,056
57	19,121	2,458	$103,085	$185,638	40	25	$19,600	$25,721	18,277	2,759	$115,540	$208,068	41	11	$14,570	$17,569
58	19,063	2,413	$101,181	$182,208	39	25	$19,184	$25,155	18,175	2,702	$113,139	$203,743	39	11	$14,121	$17,040
59	19,000	2,367	$99,259	$178,748	38	24	$18,731	$24,537	18,065	2,645	$110,704	$199,358	38	10	$13,622	$16,451
60	18,932	2,532	$106,163	$191,181	41	26	$20,106	$26,375	17,947	2,961	$123,921	$223,160	41	11	$14,871	$17,939
61	18,858	2,481	$104,019	$187,320	40	25	$19,485	$25,528	17,820	2,894	$121,054	$217,998	39	11	$14,190	$17,136
62	18,777	2,429	$101,850	$183,414	39	24	$18,806	$24,602	17,684	2,826	$118,143	$212,755	37	10	$13,442	$16,255
63	18,689	2,377	$99,650	$179,452	37	23	$18,036	$23,554	17,537	2,756	$115,183	$207,424	35	10	$12,611	$15,273
64	18,593	2,325	$97,421	$175,438	36	21	$17,204	$22,422	17,379	2,686	$112,174	$202,006	32	9	$11,713	$14,214
65	18,489	2,474	$103,517	$186,415	34	20	$16,269	$21,151	17,208	2,323	$97,058	$174,784	29	9	$10,715	$13,035
66	18,375	2,419	$101,165	$182,180	33	18	$15,238	$19,751	17,024	2,253	$94,065	$169,394	26	8	$9,621	$11,744
67	18,250	2,362	$98,766	$177,861	31	17	$14,091	$18,198	16,826	2,183	$91,025	$163,920	22	7	$8,435	$10,341
68	18,113	2,305	$96,320	$173,454	28	15	$12,818	$16,473	16,612	2,112	$87,928	$158,344	18	6	$7,114	$8,779
69	17,963	2,247	$93,820	$168,953	26	13	$11,408	$14,566	16,381	2,040	$84,776	$152,666	14	5	$5,669	$7,070
70	17,799	2,188	$91,262	$164,346	23	10	$9,847	$12,457	16,132	1,967	$81,566	$146,886	10	4	$4,095	$5,206
Total		**91,599**	**$3,868,582**	**$6,966,634**	**2,139**	**1,352**	**$1,052,602**	**$1,381,027**		**95,216**	**$4,019,217**	**$7,237,902**	**2,173**	**579**	**$780,159**	**$940,973**

Costs Avoided

- We calculated previously (see Table 16) that 298 females and 128 males in the BC birth cohort would not progress from prediabetes to diabetes due to screening and intervention. These individuals would also avoid the excess complications attributable to diabetes. In Table 17, we calculated that 42 cases of myocardial infarction, 26 cases of stroke, 97 cases of angina, 44 cases of heart failure, 13 amputations, 17 cases of nephropathy, 5 cases of blindness and 54 cases of cataracts would be avoided.
- In Table 22, we calculate that the costs avoided due to the excess complications avoided (as well as patient costs avoided) would total $40.93 million, $29.46 million in females and $11.48 million in males.

Table 22: Costs Avoided due to Excess Complications and Patient Costs Avoided

By Age and Sex in a BC Birth Cohort of 40,000

In Million$

Age	Myocardial Infarction			Stroke			Angina			Heart Failure			Amputation			Nephropathy			Blindness			Cataract			Patient Out-of-Pocket Costs			Total Costs Avoided		
	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T
35	$0.09	$0.04	$0.13	$0.25	$0.10	$0.34	$0.23	$0.09	$0.32	$0.01	$0.00	$0.01	$0.01	$0.00	$0.02	$0.02	$0.01	$0.02	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$5.40	$2.12	$7.51	**$6.00**	**$2.35**	**$8.35**
36	$0.05	$0.02	$0.07	$0.14	$0.05	$0.19	$0.76	$0.30	$1.06	$0.01	$0.00	$0.02	$0.01	$0.01	$0.02	$0.04	$0.02	$0.06	$0.010	$0.004	$0.013	$0.000	$0.000	$0.000	$0.32	$0.13	$0.45	**$1.35**	**$0.53**	**$1.88**
37	$0.04	$0.02	$0.06	$0.12	$0.05	$0.17	$0.32	$0.13	$0.44	$0.01	$0.00	$0.01	$0.01	$0.00	$0.01	$0.02	$0.01	$0.03	$0.009	$0.003	$0.012	$0.000	$0.000	$0.000	$0.31	$0.12	$0.44	**$0.85**	**$0.33**	**$1.18**
38	$0.04	$0.02	$0.06	$0.11	$0.04	$0.16	$0.24	$0.09	$0.34	$0.01	$0.00	$0.01	$0.01	$0.00	$0.01	$0.02	$0.01	$0.03	$0.005	$0.002	$0.007	$0.000	$0.000	$0.000	$0.31	$0.12	$0.43	**$0.75**	**$0.30**	**$1.05**
39	$0.05	$0.02	$0.07	$0.11	$0.04	$0.15	$0.21	$0.08	$0.30	$0.01	$0.00	$0.01	$0.01	$0.00	$0.01	$0.02	$0.01	$0.03	$0.005	$0.002	$0.007	$0.000	$0.000	$0.000	$0.30	$0.12	$0.42	**$0.72**	**$0.28**	**$1.00**
40	$0.05	$0.02	$0.07	$0.12	$0.05	$0.17	$0.21	$0.08	$0.29	$0.01	$0.00	$0.01	$0.01	$0.00	$0.02	$0.03	$0.01	$0.04	$0.005	$0.002	$0.007	$0.000	$0.000	$0.000	$0.29	$0.11	$0.41	**$0.73**	**$0.29**	**$1.02**
41	$0.05	$0.02	$0.07	$0.15	$0.06	$0.21	$0.19	$0.08	$0.27	$0.01	$0.00	$0.01	$0.01	$0.00	$0.02	$0.03	$0.01	$0.04	$0.000	$0.000	$0.001	$0.000	$0.000	$0.000	$0.29	$0.11	$0.40	**$0.73**	**$0.29**	**$1.01**
42	$0.05	$0.02	$0.08	$0.14	$0.06	$0.20	$0.18	$0.07	$0.25	$0.01	$0.00	$0.01	$0.01	$0.01	$0.02	$0.04	$0.01	$0.05	$0.002	$0.001	$0.002	$0.000	$0.000	$0.000	$0.28	$0.11	$0.39	**$0.72**	**$0.28**	**$1.00**
43	$0.06	$0.02	$0.09	$0.16	$0.06	$0.22	$0.18	$0.07	$0.25	$0.01	$0.01	$0.02	$0.02	$0.01	$0.02	$0.03	$0.01	$0.05	$0.006	$0.002	$0.009	$0.000	$0.000	$0.000	$0.27	$0.11	$0.38	**$0.74**	**$0.29**	**$1.04**
44	$0.06	$0.02	$0.08	$0.15	$0.06	$0.21	$0.17	$0.07	$0.24	$0.01	$0.01	$0.02	$0.02	$0.01	$0.03	$0.04	$0.02	$0.06	$0.005	$0.002	$0.007	$0.000	$0.000	$0.000	$0.26	$0.10	$0.36	**$0.72**	**$0.28**	**$1.01**
45	$0.06	$0.02	$0.09	$0.15	$0.06	$0.21	$0.16	$0.06	$0.22	$0.01	$0.01	$0.02	$0.02	$0.01	$0.03	$0.05	$0.02	$0.07	$0.008	$0.003	$0.011	$0.000	$0.000	$0.000	$0.26	$0.10	$0.35	**$0.72**	**$0.28**	**$1.00**
46	$0.06	$0.02	$0.09	$0.15	$0.06	$0.21	$0.16	$0.06	$0.22	$0.01	$0.01	$0.02	$0.02	$0.01	$0.03	$0.05	$0.02	$0.07	$0.008	$0.003	$0.011	$0.000	$0.000	$0.000	$0.25	$0.10	$0.34	**$0.71**	**$0.28**	**$0.99**
47	$0.06	$0.03	$0.09	$0.15	$0.06	$0.21	$0.16	$0.06	$0.22	$0.02	$0.01	$0.02	$0.02	$0.01	$0.03	$0.05	$0.02	$0.07	$0.008	$0.003	$0.011	$0.000	$0.000	$0.000	$0.24	$0.09	$0.33	**$0.71**	**$0.28**	**$0.99**
48	$0.06	$0.03	$0.09	$0.16	$0.06	$0.22	$0.16	$0.06	$0.22	$0.02	$0.01	$0.02	$0.02	$0.01	$0.03	$0.05	$0.02	$0.07	$0.008	$0.003	$0.011	$0.000	$0.000	$0.000	$0.23	$0.09	$0.32	**$0.71**	**$0.28**	**$0.98**
49	$0.06	$0.03	$0.09	$0.16	$0.06	$0.22	$0.16	$0.06	$0.22	$0.02	$0.01	$0.02	$0.02	$0.01	$0.03	$0.05	$0.02	$0.07	$0.008	$0.003	$0.011	$0.000	$0.000	$0.000	$0.22	$0.09	$0.31	**$0.70**	**$0.27**	**$0.98**
50	$0.07	$0.03	$0.09	$0.16	$0.06	$0.22	$0.16	$0.06	$0.22	$0.02	$0.01	$0.02	$0.02	$0.01	$0.03	$0.05	$0.02	$0.07	$0.008	$0.003	$0.011	$0.000	$0.000	$0.000	$0.23	$0.09	$0.32	**$0.71**	**$0.28**	**$0.98**
51	$0.07	$0.03	$0.09	$0.16	$0.06	$0.22	$0.16	$0.06	$0.22	$0.02	$0.01	$0.02	$0.02	$0.01	$0.03	$0.05	$0.02	$0.07	$0.008	$0.003	$0.011	$0.000	$0.000	$0.001	$0.22	$0.08	$0.30	**$0.70**	**$0.27**	**$0.98**
52	$0.07	$0.03	$0.09	$0.16	$0.06	$0.22	$0.15	$0.06	$0.21	$0.02	$0.01	$0.03	$0.02	$0.01	$0.03	$0.05	$0.02	$0.07	$0.008	$0.003	$0.012	$0.000	$0.000	$0.001	$0.21	$0.08	$0.29	**$0.70**	**$0.27**	**$0.97**
53	$0.07	$0.03	$0.09	$0.16	$0.06	$0.22	$0.15	$0.06	$0.21	$0.02	$0.01	$0.03	$0.02	$0.01	$0.03	$0.05	$0.02	$0.07	$0.008	$0.003	$0.012	$0.000	$0.000	$0.001	$0.20	$0.08	$0.28	**$0.69**	**$0.27**	**$0.95**
54	$0.07	$0.03	$0.10	$0.16	$0.06	$0.22	$0.15	$0.06	$0.21	$0.02	$0.01	$0.03	$0.02	$0.01	$0.03	$0.05	$0.02	$0.07	$0.008	$0.003	$0.012	$0.000	$0.000	$0.001	$0.19	$0.07	$0.27	**$0.68**	**$0.26**	**$0.94**
55	$0.07	$0.03	$0.10	$0.16	$0.06	$0.22	$0.15	$0.06	$0.21	$0.02	$0.01	$0.03	$0.03	$0.01	$0.04	$0.05	$0.02	$0.07	$0.008	$0.003	$0.012	$0.000	$0.000	$0.001	$0.19	$0.07	$0.26	**$0.67**	**$0.26**	**$0.92**
56	$0.07	$0.03	$0.10	$0.16	$0.06	$0.22	$0.15	$0.06	$0.20	$0.02	$0.01	$0.03	$0.03	$0.01	$0.04	$0.05	$0.02	$0.07	$0.008	$0.003	$0.012	$0.000	$0.000	$0.001	$0.18	$0.07	$0.24	**$0.66**	**$0.25**	**$0.91**
57	$0.07	$0.03	$0.10	$0.16	$0.06	$0.21	$0.14	$0.06	$0.20	$0.02	$0.01	$0.03	$0.03	$0.01	$0.04	$0.05	$0.02	$0.07	$0.008	$0.003	$0.012	$0.000	$0.000	$0.001	$0.17	$0.06	$0.23	**$0.64**	**$0.25**	**$0.89**
58	$0.07	$0.03	$0.10	$0.15	$0.06	$0.21	$0.14	$0.05	$0.20	$0.02	$0.01	$0.03	$0.03	$0.01	$0.04	$0.05	$0.02	$0.07	$0.008	$0.003	$0.011	$0.000	$0.000	$0.001	$0.16	$0.06	$0.22	**$0.63**	**$0.24**	**$0.87**
59	$0.07	$0.03	$0.10	$0.15	$0.06	$0.21	$0.14	$0.05	$0.19	$0.02	$0.01	$0.03	$0.03	$0.01	$0.04	$0.05	$0.02	$0.07	$0.008	$0.003	$0.011	$0.000	$0.000	$0.001	$0.15	$0.06	$0.21	**$0.62**	**$0.24**	**$0.86**
60	$0.07	$0.03	$0.10	$0.15	$0.06	$0.21	$0.14	$0.05	$0.19	$0.02	$0.01	$0.03	$0.03	$0.01	$0.04	$0.05	$0.02	$0.07	$0.008	$0.003	$0.011	$0.000	$0.000	$0.001	$0.16	$0.06	$0.21	**$0.62**	**$0.24**	**$0.86**
61	$0.07	$0.03	$0.10	$0.15	$0.06	$0.21	$0.13	$0.05	$0.19	$0.02	$0.01	$0.03	$0.03	$0.01	$0.04	$0.05	$0.02	$0.07	$0.008	$0.003	$0.011	$0.000	$0.000	$0.001	$0.14	$0.05	$0.20	**$0.61**	**$0.23**	**$0.84**
62	$0.07	$0.03	$0.10	$0.15	$0.06	$0.20	$0.13	$0.05	$0.18	$0.02	$0.01	$0.03	$0.03	$0.01	$0.04	$0.05	$0.02	$0.07	$0.008	$0.003	$0.011	$0.000	$0.000	$0.001	$0.13	$0.05	$0.18	**$0.59**	**$0.23**	**$0.82**
63	$0.07	$0.03	$0.10	$0.15	$0.06	$0.20	$0.13	$0.05	$0.18	$0.02	$0.01	$0.03	$0.03	$0.01	$0.04	$0.05	$0.02	$0.07	$0.008	$0.003	$0.011	$0.000	$0.000	$0.001	$0.12	$0.05	$0.17	**$0.57**	**$0.22**	**$0.80**
64	$0.07	$0.03	$0.10	$0.14	$0.05	$0.20	$0.12	$0.05	$0.17	$0.02	$0.01	$0.03	$0.03	$0.01	$0.04	$0.05	$0.02	$0.07	$0.008	$0.003	$0.011	$0.000	$0.000	$0.001	$0.11	$0.04	$0.15	**$0.56**	**$0.21**	**$0.77**
65	$0.07	$0.03	$0.09	$0.15	$0.06	$0.21	$0.12	$0.05	$0.17	$0.02	$0.01	$0.03	$0.03	$0.01	$0.04	$0.05	$0.02	$0.07	$0.008	$0.003	$0.011	$0.001	$0.000	$0.001	$0.10	$0.04	$0.14	**$0.55**	**$0.21**	**$0.76**
66	$0.07	$0.03	$0.09	$0.15	$0.06	$0.20	$0.12	$0.04	$0.16	$0.02	$0.01	$0.04	$0.03	$0.01	$0.04	$0.05	$0.02	$0.07	$0.008	$0.003	$0.010	$0.001	$0.000	$0.001	$0.09	$0.03	$0.12	**$0.53**	**$0.20**	**$0.73**
67	$0.07	$0.03	$0.09	$0.14	$0.06	$0.20	$0.11	$0.04	$0.15	$0.02	$0.01	$0.04	$0.03	$0.01	$0.04	$0.05	$0.02	$0.06	$0.007	$0.003	$0.010	$0.001	$0.000	$0.001	$0.08	$0.03	$0.11	**$0.51**	**$0.19**	**$0.70**
68	$0.07	$0.03	$0.09	$0.14	$0.05	$0.20	$0.11	$0.04	$0.15	$0.03	$0.01	$0.04	$0.03	$0.01	$0.04	$0.05	$0.02	$0.06	$0.007	$0.003	$0.010	$0.001	$0.000	$0.001	$0.07	$0.02	$0.09	**$0.48**	**$0.19**	**$0.67**
69	$0.06	$0.03	$0.09	$0.14	$0.05	$0.19	$0.10	$0.04	$0.14	$0.03	$0.01	$0.04	$0.03	$0.01	$0.04	$0.04	$0.02	$0.06	$0.007	$0.003	$0.010	$0.001	$0.000	$0.001	$0.05	$0.02	$0.07	**$0.46**	**$0.18**	**$0.64**
70	$0.06	$0.03	$0.09	$0.13	$0.05	$0.18	$0.09	$0.04	$0.13	$0.03	$0.01	$0.04	$0.03	$0.01	$0.04	$0.04	$0.02	$0.06	$0.007	$0.003	$0.009	$0.001	$0.000	$0.001	$0.04	$0.02	$0.06	**$0.44**	**$0.17**	**$0.60**
Total	**$2.29**	**$0.91**	**$3.21**	**$5.39**	**$2.08**	**$7.47**	**$6.28**	**$2.44**	**$8.72**	**$0.63**	**$0.27**	**$0.91**	**$0.77**	**$0.31**	**$1.08**	**$1.60**	**$0.61**	**$2.21**	**$0.253**	**$0.097**	**$0.350**	**$0.013**	**$0.006**	**$0.019**	**$12.22**	**$4.74**	**$16.96**	**$29.46**	**$11.48**	**$40.93**

Summary of CE

- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the CE associated with screening for, and treatment of, prediabetes in asymptomatic non-pregnant adults aged 35 to 70 years who have overweight or obesity in a BC birth cohort of 40,000 is cost-saving (see Table 23, row ai).

Table 23: CE of Screening for, and Treatment of, Prediabetes in Asymptomatic Non-Pregnant Adults Aged 35 to 70 Years Who Have Overweight or Obesity

Label	Variable	Base Case	Data Source
	Costs of Screening and Interventiion		
a	Costs of screening (System) - Females	$3,868,582	Table 21
b	Cost of screening (Patient) - Females	$6,966,634	Table 21
c	Costs of intervention (System) - Females	$1,052,602	Table 21
d	Cost of intervention (Patient) - Females	$1,381,027	Table 21
e	Total costs of screening and intervention - Females	$13,268,845	=a+b+c+d
f	Costs of screening (System) - Males	$4,019,217	Table 21
g	Cost of screening (Patient) - Males	$7,237,902	Table 21
h	Costs of intervention (System) - Males	$780,159	Table 21
i	Cost of intervention (Patient) - Males	$940,973	Table 21
j	Total costs of screening and intervention - Males	$12,978,251	=f+g+h+i
k	**Total costs of screening and intervention**	**$26,247,096**	=e+j
	Cost Avoided		
l	Cases of diabetes avoided - Females	297	Table 19
m	Cases of diabetes avoided - Males	127	Table 19
n	Cases of diabetes avoided - Total	**425**	=l+m
o	Costs avoided due to excess complications and patient costs avoided - Females	$29,456,404	Table 22
p	Costs avoided due to excess complications and patient costs avoided - Males	$11,476,604	Table 22
q	**Costs avoided due to excess complications and patient costs avoided - Total**	**$40,933,008**	=o+p
r	Costs avoided per case of diabetes avoided - Females	$99,023	=o/l
s	Costs avoided per case of diabetes avoided - Males	$90,022	=p/m
t	**Costs avoided per case of diabetes avoided - Total**	**$96,323**	=q/n
	CE Calculation		
u	Net cost - Females	-$16,187,559	=e-o
v	Net cost - Males	$1,501,647	=j-p
w	**Net cost - Total**	**-$14,685,912**	=k-q
x	CPB - Females	2,679	Table 20
y	CPB - Males	976	Table 20
z	**CPB - Total**	**3,655**	Table 20
aa	Net Cost (1.5% discount)- Females	-$13,811,588	Calculated
ab	Net Cost (1.5% discount)- Males	$749,645	Calculated
ac	**Net Cost (1.5% discount)- Total**	**-$13,061,943**	Calculated
ad	CPB (1.5% discount)- Females	2,338	Calculated
ae	CPB (1.5% discount)- Males	854	Calculated
af	**CPB (1.5% discount)- Total**	**3,192**	Calculated
ag	CE ($/QALY saved, 1.5% discount) - Females	Cost-saving	
ah	CE ($/QALY saved, 1..5% discount) - Males	$878	
ai	**CE ($/QALY saved, 1.5% discount) - Total**	**Cost-saving**	

We also modified several major assumptions and recalculated the cost per QALY as follows:

- Reduce the disutility associated with a stroke from 20.0% to 13.4%, angina from 8.0% to 5.2%, heart failure from 7.2% to 4.7%, amputation from 16.7% to 11.4%, nephropathy from 10.4% to 7.0%, blindness from 18.7% to 12.4%, cataract from 1.0% to 0.6% and living with diagnosed diabetes from 4.9% to 3.1%. CE = Cost-saving for total and females, $1,005 for males.
- Increase the disutility associated with a stroke from 20.0% to 26.5%, angina from 8.0% to 11.3%, heart failure from 7.2% to 10.3%, amputation from 16.7% to 22.9%, nephropathy from 10.4% to 14.7%, blindness from 18.7% to 26.0%, cataract from 1.0% to 1.5% and living with diagnosed diabetes from 4.9% to 7.2%. CE = Cost-saving for total and females, $762 for males.
- Decrease the proportion of those referred to an intensive lifestyle intervention who receive an effective dose from 44.8% to 18.7%. CE = **$4,306** ($16,855 for males and cost-saving for females).
- Increase the effectiveness of the intensive lifestyle intervention in transitioning from prediabetes to diabetes from 22.0% to 31.0%. CE = Cost-saving for females, males and total.
- Decrease the effectiveness of the intensive lifestyle intervention in transitioning from prediabetes to diabetes from 22.0% to 12.0%. CE = $1,330 ($10,875 for males and cost-saving for females).

Summary

Males and Females

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening for, and treatment of, prediabetes in asymptomatic non-pregnant adults aged 35 to 70 years who have overweight or obesity in a BC birth cohort of 40,000 is estimated to be 3,192 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is cost-saving (see Table 24).

Table 24: Screening, and Intervention, for Prediabetes in a Birth Cohort of 40,000

Summary for Females and Males

	Base Case	Range	
CPB (Potential QALYs Gained)			
Gap between No Service and 'Best in the World' (80.7%)			
1.5% Discount Rate	**3,192**	1,333	4,498
3% Discount Rate	2,838	1,185	3,999
0% Discount Rate	3,655	1,526	5,151
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**Cost-saving**	Cost-saving	$4,306
3% Discount Rate	Cost-saving	Cost-saving	$3,405
0% Discount Rate	Cost-saving	Cost-saving	$5,307
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	Cost-saving	Cost-saving	Cost-saving
3% Discount Rate	Cost-saving	Cost-saving	Cost-saving
0% Discount Rate	Cost-saving	Cost-saving	Cost-saving

Females Only

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening for, and treatment of, prediabetes in asymptomatic non-pregnant females aged 35 to 70 years who have overweight or obesity in a BC birth cohort of 40,000 is estimated to be 2,338 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is cost-saving (see Table 25).

Table 25: Screening, and Intervention, for Prediabetes in a Birth Cohort of 40,000
Summary for Females

	Base Case	Range	
CPB (Potential QALYs Gained)			
Gap between No Service and 'Best in the World' (80.7%)			
1.5% Discount Rate	**2,338**	976	3,295
3% Discount Rate	2,078	867	2,928
0% Discount Rate	2,679	1,118	3,775
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**Cost-saving**	Cost-saving	Cost-saving
3% Discount Rate	Cost-saving	Cost-saving	Cost-saving
0% Discount Rate	Cost-saving	Cost-saving	$204
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	Cost-saving	Cost-saving	Cost-saving
3% Discount Rate	Cost-saving	Cost-saving	Cost-saving
0% Discount Rate	Cost-saving	Cost-saving	Cost-saving

Males Only

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening for, and treatment of, prediabetes in asymptomatic males aged 35 to 70 years who have overweight or obesity in a BC birth cohort of 40,000 is estimated to be 854 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is $878 (see Table 26).

Table 26: Screening, and Intervention, for Prediabetes in a Birth Cohort of 40,000
Summary for Males

	Base Case	Range	
CPB (Potential QALYs Gained)			
Gap between No Service and 'Best in the World' (80.7%)			
1.5% Discount Rate	**854**	356	1,203
3% Discount Rate	760	317	1,071
0% Discount Rate	976	408	1,376
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$878**	Cost-saving	$16,855
3% Discount Rate	$283	Cost-saving	$14,649
0% Discount Rate	$1,538	Cost-saving	$19,306
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	Cost-saving	Cost-saving	Cost-saving
3% Discount Rate	Cost-saving	Cost-saving	Cost-saving
0% Discount Rate	Cost-saving	Cost-saving	Cost-saving

Canadian Task Force on Preventive Health Care (2013)[960]

> *Recommendations on screening for depression in primary care settings are provided for people 18 years of age or older who present at a primary care setting with no apparent symptoms of depression. These recommendations do not apply to people with known depression, with a history of depression or who are receiving treatment for depression.*
>
> *For adults at average risk of depression,[961] we recommend not routinely screening for depression. (Weak recommendation; very-low-quality evidence)*
>
> *For adults in subgroups of the population who may be at increased risk of depression,[962] we recommend not routinely screening for depression.[963] (Weak recommendation; very-low-quality evidence)*

Note that the 2013 recommendations from the CTFPHC are different than their 2005 recommendations. In 2005, the CTFPHC recommended the following:

> *There is fair evidence to recommend screening adults in the general population for depression in primary care settings that have integrated programs for feedback to patients and access to case management or mental health care (grade B recommendation).*
>
> *This is insufficient evidence to recommend for or against screening adults in the general; population for depression in primary care settings where effective follow-up and treatment are not available (grade I recommendation).* [964]

United States Preventive Services Task Force Recommendations (2016)

> *The USPSTF recommends screening for depression in the general adult population, including pregnant and postpartum women. Screening should be implemented with adequate systems in place to ensure accurate diagnosis, effective treatment, and appropriate follow-up. (B recommendation)* [965]

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with screening non-pregnant adults ages 18 and older for depression when staff-assisted depression care supports are in place to assure accurate diagnosis, effective treatment, and follow-up in a BC birth cohort of 40,000.

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[960] Canadian Task Force on Preventive Health Care. Recommendations on screening for depression in adults. *Canadian Medical Association Journal*. 2013; 185(9): 775-82.

[961] The average-risk population includes all individuals 18 years of age or older with no apparent symptoms of depression who are not considered to be at increased risk.

[962] Subgroups of the population who may be at increased risk of depression include people with a family history of depression, traumatic experiences as a child, recent traumatic life events, chronic health problems, substance misuse, perinatal and postpartum status, or Aboriginal origin.

[963] Clinicians should be alert to the possibility of depression, especially in patients with characteristics that may increase the risk of depression, and should look for it when there are clinical clues, such as insomnia, low mood, anhedonia and suicidal thoughts.

[964] MacMillan HL, Patterson CJ and Wathen CN. Screening for depression in primary care: recommendation statement from the Canadian Task Force on Preventive Health Care. *Canadian Medical Association Journal*. 2005; 172(1): 33-5.

[965] Siu AL and the US Preventive Services Task Force (USPSTF). Screening for depression in adults: US Preventive Services Task Force recommendation statement. *JAMA.* 2016; 315(4): 380-7.

In modelling CPB, we made the following assumptions:

- In BC in 2012, 4.6% of the population aged ≥15 had a major depressive episode (MDE) within the previous 12 months (4.0% for males and 5.2% for females). The lifetime risk for an MDE is 11.6% (9.3% for males and 13.9% for females).[966]
- The average duration of a first episode of a MDE is 71.0 weeks (1.37 years) for males and 75.9 weeks (1.46 years) for females (see Table 1).[967]

Table 1: Length of First Major Depression Episode
British Columbia in 2012 by Sex

	Males				***Females***			
Episode duration (as reported)	Episode duration (in weeks)	Number	Percent	Cumulative percent	Episode duration (in weeks)	Number	Percent	Cumulative percent
2 weeks	2.0	8	6.1%	6.1%	2.0	10	4.0%	4.0%
3 weeks	3.0	5	3.8%	9.9%	3.0	4	1.6%	5.6%
1 month	4.3	11	8.4%	18.3%	4.3	33	13.1%	18.7%
2 months	8.7	9	6.9%	25.2%	8.7	19	7.6%	26.3%
3 months	13.0	16	12.2%	37.4%	13.0	17	6.8%	33.1%
4 months	17.3	5	3.8%	41.2%	17.3	7	2.8%	35.9%
5 months	21.7	1	0.8%	42.0%	21.7	9	3.6%	39.4%
6 months	26.0	15	11.5%	53.4%	26.0	31	12.4%	51.8%
7 months	30.3	1	0.8%	54.2%	30.3	0	0.0%	51.8%
8 months	34.7	4	3.1%	57.3%	34.7	5	2.0%	53.8%
9 months	39.0	2	1.5%	58.8%	39.0	4	1.6%	55.4%
10 months	43.3	3	2.3%	61.1%	43.3	2	0.8%	56.2%
11 months	47.7	0	0.0%	61.1%	47.7	2	0.8%	57.0%
1 year	52.0	17	13.0%	74.0%	52.0	40	15.9%	72.9%
2 years*	156.0	25	19.1%	93.1%	156.0	48	19.1%	92.0%
5 years*	364.0	9	6.9%	100.0%	364.0	20	8.0%	100.0%
Total	**71.0**	**131**			**75.9**	**251**		

** Reponses were categorized as ranges: 2-4 years and 5 or more years. Assume a duration of 3 years for the first category and 7 years for the second.*

- Depression is a highly recurrent disorder.[968] On average, half of individuals experiencing at least one MDE during their lifetime will experience between 5-9 recurrent episodes during their lifetime.[969,970,971] For modelling purposes, we assumed that 50% of individuals experiencing an initial MDE would experience 7 recurrent episodes during their lifetime.
- The above information was used to generate the expected number of life years lived with depression by males and females in a BC birth cohort of 40,000. For males, an estimated 0.95% of life years lived between the age of 18 and death would be with

[966] Statistics Canada. Canadian Community Health Survey (CCHS), 2012 Public Use Microdata file (Catalogue number 82M0013X2013001). 2013: All computations, use and interpretation of these data are entirely that of H. Krueger & Associates Inc.
[967] Patten SB. A major depression prognosis calculator based on episode duration. *Clinical Practice and Epidemiology in Mental Health*. 2006; 2(1): 13-20.
[968] Burcusa SL and Iacono WG. Risk for recurrence in depression. *Clinical Psychology Review*. 2007; 27(8): 959-85.
[969] Kessler RC, Zhao S, Blazer DG et al. Prevalence, correlates, and course of minor depression and major depression in the National Comorbidity Survey. *Journal of Affective Disorders*. 1997; 45(1): 19-30.
[970] Kessler RC and Walters EE. Epidemiology of DSM-III-R major depression and minor depression among adolescents and young adults in the national comorbidity survey. *Depression and Anxiety*. 1998; 7(1): 3-14.
[971] Colman I, Naicker K, Zeng Y et al. Predictors of long-term prognosis of depression. *Canadian Medical Association Journal*. 2011; 183(17): 1969-76.

diagnosed depression (see Tables 2). For females, an estimated 1.33% of life years lived between the age of 18 and death would be with diagnosed depression (see Tables 3).

Table 2: Years of Life Lived with Depression
in a British Columbia Male Birth Cohort of 20,000

Age Group	Individuals in Birth Cohort	Estimated First MDE	Estimated Subsequent MDE	Years of Life with Depression in Birth Cohort	Years of Life in Birth Cohort	% of Life Years with Depression
18-19	19,870	58.7	205.3	376.9	39,740	0.95%
20-24	19,815	146.3	511.9	939.7	99,073	0.95%
25-29	19,701	145.4	508.9	934.3	98,505	0.95%
30-34	19,564	144.4	505.4	927.8	97,819	0.95%
35-39	19,408	143.2	501.4	920.4	97,038	0.95%
40-44	19,223	141.9	496.6	911.6	96,115	0.95%
45-49	18,993	140.2	490.7	900.7	94,967	0.95%
50-54	18,690	138.0	482.8	886.3	93,451	0.95%
55-59	18,270	134.9	472.0	866.4	91,351	0.95%
60-64	17,673	130.4	456.6	838.1	88,366	0.95%
65-69	16,810	124.1	434.3	797.2	84,050	0.95%
70-74	15,550	114.8	401.7	737.4	77,750	0.95%
75-79	13,720	101.3	354.4	650.7	68,602	0.95%
80+	9,117	26.9	94.2	172.9	18,234	0.95%
Total Ages 18+		**1,690**	**5,916**	**10,860**	**1,145,062**	**0.95%**

Table 3: Years of Life Lived with Depression
in a British Columbia Female Birth Cohort of 20,000

Age Group	Individuals in Birth Cohort	Estimated First MDE	Estimated Subsequent MDE	Years of Life with Depresion in Birth Cohort	Years of Life in Birth Cohort	% of Life Years with Depression
18-19	19,891	82.5	288.9	530.3	39,782	1.33%
20-24	19,867	206.1	721.3	1,324.1	99,333	1.33%
25-29	19,825	205.6	719.8	1,321.3	99,124	1.33%
30-34	19,773	205.1	717.9	1,317.8	98,864	1.33%
35-39	19,707	204.4	715.5	1,313.4	98,536	1.33%
40-44	19,624	203.6	712.5	1,307.9	98,118	1.33%
45-49	19,509	202.4	708.3	1,300.3	97,547	1.33%
50-54	19,349	200.7	702.5	1,289.5	96,744	1.33%
55-59	19,116	198.3	694.0	1,274.1	95,582	1.33%
60-64	18,770	194.7	681.5	1,251.0	93,850	1.33%
65-69	18,238	189.2	662.1	1,215.5	91,189	1.33%
70-74	17,402	180.5	631.8	1,159.8	87,008	1.33%
75-79	16,072	166.7	583.5	1,071.1	80,358	1.33%
80+	12,031	149.8	524.2	962.2	72,188	1.33%
Total Ages 18+		**2,590**	**9,064**	**16,638**	**1,248,224**	**1.33%**

- Depression increases an individual's mortality risk. Males living with depression are 21 times as likely to commit suicide as males without depression. For females, this ratio increases to 27 times.[972] Individuals living with depression also have higher rates of overall excess mortality with an early meta-analysis suggesting a RR of 1.81 (95% CI of 1.58 to 2.07).[973] This review, however, did not adjust for confounding variables such as chronic illness and lifestyle. After adjusting for tobacco smoking and heavy alcohol use, Murphy et al. found a non-significant increase in mortality associated with depression in men (RR 1.6, 95% CI of 0.8 to 3.1).[974] Other research has found that the effect of depression on mortality is independent of chronic illnesses such as diabetes[975] and congestive heart failure.[976] After adjusting for a number of potentially confounding covariates, including the presence of chronic disease, Schoevers, et al. found a 41% higher mortality rate associated with chronic depression.[977] A more recent meta-analysis of excess mortality associated with depression found a RR of 1.52 (95% CI of 1.45 to 1.59).[978] For modelling purposes we calculated the number of deaths occurring for males and females between the ages of 20 and 74 in our birth cohort and then estimated how many of these deaths would be in individuals living with depression. We assumed that depression would increase the premature mortality rate by 52% and varied this in the sensitivity analysis from 45% to 59%. In males, 21 deaths and 529 life years lost in the cohort are attributable to depression (see Table 4). In females, 17 deaths and 451 life years lost are attributable to depression (see Table 5).

[972] Lépine J-P and Briley M. The increasing burden of depression. *Neuropsychiatric Disease and Treatment*. 2011; 7(Suppl 1): 3-7.
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[974] Murphy JM, Burke Jr JD, Monson RR et al. Mortality associated with depression: A forty-year perspective from the Stirling County Study. *Social Psychiatry and Psychiatric Epidemiology*. 2008; 43(8): 594-601.
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[977] Schoevers R, Geerlings M, Deeg D et al. Depression and excess mortality: evidence for a dose response relation in community living elderly. *International Journal of Geriatric Psychiatry*. 2009; 24(2): 169-76.
[978] Cuijpers P, Vogelzangs N, Twisk J et al. Comprehensive meta-analysis of excess mortality in depression in the general community versus patients with specific illnesses. *American Journal of Psychiatry*. 2014; 171(4): 453-62.

Table 4: Deaths and Life Years Lost Attributable to Depression
in a British Columbia Male Birth Cohort of 20,000

Age Group	Individuals in Birth Cohort	Deaths	Proportion with Depression	Unadjusted Deaths in Pop. With Depression	Adjusted Deaths in Pop. With Depression	Deaths Attributable to Depression	Average Life Years Lived	Life Years Lost to Depression
18-19	19,870							
20-24	19,815	55	0.95%	0.5	0.8	0.3	58.6	16
25-29	19,701	114	0.95%	1.1	1.6	0.6	53.9	30
30-34	19,564	137	0.95%	1.3	2.0	0.7	49.3	33
35-39	19,408	156	0.95%	1.5	2.3	0.8	44.6	34
40-44	19,223	185	0.95%	1.8	2.7	0.9	40.1	36
45-49	18,993	230	0.95%	2.2	3.3	1.1	35.5	40
50-54	18,690	303	0.95%	2.9	4.4	1.5	31.0	46
55-59	18,270	420	0.95%	4.0	6.1	2.1	26.7	55
60-64	17,673	597	0.95%	5.7	8.6	2.9	22.5	66
65-69	16,810	863	0.95%	8.2	12.4	4.3	18.5	79
70-74	15,550	1,260	0.95%	12.0	18.2	6.2	14.8	92
Total		**4,320**		**41**	**62**	**21**		**529**

Table 5: Deaths and Life Years Lost Attributable to Depression
in a British Columbia Female Birth Cohort of 20,000

Age Group	Individuals in Birth Cohort	Female Deaths	Proportion with Depression	Unadjusted Deaths in Pop. With Depression	Adjusted Deaths in Pop. With Depression	Deaths Attributable to Depression	Average Life Years Lived	Life Years Lost to Depression
18-19	19,891							
20-24	19,867	24	1.33%	0.3	0.5	0.2	63.4	11
25-29	19,825	42	1.33%	0.6	0.8	0.3	58.6	17
30-34	19,773	52	1.33%	0.7	1.1	0.4	53.7	19
35-39	19,707	66	1.33%	0.9	1.3	0.5	48.9	22
40-44	19,624	84	1.33%	1.1	1.7	0.6	44.1	26
45-49	19,509	114	1.33%	1.5	2.3	0.8	39.3	31
50-54	19,349	161	1.33%	2.1	3.3	1.1	34.6	39
55-59	19,116	232	1.33%	3.1	4.7	1.6	30.0	48
60-64	18,770	347	1.33%	4.6	7.0	2.4	25.5	61
65-69	18,238	532	1.33%	7.1	10.8	3.7	21.2	78
70-74	17,402	836	1.33%	11.1	16.9	5.8	17.1	99
Total		**2,489**		**33**	**50**	**17**		**451**

- Diagnosing depression is challenging. "The diagnosis of a mental health disorder is a process that often takes time and develops in a context of trust. Both patient and doctor may need to be sure that the somatic symptoms of depression are exactly that, and not the symptoms of an underlying physical illness."[979]
- Based on a meta-analysis of 41 studies including 50,371 patients, for every 100 patients, GPs identify 10 true positive cases of depression, diagnose 15 patients with depression who do not have depression (false positives) and miss 10 cases of depression (false negatives). Accuracy is improved with prospective examination

[979] Kessler D, Sharp D and Lewis G. Screening for depression in primary care. *British Journal of General Practice*. 2005; 55(518): 659-60.

over an extended period of time (3-12 months) rather than relying on a one-time assessment or case-note records.[980]

- Those who meet screening criteria and were previously undiagnosed by their primary care physician tend to be less severely ill than those who were previously diagnosed.[981,982] Approximately half (52%) of primary care patients identified by screening have transient symptoms (possibly related to life events) lasting less than two weeks and do not require treatment.[983]
- Zimmerman et al. found that 71% of patients diagnosed with major depressive disorder in their outpatient practice had a Hamilton Depression Rating Scale (HDRS) score of less than 22.[984] Scores on the HDRS can be interpreted as follows: no depression (0-7), mild depression (8-16), moderate depression (17-23) and severe depression (≥24).[985]
- When a longitudinal perspective is taken, 30% of patients with depression remain undetected at 1 year and only 14% at the end of 3 years, or approximately one out of seven patients with treatable depression.[986,987,988] For modelling purposes, we assumed that 14% of depression is undiagnosed treatable depression (see Table 6, row *i*) and increased this to 30% in the sensitivity analysis.
- 85% of patients diagnosed with depression were prescribed anti-depressant medication (ADM) in 2011/12 in Canada.[989]
- Approximately 60% of patients stay on ADM for at least 3 months and 45% for at least 6 months.[990,991]

[980] Mitchell AJ, Vaze A and Rao S. Clinical diagnosis of depression in primary care: a meta-analysis. *The Lancet*. 2009; 374(9690): 609-19.
[981] Ormel J, Koeter MW, Van den Brink W et al. Recognition, management, and course of anxiety and depression in general practice. *Archives of General Psychiatry*. 1991; 48(8): 700-6.
[982] Simon GE and VonKorff M. Recognition, management, and outcomes of depression in primary care. *Archives of Family Medicine*. 1995; 4(2): 99-105.
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[986] Kessler D, Heath I, Lloyd K et al. Cross sectional study of symptom attribution and recognition of depression and anxiety in primary care. *BMJ*. 1999; 318(7181): 436-40.
[987] Kessler D, Bennewith O, Lewis G et al. Detection of depression and anxiety in primary care: follow up study. *BMJ*. 2002; 325(7371): 1016-7.
[988] Tylee A and Walters P. Underrecognition of anxiety and mood disorders in primary care: why does the problem exist and what can be done? *The Journal of Clinical Psychiatry*. 2006; 68(2): 27-30.
[989] Wong ST, Manca D, Barber D et al. The diagnosis of depression and its treatment in Canadian primary care practices: an epidemiological study. *Canadian Medical Association Journal*. 2014; 2(4): e337-e42.
[990] Solberg LI, Trangle MA and Wineman AP. Follow-up and follow-through of depressed patients in primary care: the critical missing components of quality care. *The Journal of the American Board of Family Practice*. 2005; 18(6): 520-7.
[991] Cantrell CR, Eaddy MT, Shah MB et al. Methods for evaluating patient adherence to antidepressant therapy: a real-world comparison of adherence and economic outcomes. *Medical Care*. 2006; 44(4): 300-3.

- The use of ADM for major depression is associated with a 64% (OR = 0.36, 95% CI of 0.15 to 0.88) reduced risk of recurrent depression eight years later[992] and a 70% (OR = 0.30, 95% CI of 0.1 to 1.0) reduced risk after 10 years.[993]
- The theoretical cumulative effectiveness of achieving remission through four levels of treatment (primarily medication switching or augmentation) based on the Sequenced Treatment Alternatives to relieve Depression (STAR*D) trial is 36.8% at Level 1, 56.1% at Level 2, 62.1% at Level 3 and 67.1% at Level 4.[994,995] For modelling purposes we used Level 2 (56.1%) results as the base with sensitivity analysis using Level 1 and Level 4 results (see Table 6, row *n*).
- Depression has an important influence on a person's QoL. Studies have also shown that individuals with current or treated depression report lower preference scores for depression health states that the general population.[996,997] Pyne and colleagues suggest that "public stigma may result in the general population being less sympathetic to the suffering of individuals with depression and less willing to validate the impact of depression symptoms."[998] Revicki and Wood, based on input from patients with depression who had completed at least eight weeks of ADM, identified the following health state utilities: severe depression =0.30, moderate depression = 0.55 to 0.63, mild depression = 0.64 to 0.73 and antidepressant maintenance therapy = 0.72 to 0.83.[999] Whiteford and colleagues[1000] suggest the following health utilities:
    - Severe depression = 0.35 (95% CI of 0.18-0.53)
    - Moderate depression = 0.59 (95% CI of 0.45-0.72)
    - Mild depression = 0.84 (95% CI of 0.78-0.89)

    For modelling purposes we assumed an equal proportion of individuals with mild, moderate and severe depression and used the average health utilities provided by Whiteford and colleagues (0.59, 95% CI of 0.47-0.72) adjusted for a general population QoL of 0.848 (see Reference Document) resulting in a QoL reduction of 0.30 (see Table 6, row *p*), ranging from 0.16 to 0.45.
- Other assumptions used in assessing the clinically preventable burden are detailed in the Reference Document.

Based on these assumptions, screening for depression results in a CPB of 94 quality-adjusted life years saved (see Table 6, row s). The CPB of 94 represents the gap between existing coverage (no coverage) and the 'best in the world' coverage estimated at 12%.

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[992] Colman I, Zeng Y, Ataullahjan A et al. The association between antidepressant use and depression eight years later: a national cohort study. *Journal of Psychiatric Research*. 2011; 45(8): 1012-8.
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[996] Pyne JM, Fortney JC, Tripathi S et al. How bad is depression? Preference score estimates from depressed patients and the general population. *Health Services Research*. 2009; 44(4): 1406-23.
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[998] Pyne JM, Fortney JC, Tripathi S et al. How bad is depression? Preference score estimates from depressed patients and the general population. *Health Services Research*. 2009; 44(4): 1406-23.
[999] Revicki DA and Wood M. Patient-assigned health state utilities for depression-related outcomes: differences by depression severity and antidepressant medications. *Journal of Affective Disorders*. 1998; 48(1): 25-36.
[1000] Whiteford HA, Degenhardt L, Rehm J et al. Global burden of disease attributable to mental and substance use disorders: findings from the Global Burden of Disease Study 2010. *The Lancet*. 2013; 382(9904): 1575-86.

Table 6: CPB of Screening for Depression in a Birth Cohort of 40,000			
Row Label	**Variable**	**Base Case**	**Data Source**
a	Life years lived from age 18 to death in a birth cohort of 20,000 males	1,145,062	Table 2
b	Life years lived from age 18 to death in a birth cohort of 20,000 females	1,248,224	Table 3
c	Life years lived with depression in a birth cohort of 20,000 males	10,860	Table 2
d	Life years lived with depression in a birth cohort of 20,000 females	16,638	Table 3
e	Proportion of life years lived with depression in a birth cohort of 20,000 males	0.95%	= c / a
f	Proportion of life years lived with depression in a birth cohort of 20,000 females	1.33%	= d / b
g	Life years lost attributable to depression in a birth cohort of 20,000 males	529	Table 4
h	Life years lost attributable to depression in a birth cohort of 20,000 females	451	Table 5
i	Proportion of treatable depression undiagnosed	14%	√
j	Life years lived with undiagnosed treatable depression in a birth cohort of 20,000 males	1,520	= c * i
k	Life years lived with undiagnosed treatable depression in a birth cohort of 20,000 females	2,329	= d * i
l	Adherence with screening	12%	√
m	Life years lived with undiagnosed treatable depression identified by screening	462	= (j + k) * l
n	Effectiveness of ADM in achieving remission	56%	√
o	Life years lived in remission with treated depression identified by screening	259	= m * n
p	Quality of life reduction	30%	√
q	QALYs gained	78	= o * p
r	Life-years gained / death averted	16	= (g + h) * i * l
s	**Potential QALYs gained, Screening increasing from 0% to 12%**	**94**	= q + r

√ = Estimates from the literature

We also modified a number of major assumptions and recalculated the CPB as follows:

- Assume that the RR of excess mortality associated with depression is reduced from 1.52 to 1.45 (Table 4 and 5): CPB = 92.
- Assume that the RR of excess mortality associated with depression is increased from 1.52 to 1.59 (Table 4 and 5): CPB = 96.
- Assume the proportion of treatable depression that is undiagnosed is increased from 14% to 30% (Table 6, row *i*): CPB = **202**.
- Assume the effectiveness of ADM in achieving remission is reduced from 56% to 37% (Table 6, row *n*): CPB = 68.
- Assume the effectiveness of ADM in achieving remission is increased from 56% to 67% (Table 6, row *n*): CPB = 109.
- Assume the QoL adjustment is reduced from 30% to 16% (Table 6, row *p*): CPB = **57**.
- Assume the QoL adjustment is increased from 30% to 45% (Table 6, row *p*): CPB = 132.

To this point we have not considered some of the potential harms associated with screening for depression, including the negative side-effects of ADM or the possibility that individuals may be diagnosed with depression who do not have depression (false positives).

- There is a side effect burden associated with taking ADM: 48.7% of individuals taking ADM experienced side effects at least 50% of the time, with the maximum side effect burden being at least moderate 34.2% of the time.[1001] Based on input from patients with depression who had completed at least eight weeks of ADM, Revicki and Wood identified a health state utility of between 0.72 and 0.83 associated with antidepressant maintenance therapy.[1002] With an average population health state utility of 0.848 (see Reference Document), this represents a disutility of between 0.02 (or 2.4%) and 0.13 (15.3%). For modelling purposes we assumed a disutility of 8.8% (the midpoint) and varied this assumption from 2.4% and 15.3% in the sensitivity analysis (Table 7, row *t*).
- Screening for depression may result in 15 patients being diagnosed with depression who do not have depression (false positives) for every 10 patients who are true positive cases of depression.[1003] For modelling purposes, we have assumed a ratio of 1.5 to 1 false positives to true positives (Table 7, row *n*) and that false positive patients will be prescribed ADM the same as true positive patients.
- One of the harms associated with a diagnosis of depression is being rated (i.e. charged a higher life insurance premium) or being refused insurance coverage when the diagnosis of depression is included in the patient's medical chart. Bell suggests that this is one reason why underdiagnoses may be by design rather than accident.[1004] We have not included this potential harm in the modelling.

Based on these additional assumptions, the calculation of CPB is reduced from 94 to -7 quality-adjusted life years saved (see Table 7, row *v*). ***That is, when these harms are taken into account, screening for depression does more harm than good.***

[1001] Thase ME, Friedman ES, Biggs MM et al. Cognitive therapy versus medication in augmentation and switch strategies as second-step treatments: a STAR* D report. *The American Journal of Psychiatry*. 2007; 164(5): 739-52.
[1002] Revicki DA and Wood M. Patient-assigned health state utilities for depression-related outcomes: differences by depression severity and antidepressant medications. *Journal of Affective Disorders*. 1998; 48(1): 25-36.
[1003] Mitchell AJ, Vaze A and Rao S. Clinical diagnosis of depression in primary care: a meta-analysis. *The Lancet*. 2009; 374(9690): 609-19.
[1004] Bell JR. Underdiagnosis of depression in primary care: by accident or design? *Journal of the American Medical Association*. 1997; 277(18): 1433-33.

Table 7: CPB of Screening for Depression in a Birth Cohort of 40,000			
Row Label	**Variable**	**Base Case**	**Data Source**
a	Life years lived from age 18 to death in a birth cohort of 20,000 males	1,145,062	Table 2
b	Life years lived from age 18 to death in a birth cohort of 20,000 females	1,248,224	Table 3
c	Life years lived with depression in a birth cohort of 20,000 males	10,860	Table 2
d	Life years lived with depression in a birth cohort of 20,000 females	16,638	Table 3
e	Proportion of life years lived with depression in a birth cohort of 20,000 males	0.95%	= c / a
f	Proportion of life years lived with depression in a birth cohort of 20,000 females	1.33%	= d / b
g	Life years lost attributable to depression in a birth cohort of 20,000 males	529	Table 4
h	Life years lost attributable to depression in a birth cohort of 20,000 females	451	Table 5
i	Proportion of treatable depression undiagnosed	14%	√
j	Life years lived with undiagnosed treatable depression in a birth cohort of 20,000 males	1,520	= c * i
k	Life years lived with undiagnosed treatable depression in a birth cohort of 20,000 females	2,329	= d * i
l	Adherence with screening	12%	√
m	Life years lived with undiagnosed treatable depression identified by screening	462	= (j + k) * l
n	Life years treated for depression - false positives	693	= m * 1.5
o	Effectiveness of ADM in achieving remission	56%	√
p	Life years lived in remission with treated depression identified by screening	259	= m * o
q	Quality of life adjustment	30%	√
r	QALYs gained	78	= p * q
s	Life-years gained / death averted	16	= (g + h) * i * l
t	Disutility associated with ADM	-8.8%	√
u	QALYs lost associated with ADM	-102	= (m + n) * t
v	**Potential QALYs gained, Screening increasing from 0% to 12%**	**-7**	= r + s + u

√ = Estimates from the literature

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with screening non-pregnant adults ages 18 and older for depression when staff-assisted depression care supports are in place to assure accurate diagnosis, effective treatment, and follow-up in a BC birth cohort of 40,000.

In modelling CE, we made the following assumptions:

- We did not include false positives or the potential disutility associated with taking ADM, as identified in Table 7.
- We assumed that screening would occur annually (Table 8, row *c*).
- For patient time and travel costs, we estimated two hours of patient time required per screening visit (Table 8, row *g*).

- We assumed that diagnosed depression results in an additional 6 physician visits per year and modified this assumption from 4 to 8 in the sensitivity analysis (see Table 8, row *m*).
- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the estimated cost per QALY would be $171,912 (see Table 8, row *s*).

Table 8: CE of Screening for Depression in a Birth Cohort of 40,000

Row Label	Variable	Base Case	Data Source
a	Life years lived from age 18 to death without diagnosed depression in a birth cohort of 20,000 males	1,134,202	Table 6, row a - row c
b	Life years lived from age 18 to death without diagnosed depression in a birth cohort of 20,000 females	1,231,586	Table 6, row b - row d
	Costs of intervention		
c	Frequency of screening (every x years)	1	Assumed
d	Total number of screens (100% adherence)	2,365,788	= (a + b) / c
e	Adherence with screening	12%	Table 6, row l
f	Cost of 10-minute office visit	$35.97	Ref Doc
g	Value of patient time and travel for office visit	$74.32	Ref Doc
h	Portion of 10-minute office visit for screen	50%	Assumed
i	Cost of screening	$15,655,365	= (d * e) * (f + g) * h
j	Life years treated for depression	462	Table 6, row m
k	Annual cost of ADM	$492	Ref Doc
l	Cost of ADM	$227,076	= j * k
m	Annual # of additional visits to a clinician associated with treatment for depression	6	Assumed
n	Cost of additional follow-up office visits to a clinician	$305,708	= (m * j) * (f + g)
	CE calculation		
o	Cost of intervention over lifetime of birth cohort	$16,188,149	= (i + l + n)
p	QALYs saved	94	Table 6, row s
q	Cost of intervention over lifetime of birth cohort (1.5% discount)	$10,255,578	Calculated
r	QALYs saved (1.5% discount)	60	Calculated
s	**CE ($/QALY saved)**	**$171,912**	= q / r

√ = Estimates from the literature

We also modified a number of major assumptions and recalculated the CE as follows:

- Assume the proportion of treatable depression that is undiagnosed is increased from 14% to 30% (Table 6, row *i*): CE = **$82,243**.
- Assume the effectiveness of ADM in achieving remission is reduced from 56% to 37% (Table 6, row *n*): CE = $238,745.
- Assume the effectiveness of ADM in achieving remission is increased from 56% to 67% (Table 6, row *n*): CPB = CE = $147,936.
- Assume the QoL adjustment is reduced from 30% to 16% (Table 6, row *p*): CE = **$285,291**.

- Assume the QoL adjustment is increased from 30% to 45% (Table 6, row *p*): CE = $122,831.
- Assume that the proportion of an office visit required for screening is reduced from 50% to 33% (Table 8, row *h*): CE = $115,385.
- Assume that the proportion of an office visit required for screening is increased from 50% to 67% (Table 8, row *h*): CE = $228,438.
- Assume that diagnosed depression results in an additional 4 physician visits per year rather than 6 (see Table 8, row *m*): CE = $170,830.
- Assume that diagnosed depression results in an additional 8 physician visits per year rather than 6 (see Table 8, row *m*): CE = $172,994.

Summary – Excluding Harms

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening non-pregnant adults ages 18 and older for depression (excluding harms) is estimated to be 60 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $171,912 per QALY (see Table 9).

Table 9: Screening for Depression in a Birth Cohort of 40,000

Summary Excluding Harms

	Base Case	Range	
CPB (Potential QALYs Gained)			
Gap between B.C. Current (0%) and 'Best in the World' (12%)			
1.5% Discount Rate	**60**	36	128
3% Discount Rate	40	24	86
0% Discount Rate	94	57	202
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$171,912**	$82,243	$285,291
3% Discount Rate	$171,912	$82,243	$285,291
0% Discount Rate	$171,912	$82,243	$285,291
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$57,692	$28,774	$95,742
3% Discount Rate	$57,692	$28,774	$95,742
0% Discount Rate	$57,692	$28,774	$95,742

Summary – Including Harms

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening non-pregnant adults ages 18 and older for depression (including harms) is estimated to be -5 (that is, harmful) quality-adjusted life years (QALYs). This results in the cost-effectiveness (CE) being dominated (see Table 10).

Table 10: Screening for Depression in a Birth Cohort of 40,000

Summary Including Harms

	Base Case	Range	
CPB (Potential QALYs Gained)			
Gap between B.C. Current (0%) and 'Best in the World' (12%)			
1.5% Discount Rate	**-5**	-28	-10
3% Discount Rate	-3	-19	-7
0% Discount Rate	-7	-45	-16
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate			
3% Discount Rate	Dominated	Dominated	Dominated
0% Discount Rate			
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate			
3% Discount Rate	Dominated	Dominated	Dominated
0% Discount Rate			

Canadian Task Force on Preventive Health Care (2013)

> *For adults in subgroups of the population who may be at increased risk of depression,* [including pregnant and postpartum women, phrase added][1005] *we recommend not routinely screening for depression.*[1006] *(Weak recommendation; very-low-quality evidence)* [1007]

United States Preventive Services Task Force Recommendations (2016)

> *The USPSTF recommends screening for depression in the general adult population,* ***including pregnant and postpartum women*** [emphasis added]. *Screening should be implemented with adequate systems in place to ensure accurate diagnosis, effective treatment, and appropriate follow-up. (B recommendation)* [1008]

The Lifetime Prevention Schedule Expert Oversight Committee acknowledges the conflict between the two recommendations. Upon further examination, the USPSTF review included literature investigating screening and treatment of depression in perinatal and postpartum women. The CTFPHC included literature examining screening only, which was sparse; literature examining screening and treatment was excluded. In BC, the current standard for delivery of public health services is offering the Edinburgh Postnatal Depression Scale (EPDS) by eight weeks postpartum, with education/intervention/referral for treatment as needed. The USPSTF review includes a number of validation studies on perinatal and postpartum depression screening tools (including the Edinburgh Postnatal Depression Scale) in a variety of settings. These do not appear in the CTFPHC review. Finally, there are several studies on perinatal and postpartum depression screening and treatment that were published after the CTFPHC review in 2013, but were included in the more recent USPSTF review. Therefore, the LPS will use the USPSTF recommendation as the most current evidence of clinical effectiveness and proceed with the modelling of population health impact and cost-effectiveness of screening and treatment for depression in perinatal and postpartum women.

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with screening pregnant and postpartum women for depression in a BC birth cohort of 40,000.

In modelling CPB, we made the following assumptions:

- On average, each female in a BC birth cohort would be expected to birth 1.20 children over their lifetime, based on data from 2018 to 2022 (Table 1, row *a*).[1009]

[1005] Subgroups of the population who may be at increased risk of depression include people with a family history of depression, traumatic experiences as a child, recent traumatic life events, chronic health problems, substance misuse, perinatal and postpartum status, or Aboriginal origin.
[1006] Clinicians should be alert to the possibility of depression, especially in patients with characteristics that may increase the risk of depression, and should look for it when there are clinical clues, such as insomnia, low mood, anhedonia and suicidal thoughts.
[1007] Canadian Task Force on Preventive Health Care. Recommendations on screening for depression in adults. *Canadian Medical Association Journal*. 2013; 185(9): 775-82.
[1008] Siu AL and the US Preventive Services Task Force (USPSTF). Screening for depression in adults: US Preventive Services Task Force recommendation statement. *JAMA.* 2016; 315(4): 380-7.
[1009] Statistics Canada. *Fertility Indicators, Provinces and Territories: Interactive Dashboard*. Available online at https://www150.statcan.gc.ca/n1/pub/71-607-x/71-607-x2022003-eng.htm. Accessed November 2023.

- In 2003/04, 11.9% of pregnant women in BC visited a physician at least once for depression services during the 27 month time period surrounding their child's birth (9 months before conception to 9 months after giving birth).[1010]
- A 2004 systematic review found prevalence rates of depression of 7.4%, 12.8% and 12.0% during the first, second and third trimesters.[1011]
- A 2005 systematic review found that the point prevalence of minor and major depressions ranged from approximately 8-11% during pregnancy, peaked at approximately 13% three months after giving birth and then fell to about 6% eight months after giving birth. Less than half of the depressive episodes are MDE.[1012] MDE is a distinct clinical syndrome for which treatment is clearly indicated.[1013]
- The majority of depressive episodes resolve within three to six months postpartum. A subset of new mothers (approximately 30%), however, remain chronically depressed after this time period.[1014]
- For modelling purposes we assumed that screening would occur at 7 weeks post birth (Table 1, row *d*) and modified this to screen at 30 weeks pregnancy in the sensitivity analysis (Table 1, row *e*).
- For modelling purposes we assumed a prevalence of depression of 7.4% during the first trimester, 12.8% during the second trimester, 12.0% during the third trimester and 13% during the eight months after giving birth. We also assumed an equal distribution between mild, moderate and severe depression, yielding a weighted average prevalence of 7.9% for moderate to severe depression (Table 1, row *v*). If we screen at 7 weeks post birth, a potential total of 1,274 years lived with moderate to severe depression between 7 weeks and eight months post birth would be identified in the cohort (Table 1, row *d*). If we screen at 30 weeks pregnant, a potential total of 1,996 years lived with moderate to severe depression between 30 weeks pregnant and eight months post birth would be identified in the cohort (Table 1, row *e*).
- Depression is associated with the following disutility:[1015]
    - Severe depression = 0.65 (95% CI of 0.47-0.82)
    - Moderate depression = 0.41 (95% CI of 0.28-0.55)
    - Mild depression = 0.16 (95% CI of 0.11-0.22)

  We assumed an equal distribution between mild, moderate and severe depression, yielding an average disutility of 0.53 (95% CI of 0.38-0.69) for moderate to severe depression. The average QoL for a 18-39 year old is 0.90 (see Reference Document), resulting in a % reduction in QoL of 59% (0.53 / 0.90) (Table 1, row *f*).

[1010] BC Reproductive Mental Health Program. *Addressing Perinatal Depression - A Framework for BC's Health Authorities*. 2006. Available at http://www.health.gov.bc.ca/library/publications/year/2006/MHA_PerinatalDepression.pdf. Accessed March 2016.
[1011] Bennett HA, Einarson A, Taddio A et al. Prevalence of depression during pregnancy: systematic review. *Obstetrics & Gynecology*. 2004; 103(4): 698-709.
[1012] Gavin NI, Gaynes BN, Lohr KN et al. Perinatal depression: a systematic review of prevalence and incidence. *Obstetrics & Gynecology*. 2005; 106(5, Part 1): 1071-83.
[1013] Gaynes BN, Gavin N, Meltzer-Brody S et al. Perinatal depression: Prevalence, screening accuracy, and screening outcomes: Summary. *Evidence Report/Technology Assessment (Summary)* 2005; (119): 1-8.
[1014] Vliegen N, Casalin S and Luyten P. The course of postpartum depression: a review of longitudinal studies. *Harvard Review of Psychiatry*. 2014; 22(1): 1-22.
[1015] Whiteford HA, Degenhardt L, Rehm J et al. Global burden of disease attributable to mental and substance use disorders: findings from the Global Burden of Disease Study 2010. *The Lancet*. 2013; 382(9904): 1575-86.

- Suicide during the perinatal period is rare, with estimates between one and five per 100,000 live births in high income settings. For modelling purposes we have used a rate of 3/100,000 as the base case and modified this from 1 to 5/100,000 in the sensitivity analysis (Table 1, row *h*). When suicides do occur during this period, the mean age of the mother is 30.5 years, resulting in a loss of 55 QALYs per suicide (Table 1, row *j*).[1016] Women who commit suicide during the perinatal period are twice as likely (RR of 2.19, 95% CI of 1.43 to 3.34) to have a diagnosis of depression as women who commit suicide outside of the perinatal period (Table 1, row *k*).[1017]
- Mothers with a high level of depressive symptoms report significantly poorer adherence with childhood safety prevention practices such as the consistent use of car seats, covering electrical plugs, and having syrup of ipecac in the home.[1018]
- Postpartum depression does not appear to influence the number of well-baby visits or the likelihood of immunization but it may increase the likelihood of infant hospitalization and sick/emergency visits during the first year of life.[1019,1020]
- Postpartum depression is associated with a 59% (OR of 1.59, 95% CI of 1.24 to 2.04) increase in unintentional injury (Table 1, row *o*) and a 41% (OR of 1.41, 95% CI of 1.02 to 1.95) increase in falls in infants.[1021]
- In BC, the rate of hospital separations due to unintentional injuries in children less than 5 years of age is 671 per 100,000 (Table 1, row *m*). The rate of deaths due to unintentional injuries is 10.7 per 100,000 (Table 1, row *n*).[1022] If we assume that the average death occurs at age 2, then each death results in 80 years of life lost (Table 1, row *r*).[1023]
- Pregnancy and postpartum depression are associated with a shorter duration of breastfeeding.[1024] An Australian study found the median duration of breastfeeding to be 26-28 weeks in women with depression and 39 weeks in women without depression.[1025] Maternal depressive symptoms at 2 to 4 months postpartum are associated with a 27% (95% CI of 12% to 39%) reduced odds of continuing breastfeeding.[1026] For modelling purposes, we assumed a 27% reduction of exclusive

[1016] See http://www.statcan.gc.ca/pub/84-537-x/2013005/tbl-eng.htm. Accessed December 2015.
[1017] Khalifeh H, Hunt IM, Appleby L et al. Suicide in perinatal and non-perinatal women in contact with psychiatric services: 15 year findings from a UK national inquiry. *The Lancet Psychiatry*. 2016: 1-10.
[1018] McLennan JD and Kotelchuck M. Parental prevention practices for young children in the context of maternal depression. *Pediatrics*. 2000; 105(5): 1090-5.
[1019] Farr SL, Dietz PM, Rizzo JH et al. Health care utilisation in the first year of life among infants of mothers with perinatal depression or anxiety. *Paediatric and Perinatal Epidemiology*. 2013; 27(1): 81-8.
[1020] Minkovitz CS, Strobino D, Scharfstein D et al. Maternal depressive symptoms and children's receipt of health care in the first 3 years of life. *Pediatrics*. 2005; 115(2): 306-14.
[1021] Yamaoka Y, Fujiwara T and Tamiya N. Association between maternal postpartum depression and unintentional injury among 4-month-old infants in Japan. *Maternal and Child Health Journal*. 2015; 20: 326-36.
[1022] Rajabali F, Han G, Artes S et al. *Unintentional Injuries in British Columbia: Trends and Patterns Among Children & Youth*. 2005. B.C. Injury Research and Prevention Unit. Available at https://northernhealth.ca/Portals/0/Your_Health/Programs/Injury%20Prevention/Unintentional%20Injuries%20in%20BC%20Trends%20Among%20Children%20and%20Youth%202005.pdf. Accessed March 2016.
[1023] See http://www.statcan.gc.ca/pub/84-537-x/2013005/tbl-eng.htm. Accessed December 2015.
[1024] Dias CC and Figueiredo B. Breastfeeding and depression: A systematic review of the literature. *Journal of Affective Disorders*. 2015; 171: 142-54.
[1025] Henderson JJ, Evans SF, Straton JA et al. Impact of postnatal depression on breastfeeding duration. *Birth*. 2003; 30(3): 175-80.
[1026] McLearn KT, Minkovitz CS, Strobino DM et al. Maternal depressive symptoms at 2 to 4 months post partum and early parenting practices. *Archives of Pediatrics & Adolescent Medicine*. 2006; 160(3): 279-84.

breastfeeding to six months associated with maternal depression (Table 1, row *u*) and varied this from 12% to 39% in the sensitivity analysis.

- Breastfeeding is associated with a reduced risk of excess weight, otitis media, atopic dermatitis, gastrointestinal infection, lower respiratory tract infection, asthma, type 1 diabetes, childhood leukemia and sudden infant death syndrome in infants and breast and ovarian cancers in the mother.[1027,1028] In a previous analysis of the promotion of breastfeeding, we calculated that exclusive breastfeeding to six months is associated with an increase of 0.40 QALYs per infant/mother pair (Table 1, row *t*).[1029]
- Depression *in the year before birth* is independently associated with an increase in the risk of Sudden Infant Death Syndrome (SIDS) (OR of 4.9, 95% CI of 1.1 to 22.1). Depression *during pregnancy or after birth* is not significantly associated with SIDS.[1030] Since the proposed screening for depression would take place during pregnancy or shortly after birth, we have not included SIDS in this analysis.
- An increased risk of preterm birth is associated with antenatal depression and has been estimated at 37% (OR of 1.37, 95% CI of 1.04 to 1.81) and 39% (OR of 1.39, 95% CI of 1.19 to 1.61) in two meta-analyses.[1031,1032]
- Preterm births, including late preterm births, are associated with a greater risk of developmental delay, mental retardation, cerebral palsy, and poor health related outcomes (and utilization) during their first year.[1033,1034,1035]
- Children born preterm tend to have a lower overall QoL than their full term counterparts. The difference in QoL decreases with age (a disutility of 0.13 from birth to age 12 and a disutility of 0.06 from age 13 to 19) and tends to disappear when they become adults.[1036]
- Screening and treatment for depression starting late in pregnancy or shortly after birth, however, is unlikely to have an impact on pre-term birth rates and has not been included in this analysis.
- Maternal depressive symptoms at 2 to 4 months postpartum are associated with a 19% reduced odds of showing books, 30% reduced odds of playing with the infant,

[1027] Chung M, Raman G, Trikalinos T et al. Interventions in primary care to promote breastfeeding: an evidence review for the US Preventive Services Task Force. *Annals of Internal Medicine*. 2008; 149(8): 565-82.
[1028] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.
[1029] H. Krueger & Associates Inc. *Establishing Priorities among Effective Clinical Prevention Services in British Columbia (Update): Technical Report for Breastfeeding, Screening for Type 2 Diabetes, STI Behavioural Counselling and Obesity in Adults.* March 30, 2015.
[1030] Howard LM, Kirkwood G and Latinovic R. Sudden infant death syndrome and maternal depression. *The Journal of Clinical Psychiatry*. 2007; 68(8): 1279-83.
[1031] Grigoriadis S, VonderPorten EH, Mamisashvili L et al. The impact of maternal depression during pregnancy on perinatal outcomes: a systematic review and meta-analysis. *The Journal of Clinical Psychiatry*. 2013; 74(4): e321-e41.
[1032] Grote NK, Bridge JA, Gavin AR et al. A meta-analysis of depression during pregnancy and the risk of preterm birth, low birth weight, and intrauterine growth restriction. *Archives of General Psychiatry*. 2010; 67(10): 1012-24.
[1033] Dong Y and Yu JL. An overview of morbidity, mortality and long-term outcome of late preterm birth. *World Journal of Pediatrics*. 2011; 7(3): 199-204.
[1034] McGowan JE, Alderdice FA, Holmes VA et al. Early childhood development of late-preterm infants: a systematic review. *Pediatrics*. 2011; 127(6): 1111-24.
[1035] Samra HA, McGrath JM and Wehbe M. An integrated review of developmental outcomes and late-preterm birth. *Journal of Obstetric, Gynecologic, and Neonatal Nursing*. 2011; 40(4): 399-411.
[1036] Zwicker JG and Harris SR. Quality of life of formerly preterm and very low birth weight infants from preschool age to adulthood: a systematic review. *Pediatrics*. 2008; 121(2): e366-e76.

26% reduced odds of talking to the infant and 39% reduced odds of following routines, compared to mothers without depressive symptoms.[1037]

- Few studies have assessed the benefits of treating depression during the perinatal period and the subsequent well-being of the child. The limited research available "has yielded a mixed pattern of results suggesting additional investigations are needed."[1038]
- A commonly used depression screening instrument in postpartum and pregnant women is the Edinburgh Postnatal Depression Scale (EPDS). The sensitivity of the EPDS is 0.79 (95% CI of 0.72 to 0.85) and the specificity is always higher than 0.87.[1039] This means that the test would identify 79% of true positive cases (women with perinatal depression) and would falsely identify 13% of cases as positive (the false positive rate) (Table 1, row *y*).
- Involvement in screening programs, with or without additional treatment components, is associated with an 18% to 59% (weighted mean of 32%) reduced risk of depression (Table 1, row *ab*).[1040]
- The use of second generation antidepressants during pregnancy may be associated with increased risk of some serious side-effects,[1041] although the research remains unclear.[1042,1043]
- Cognitive behavioural therapy (CBT) is associated with a 34% (RR of 1.34, 95% CI of 1.19 to 1.50) increase in the likelihood of remission.[1044]
- Other assumptions used in assessing the clinically preventable burden are detailed in the Reference Document.

Based on these assumptions, the CPB is 99 quality-adjusted life years saved (see Table 1, row *ae*). The CPB of 99 represents the gap between no coverage and the 'best in the world' coverage estimated at 40%.

[1037] McLearn KT, Minkovitz CS, Strobino DM et al. Maternal depressive symptoms at 2 to 4 months post partum and early parenting practices. *Archives of Pediatrics & Adolescent Medicine*. 2006; 160(3): 279-84.
[1038] Stein A, Pearson RM, Goodman SH et al. Effects of perinatal mental disorders on the fetus and child. *The Lancet*. 2014; 384(9956): 1800-19.
[1039] O'Connor E, Rossom RC, Henninger M et al. Primary care screening for and treatment of depression in pregnant and postpartum women: evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2016; 315(4): 388-406.
[1040] Ibid.
[1041] Ibid.
[1042] Molyneaux E, Trevillion K and Howard LM. Antidepressant treatment for postnatal depression. *JAMA*. 2015; 313(19): 1965-6.
[1043] Furu K, Kieler H, Haglund B et al. Selective serotonin reuptake inhibitors and venlafaxine in early pregnancy and risk of birth defects: population based cohort study and sibling design. *BMJ*. 2015; 350: h1798-h806.
[1044] O'Connor E, Rossom RC, Henninger M et al. Primary care screening for and treatment of depression in pregnant and postpartum women: evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2016; 315(4): 388-406.

Table 1: Calculation of Clinically Preventable Burden (CPB) Estimate for Screening Pregnant and Postpartum Women for Depression in a Birth Cohort of 40,000 (B.C.)			
Row Label	**Variable**	**Base Case**	**Data Source**
a	Lifetime live births per female	1.20	√
b	Proportion of females surviving to age 20 in the cohort	99.41%	√
c	Number of pregnancies in the birth cohort	23,857	= (b * 20,000) * a
d	Estimated years lived with moderate to severe perinatal depression - 7 weeks post birth to 34 weeks post birth	1,274	√
e	Estimated years lived with moderate to severe perinatal depression - 30 weeks pregnant to 34 weeks post birth	1,996	√
f	Disutility associated with moderate to severe depression	0.59	√
g	QALYs lost due to moderate to severe perinatal depression	750	= d * f
h	Rate of suicide in perinatal women without depression	0.00003	√
i	Suicides in perinatal women without depression	0.72	= c * h
j	Years of life lost due to suicide	55	√
k	Increase in risk of suicide in perinatal women with depression	119%	√
l	QALYs lost due to suicide attributable to perinatal depression	46.8	= (i * k) * j
m	Rate of hospitalizations due to unintentional injuries in children age 0-4; mothers without depression	0.0067	√
n	Mortality rate due to unintentional injuries in children age 0-4; mothers without depression	0.00011	√
o	Increased risk of unintentional injuries; mothers with depression	59%	√
p	Hospitalizations due unintentional injuries in children age 0-4 attributable to mothers with depression	94	= (r * c) * t
q	Deaths due to unintentional injuries in children age 0-4 attributable to mothers with depression	1.5	= (s * c) * t
r	Years of life lost due to death of child from unintentional injury	80	√
s	QALYs lost due to unintentional injury attributable to perinatal depression	120	= q * r
t	QALYs lost per mother/infant pair due to not exclusively breastfeeding to six months	0.40	√
u	Reduced risk of exclusive breastfeeding to six months associated with maternal depression	27%	√
v	Estimated prevalence of moderate to severe perinatal depression	7.9%	√
w	QALYs lost due to shorter duration of breastfeeding	204	= v * c * t * u
x	**Total QALYs lost due to moderate to severe perinatal depression**	**1,129**	= g + j + s + w
y	Proportion of true positive cases identified by using the EPDS	79%	√
z	Adherence with screening	39%	Ref Doc
aa	Years lived with moderate to severe perinatal depression identified b	348	= (w * z) * y
ab	Effectiveness of screening in reducing the risk of moderate to severe depression	32%	√
ac	Years lived with moderate to severe perinatal depression reduced by	111	= aa * ab
ad	% of years lived with moderate to severe perinatal depression reduced by screening	8.7%	= ac / d
ae	**Potential QALYs saved (CPB) - Screening increasing from 0% to 40%**	**99**	= x * ad

√ = Estimates from the literature

We also modified a number of major assumptions and recalculated the CPB as follows:

- Assume that screening would occur at 30 weeks pregnant and again at 7 weeks post birth instead of just at 7 weeks post birth (Table 1, row *e*): CPB = 119.
- Assume that the disutility associated with moderate to severe depression is reduced from 0.59 to 0.42 (Table 1, row *f*): CPB = 64.
- Assume that the disutility associated with moderate to severe depression is increased from 0.59 to 0.76 (Table 1, row *f*): CPB = 141.
- Assume that the increased risk of unintentional injuries in children (mothers with depression) is reduced from 59% to 24% (Table 1, row *o*): CPB = 87.
- Assume that the increased risk of unintentional injuries in children (mothers with depression) is increased from 59% to 104% (Table 1, row *o*): CPB = 115.
- Assume that the effectiveness of screening in reducing the risk of moderate to severe depression is reduced from 32% to 18% (Table 1, row *ab*): **CPB = 56**.
- Assume that the effectiveness of screening in reducing the risk of moderate to severe depression is increased from 32% to 59% (Table 1, row *ab*): **CPB = 182**.
- Assume that the reduced risk of exclusive breastfeeding to six months associated with maternal depression is reduced from 27% to 12% (Table 1, row *u*): CPB = 80.
- Assume that the reduced risk of exclusive breastfeeding to six months associated with maternal depression is increased from 27% to 39% (Table 1, row *u*): CPB = 115.

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with screening pregnant and postpartum women for depression in a BC birth cohort of 40,000.

In modelling CE, we made the following assumptions:

- **Expected screens** - We assumed that screening would occur once per pregnancy (Table 2, row *a*) and modified this to twice in the sensitivity analysis. [1045,1046]
- **Cost of office visit** - Screening with the EPDS takes approximately 5 minutes.[1047] We therefore assumed that 50% of a 10-minute office visit would be required for the screening and varied this from 33% to 67% in the sensitivity analysis (Table 2, row *h*).
- **Evaluation of women with positive screens** – Women who test positive for depression on the EPDS should be offered a psychiatric diagnostic assessment.[1048] We assumed a cost of $252.38 for this assessment, based on fee code 00610 – full

[1045] British Columbia. *Healthy Start Initiative: Provincial Perinatal, Child and Family Public Health Services.* April 2013

[1046] BC Reproductive Mental Health Program and Perinatal Services BC. *Best Practice Guidelines for Mental Health Disorders in the Perinatal Period*. 2014. Available at http://www.perinatalservicesbc.ca/Documents/Guidelines-Standards/Maternal/MentalHealthDisordersGuideline.pdf. Accessed March 2016.

[1047] Ibid.

[1048] Wisner KL, Sit DK, McShea MC et al. Onset timing, thoughts of self-harm, and diagnoses in postpartum women with screen-positive depression findings. *JAMA Psychiatry*. 2013; 70(5): 490-8.

diagnostic interview by a psychiatrist in the BC MSC Payment Schedule (Table 2, row *o*).[1049] The assessment and fee applies to all true and false positive cases.

- **Treatment for depression** – For the base model, we assumed that women with severe depression would be treated with CBT rather than antidepressant medication, due to potential safety concerns. CBT can be provided in a group or to an individual. Individual therapy consists of 12 – 90 minute sessions with 1-2 follow-up sessions lasting from 10-30 minutes for a total therapy time of approximately 19 hours.[1050] The cost of psychiatric treatment in BC is $219.74 per hour, based on fee code 00632 – individual patient per 1 hour in the BC MSC Payment Schedule[1051] for a total cost of $4,175 per individual. Group therapy general consists of 1 initial individual session lasting 90 minutes, eight individuals receiving 12 – 120 minute sessions with 1-2 follow-up sessions lasting from 10-30 minutes.[1052] The cost of group therapy in BC with eight clients is $404 per hour.[1053] The cost of group therapy would therefore be $1,592 per person (Table 2, row *q*). For modelling purposes, we assumed in the base model that CBT would be provided as group therapy and then included the costs for individual therapy in the sensitivity analysis. For patient time and travel costs associated with CBT we assumed 26.5 hours in therapy plus 1 hour travel for each session for a total of 41 hours. If antidepressant medication is used, the cost/day for antidepressant prescriptions in BC ranges from $1.00 for prescriptions paid by the provincial government to $1.19 for prescription paid for by uninsured patients and $1.27 paid for by private insurers (in 2012 CAD)[1054] or $1.17 / $1.39 / $1.48 respectively in 2022 CAD. The average is $1.35/day or $492/year.
- **Hospitalizations avoided due to unintentional injury** – We assumed that the hospital costs per unintentional injury would be $19,485 (in 2010 Can$)[1055] or $23,794 in 2022 Can$ (Table 2, row *u*).
- **Costs avoided due to increased duration of breastfeeding** - In the previous analysis of the promotion of breastfeeding, we calculated that exclusive breastfeeding

[1049] Medical Services Commission. *MSC Payment Schedule*. 2023. Available online at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msc_payment_schedule_-_march_2023.pdf. Accessed November 2023.
[1050] Stevenson M, Scope A, Sutcliffe P et al. Group cognitive behavioural therapy for postnatal depression: a systematic review of clinical effectiveness, cost-effectiveness and value of information analyses. *Health Technology Assessment*. 2010; 14(44): 1-135.
[1051] Medical Services Commission. *MSC Payment Schedule*. 2023. Available online at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msc_payment_schedule_-_march_2023.pdf. Accessed November 2023.
[1052] Stevenson M, Scope A, Sutcliffe P et al. Group cognitive behavioural therapy for postnatal depression: a systematic review of clinical effectiveness, cost-effectiveness and value of information analyses. *Health Technology Assessment*. 2010; 14(44): 1-135.
[1053] Medical Services Commission. *MSC Payment Schedule*. 2023. Available online at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msc_payment_schedule_-_march_2023.pdf. Accessed November 2023.
[1054] Morgan S, Smolina K, Mooney D et al. *The Canadian Rx Atlas, Third Edition*. 2013. UBC Centre for Health Services and Policy Research. Available at http://www.chspr.ubc.ca/sites/default/files/file_upload/publications/2013/RxAtlas/canadianrxatlas2013.pdf. Accessed January 2018.
[1055] British Columbia Injury Research and Prevention Unit. *Economic Burden of Injury in British Columbia*. 2015. Available at http://www.injuryresearch.bc.ca/wp-content/uploads/2015/08/BCIRPU-EB-2015.pdf. Accessed March 2016.

to six months is associated with costs avoided of $6,189 per infant/mother pair (Table 2, row *w*).[1056]

- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the estimated cost per QALY would be $25,553 (Table 2, row *ad*).

Table 2. Calculation of Cost-effectiveness (CE) for Screening Pregnant and Postpartum Women for Depression in a Birth Cohort of 40,000

Row Label	Variable	Base Case	Data Source
a	Number of screens per pregnancy	1	√
b	Number of pregnancies in the birth cohort	23,857	= Table 1, row c
c	Total # of screens in birth cohort - 100% adherence	23,857	= a * b
d	Adherence with screening	39%	= Table 1, row z
e	Total # of screens in birth cohort - 40% adherence	9,304	= c * d
f	Cost of 10-minute office visit	$35.97	Ref Doc
g	Value of patient time and travel for office visit	$74.32	Ref Doc
h	Portion of 10-minute office visit for screen	50%	√
i	Cost of screening	$513,091	= e* (f + g) * h
j	Estimated prevalence of perinatal depression	7.9%	= Table 1, row v
k	EPDS true positive %	79%	= Table 1, row y
l	EPDS false positive %	13%	√
m	# of true positive screens	581	= b * d * j * k
n	# of false positive screens	96	= b * d * j * l
o	Cost per psychiatric assessment	$252.38	√
p	Cost of psychiatric assessment	$221,097	= (m + n) * o + (m + n) * g
q	Cost of CBT / ADM per individual	$1,592	√
r	Costs of patient time for CBT per individual	$1,524	= 41 * (g / 2)
s	Cost of CBT	$1,810,541	= (q + r) *m
t	Hospitalizations due to unintentional injuries avoided with screening	8.3	= Table 1, row p * Table 1, row ad
u	Cost of hospital treatment	-$23,794	√
v	Costs avoided due to unintentional injury hospitalizations avoided	-$196,444	= t * u
w	Costs avoided due to exclusive breastfeeding to six months per mother / infant pair	-$6,189	√
x	Reduced risk of exclusive breastfeeding associated with maternal depression	27%	= Table 1, row u
y	Costs avoided due to longer duration of breastfeeding	-$275,511	= Table 1, row v * Table 1, row c * Table 1, row ad * w * x
z	Net screening and patient costs (undiscounted)	$2,072,775	= i + p + s + v + y
aa	QALYs saved (undiscounted)	99	= Table 1, row ae
ab	Net screening and patient costs (1.5% discount)	$2,153,634	Calculated
ac	QALYs saved (1.5% discount)	85	Calculated
ad	**CE ($/QALY saved)**	**$25,425**	= ab / ac

√ = Estimates from the literature

[1056] In the promotion of breastfeeding model, an increase in exclusive 6-month breastfeeding in 7,788 additional infant/mother pairs (Table 2, row *g*) results in $48.2 million in costs avoided of (Table 3, row *ww*), or $6,189 per infant/mother pair.

We also modified a number of major assumptions and recalculated the CE as follows:

- Assume that screening would occur at 30 weeks pregnant and again at 7 weeks post birth instead of just at 7 weeks post birth (Table 1, row *e*): CE = $20,680.
- Assume that the disutility associated with moderate to severe depression is reduced from 0.59 to 0.42 (Table 1, row *f*): CE = $42,180.
- Assume that the disutility associated with moderate to severe depression is increased from 0.59 to 0.76 (Table 1, row *f*): CE = $16,922.
- Assume that the increased risk of unintentional injuries in children (mothers with depression) is reduced from 59% to 24% (Table 1, row *o*): CE = $30,221.
- Assume that the increased risk of unintentional injuries in children (mothers with depression) is increased from 59% to 104% (Table 1, row *o*): CE = $20,445.
- Assume that the effectiveness of screening in reducing the risk of depression is reduced from 32% to 18% (Table 1, row *ab*): **CE = $48,691**.
- Assume that the effectiveness of screening in reducing the risk of depression is increased from 32% to 59% (Table 1, row *ab*): **CE = $11,940**.
- Assume that the portion of a 10-minute office visit required for screening is reduced from 50% to 33% (Table 2, row *h*): CE = $23,514.
- Assume that the portion of a 10-minute office visit required for screening is increased from 50% to 67% (Table 2, row *h*): CE = $27,593.
- Assume that the cost of CBT per individual is increased from $1,592 to $4,175 (Table 2, row *q*): CE = $43,101.
- Assume that 50% of individuals use group CBT and 50% ADM (Table 2, row *q*): CE = $21,817.
- Assume that the reduced risk of exclusive breastfeeding to six months associated with maternal depression is reduced from 27% to 12% (Table 1, row *u*): CE = $32,156.
- Assume that the reduced risk of exclusive breastfeeding to six months associated with maternal depression is increased from 27% to 39% (Table 1, row *u*): CE = $21,312.

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening pregnant and postpartum women for depression is estimated to be 85 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $25,425 per QALY (see Table 3).

Table 3: Offer of Screening Pregnant and Postpartum Women for Depression in a Birth Cohort of 40,000

Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Gap between 0% and 'Best in the World' (39%)			
1.5% Discount Rate	**85**	48	156
3% Discount Rate	74	41	136
0% Discount Rate	99	56	182
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$25,425**	$11,880	$48,446
3% Discount Rate	$29,616	$14,266	$55,704
0% Discount Rate	$21,003	$9,203	$41,059
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$10,520	$3,796	$21,949
3% Discount Rate	$12,725	$5,105	$25,676
0% Discount Rate	$8,019	$2,161	$17,975

Canadian Task Force on Preventive Health Care Recommendations (2023)

We recommend "risk assessment–first" screening for prevention of fragility fractures in females aged 65 years and older, with initial application of the Canadian clinical Fracture Risk Assessment Tool (FRAX) without bone mineral density (BMD). The FRAX result should be used to facilitate shared decision-making about the possible benefits and harms of preventive pharmacotherapy. After this discussion, if preventive pharmacotherapy is being considered, clinicians should request BMD measurement using dual-energy x-ray absorptiometry (DXA) of the femoral neck, and re-estimate fracture risk by adding the BMD T-score into FRAX (conditional recommendation, low-certainty evidence).

We recommend against screening females aged 40–64 years and males aged 40 years and older (strong recommendation, very low-certainty evidence).

These recommendations apply to community-dwelling individuals who are not currently on pharmacotherapy to prevent fragility fractures. [1057]

United States Preventive Services Task Force Recommendations (2018)

The USPSTF recommends screening for osteoporosis with bone measurement testing to prevent osteoporotic fractures in women 65 years and older. (B recommendation)

The USPSTF recommends screening for osteoporosis with bone measurement testing to prevent osteoporotic fractures in postmenopausal women younger than 65 years at increased risk of osteoporosis, as determined by a formal clinical risk assessment tool. (B recommendation)

The USPSTF concludes that the current evidence is insufficient to assess the balance of benefits and harms of screening for osteoporosis to prevent osteoporotic fractures in men. (I statement)[1058]

Best in the World

Screening

- Based on a retrospective longitudinal cohort study within 13 primary care clinics in the Sacramento, CA region, 57.8% of 65-74 year old women are referred to and receive a bone density scan within a 7 year period.[1059]
- The rate of screening for fragility fractures with either FRAX and/or BMD in females 65 years of age and older in BC is unknown.

[1057] Theriault G, Limburg H, Klarenbach S et al. Recommendation on screening for primary prevention of fragility fractures. *CMAJ*. 2023; 195: E639-49.
[1058] Curry S, Krist A, Owens D et al. Screening for osteoporosis to prevent fractures: US Preventive Services Task Force recommendation statement. *Journal of the American Medical Association.* 2018; 319(24): 2521-31.
[1059] Amarnath A, Franks P, Robbins J et al. Underuse and Overuse of Osteoporosis Screening in a Regional Health System: a Retrospective Cohort Study. *Journal of General Internal Medicine*. 2015; 12(30): 1733-40.

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with screening for, and treatment of, fragility fractures in community-dwelling females ages 65 and older.

"The aim of screening is not to detect the existence of osteoporosis but rather to reduce fracture-related burden of morbidity, mortality, and costs."[1060]

Definitions

- "Fragility fractures are those that occur spontaneously during normal daily activities or that result from minor impacts that would not normally cause a fracture in healthy adults."[1061]
- Risk factors for fragility factors include older age, female sex, low body weight, smoking, alcohol use, the use of certain medications (e.g. glucocorticoids), family history of fracture, history of falls, type 2 diabetes and a prior history of fragility fractures.[1062]

Defining and Estimating the Population at Risk

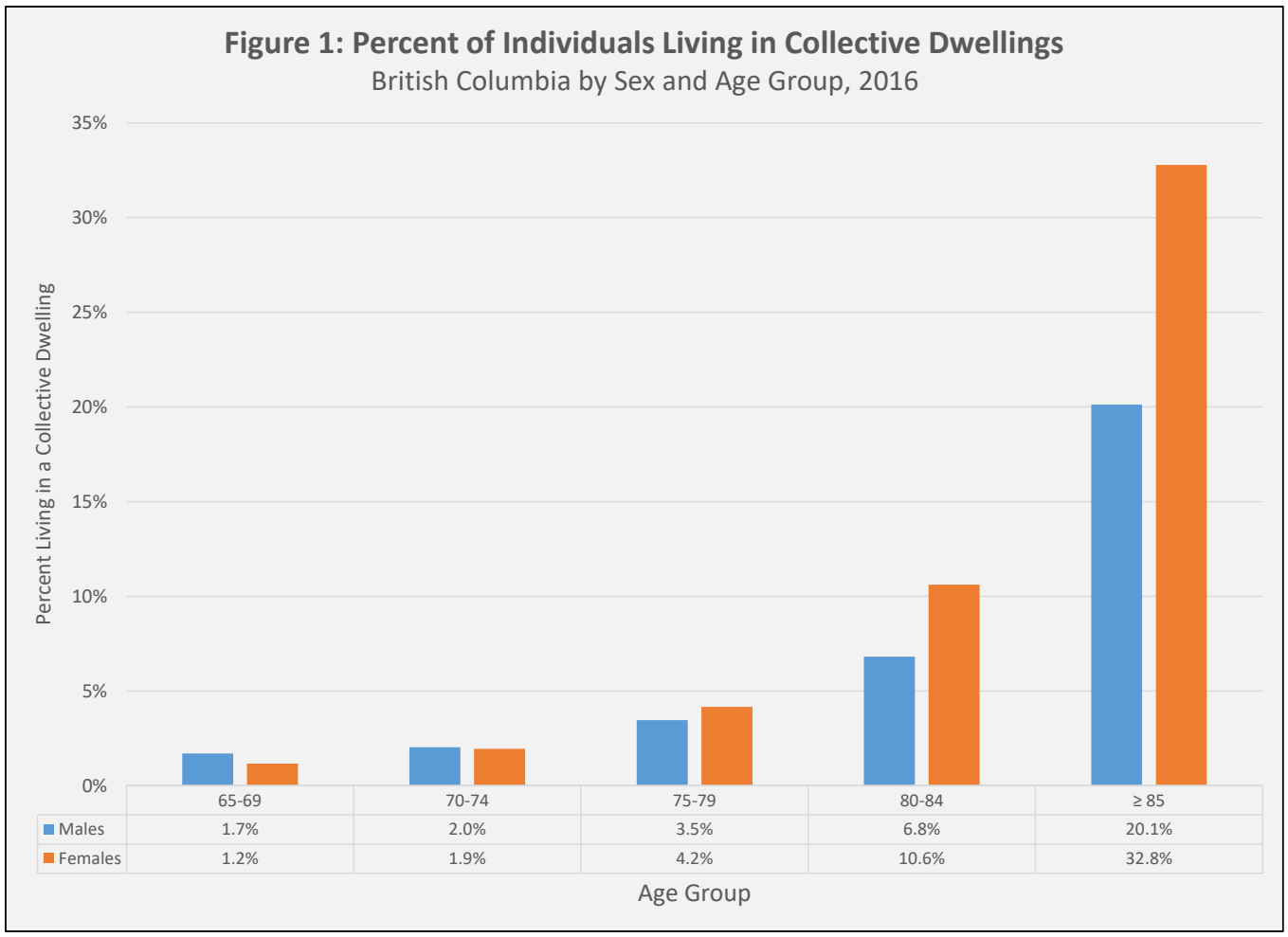
Community-Dwelling Females Ages ≥65

- The rate of fragility fractures varies significantly by place of residence at the time of the fracture and by the place of residence after the fracture. In Ontario in 2018/19 the hip fracture rate per 10,000 in females ages 66 and older was 33 for those remaining in the community (community to community), 254 for those living in long-term care (long-term care to long-term care) and 567 for those transferring from the community to long-term care (community to long-term care).[1063]
- In 2015/16, an estimated 45,646 BC seniors lived in residential care,[1064] or an estimated 5.38% of the population aged 65 or older (45,646 of 848,990[1065]).
- The Statistics Canada dwelling universe consists of collective and private dwellings.[1066] Collective dwellings are organized into 10 broad categories[1067]

[1060] Gates M, Pillay J, Theriault G et al. Screening to prevent fragility fractures among adults 40 years and older in primary care: Protocol for a systematic review. *BMC Systematic Reviews*. 2019; 8(216):
[1061] Ibid.
[1062] Ibid.
[1063] Jaglal S, MacKay C, Cameron C et al. *Ontario Osteoporosis Strategy - Provincial Performance Data for Osteoporosis Management: Technical Report*. March 17. 2023. Available online at https://osteostrategy.on.ca/wp-content/uploads/OOS-Provincial-Performance-Data-Technical-Report-Mar-17-23.pdf. Accessed January 2024.
[1064] Peterson S, Yung S, Beaumier J et al. *Residential Care and Administrative Data in British Columbia: Developing Methods to Identify Residents*. November 2020. UBC Centre for Health Services and Policy Research. Available online at https://www.popdata.bc.ca/sites/default/files/documents/data%20access/methodological/CHSPR-Residential-Care-2020.pdf. Accessed January 2024.
[1065] Statistics Canada. *British Columbia – Age distribution, 2001 to 2021*. Available online at https://www12.statcan.gc.ca/census-recensement/2021/as-sa/fogs-spg/alternative.cfm?topic=2&lang=E&dguid=2021A000259&objectId=1. Accessed January 2024.
[1066] Statistics Canada. *Structural Type of Dwelling and Collectives Reference Guide, Census of Population, 2016*. Available online at https://www12.statcan.gc.ca/census-recensement/2016/ref/guides/001/98-500-x2016001-eng.cfm. Accessed January 2024.
[1067] Collective dwellings are organized into the following 10 broad categories: hospital, nursing home and/or residence for senior citizens, residential care facility, shelter, correction or custodial facility, lodging or rooming house, religious establishment, Hutterite colony, establishment with temporary accommodation services and other establishment.

although the majority of individuals, especially seniors, in the collective dwellings category live in the nursing home and/or residence for senior citizens category.

- Figure 1 provides an overview of the proportion of males and females ages 65 and older living in collective dwellings in British Columbia in 2016.[1068]



[1068] Statistics Canada. *Dwelling Type (5), Age (20) and Sex (3) for the Population in Occupied Dwellings of Canada, Provinces and Territories, Census Metropolitan Areas and Census Agglomerations, 2016 Census*. Accessed January 2024.

- The CTFPHC recommends screening in community-dwelling females ages ≥ 65. Based on the information in Figure 1, we estimated the number of females ages ≥ 65 that would live in private (i.e. community) versus collective dwellings (see Table 1).

Table 1: Screening for Fragility Fractures
Place of Residence, Females Ages ≥65
In a BC Birth Cohort of 40,000

		Place of Residence			
		Private Dwellings		Collective Dwellings	
Age	# in Cohort	%	#	%	#
64	18,593				
65	18,489	99.1%	18,330	0.9%	159
66	18,375	99.0%	18,188	1.0%	186
67	18,250	98.8%	18,036	1.2%	213
68	18,113	98.7%	17,873	1.3%	240
69	17,963	98.5%	17,698	1.5%	265
70	17,799	98.4%	17,508	1.6%	290
71	17,619	98.2%	17,304	1.8%	315
72	17,421	98.1%	17,083	1.9%	338
73	17,204	97.6%	16,794	2.4%	410
74	16,966	97.2%	16,486	2.8%	480
75	16,704	96.7%	16,158	3.3%	547
76	16,417	96.3%	15,807	3.7%	610
77	16,102	95.8%	15,432	4.2%	670
78	15,757	94.5%	14,897	5.5%	859
79	15,378	93.3%	14,341	6.7%	1,037
80	14,963	92.0%	13,761	8.0%	1,202
81	14,510	90.7%	13,157	9.3%	1,353
82	14,016	89.4%	12,528	10.6%	1,488
83	13,478	85.0%	11,450	15.0%	2,028
84	12,895	80.5%	10,383	19.5%	2,512
85	12,264	76.1%	9,332	23.9%	2,933
86	11,585	71.7%	8,302	28.3%	3,284
87	10,859	67.2%	7,300	32.8%	3,559
88	10,086	64.1%	6,462	35.9%	3,625
89	9,271	60.6%	5,620	39.4%	3,651
90	8,417	57.0%	4,796	43.0%	3,621

Risk of Fragility Fractures

- The study by Hopkins and colleagues calculated the total number of patients with fractures in Canada between April 1, 2010 and March 31, 2011, by sex, age and type of fracture using data from the Canadian Institute for Health Information (CIHI).[1069] Individuals were identified as having a fracture if they reported a hospital admission, day surgery, emergency room visit, or hospital-based clinic visit with an International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Canada (ICD-10-CA) code for the various types of fractures. We compiled the relevant data for women ages 50-99 and calculated the incidence rate per 100,000 by age group (50-59, 60-69, 70-79, 80-89 and 90-99) and by fracture type (see Table 2).
- It is possible that up to two-thirds of *asymptomatic* vertebral fractures are not accounted for in this data, though they are clinically relevant.[1070]

Table 2: Fragilty Fractures in Females Ages 50 and Older
Incidence of Fractures by Type of Fracture and Age Group

	Age Group					
	50 - 59	60 - 69	70 - 79	80 - 89	90 - 99	Total
Female Population in 2011	2,472,362	1,760,036	1,085,293	681,159	153,566	6,152,416
Number of Fractures in Canada in 2011						
Hip	737	1,826	4,238	9,612	4,924	21,337
Vertebral	624	904	1,673	2,540	835	6,576
All Other						
Wrist	8,064	7,584	5,131	4,486	1,149	26,414
Humerus	1,314	1,844	2,015	2,423	727	8,323
Other	9,351	8,867	8,055	11,779	4,845	42,897
Multiple	918	1,271	1,835	2,769	1,369	8,162
Subtotal All Other	19,647	19,566	17,036	21,457	8,090	85,796
Total	**21,008**	**22,296**	**22,947**	**33,609**	**13,849**	**113,709**
Fracture Rate per 100,000 person years						
Hip	30	104	390	1,411	3,206	347
Vertebral	25	51	154	373	544	107
All Other						
Wrist	326	431	473	659	748	429
Humerus	53	105	186	356	473	135
Other	378	504	742	1,729	3,155	697
Multiple	37	72	169	407	891	133
Subtotal All Other	795	1,112	1,570	3,150	5,268	1,395
Total	**850**	**1,267**	**2,114**	**4,934**	**9,018**	**1,848**

[1069] Hopkins R, Burke N, Von Keyserlingk C et al. The current economic burden of illness of osteoporosis in Canada. *Osteoporosis International*. 2016; 27(10): 3023-32.
[1070] de Klerk G, Hegeman J, Bronkhorst P et al. The (a)-symptomatic vertebral fracture: A frequently discovered entity with clinical relevance in fracture patients screened on osteoporosis. Geriatric Orthopaedic Surgery & Rehabilitation. 2012; 3(2): 74-78.

- The rates in Table 2 were combined with the information in Table 1 to estimate the number of fragility fractures that would occur in community-dwelling females ages ≥ 65 in a BC birth cohort of 40,000 (20,000 females). In estimating the rates for each year, we assumed that the rate in Table 2 would occur at the mid-point of the age group (e.g. at age 65 in the 60-69 year age group) and would increase linearly between posted rates.

Number of Fragility Fractures in a BC Birth Cohort

- We would expect 9,822 fragility fractures to occur in a BC birth cohort of 20,000 females between the ages of 65 and 90, 2,272 hip fractures, 678 vertebral fractures, 1,829 wrist fractures, 758 humerus (upper arm) fractures, 783 fractures at multiple sites and 3,502 other fractures (see Table 3).

Table 3: Estimated Number of Fragility Fractures

Community-Dwelling Females Ages ≥65

In the Absence of Screening / Intervention

In a BC Birth Cohort of 40,000

			Hip		*Vertebral*		*Wrist*		*Humerus*		*Multiple*		*All Other*		***Total***	
Age	# in Cohort	# in Private Dwelling	Rate / 100,000	#	Rate / 100,000	#	Rate / 100,000	#	Rate / 100,000	#	Rate / 100,000	#	Rate / 100,000	#	Rate / 100,000	#
65	18,489	18,330	104	19	51	9	431	79	105	19	72	13	504	92	1,267	**232**
66	18,375	18,188	132	24	62	11	435	79	113	21	82	15	528	96	1,352	**246**
67	18,250	18,036	161	29	72	13	439	79	121	22	92	17	551	99	1,436	**259**
68	18,113	17,873	190	34	82	15	443	79	129	23	101	18	575	103	1,521	**272**
69	17,963	17,698	218	39	92	16	448	79	137	24	111	20	599	106	1,606	**284**
70	17,799	17,508	247	43	103	18	452	79	145	25	121	21	623	109	1,691	**296**
71	17,619	17,304	276	48	113	20	456	79	153	27	130	23	647	112	1,775	**307**
72	17,421	17,083	304	52	123	21	460	79	161	28	140	24	671	115	1,860	**318**
73	17,204	16,794	333	56	134	22	464	78	169	28	150	25	695	117	1,945	**327**
74	16,966	16,486	362	60	144	24	469	77	178	29	159	26	718	118	2,030	**335**
75	16,704	16,158	390	63	154	25	473	76	186	30	169	27	742	120	2,114	**342**
76	16,417	15,807	493	78	176	28	491	78	203	32	193	30	841	133	2,396	**379**
77	16,102	15,432	595	92	198	31	510	79	220	34	217	33	940	145	2,678	**413**
78	15,757	14,897	697	104	220	33	529	79	237	35	240	36	1,038	155	2,960	**441**
79	15,378	14,341	799	115	242	35	547	78	254	36	264	38	1,137	163	3,242	**465**
80	14,963	13,761	901	124	264	36	566	78	271	37	288	40	1,236	170	3,524	**485**
81	14,510	13,157	1,003	132	285	38	584	77	288	38	312	41	1,334	176	3,806	**501**
82	14,016	12,528	1,105	138	307	38	603	76	305	38	335	42	1,433	180	4,088	**512**
83	13,478	11,450	1,207	138	329	38	621	71	322	37	359	41	1,532	175	4,370	**500**
84	12,895	10,383	1,309	136	351	36	640	66	339	35	383	40	1,631	169	4,652	**483**
85	12,264	9,332	1,411	132	373	35	659	61	356	33	407	38	1,729	161	4,934	**460**
86	11,585	8,302	1,591	132	390	32	668	55	367	31	455	38	1,872	155	5,343	**444**
87	10,859	7,300	1,770	129	407	30	677	49	379	28	504	37	2,014	147	5,751	**420**
88	10,086	6,462	1,950	126	424	27	685	44	391	25	552	36	2,157	139	6,159	**398**
89	9,271	5,620	2,129	120	441	25	694	39	403	23	600	34	2,300	129	6,568	**369**
90	8,417	4,796	2,309	111	458	22	703	34	415	20	649	31	2,442	117	6,976	**335**
Total				**2,272**		**678**		**1,829**		**758**		**783**		**3,502**		**9,822**

- In their meta-analysis on morbidity associated with hip fractures, Haentjen and colleagues calculated a hazard ratio of 2.87 (95% CI 2.52 – 3.27) of death in the first year for females 50 and older with a hip fracture compared to those without.[1071] A hazard ratio of 1.00 suggests that the death rate in the group of interest is the same as that in the general population.
- When stratified by age group, the probability of dying in the first year following a hip fracture was 5 times as high (OR of 5.0; 95% CI of 2.6 to 9.5) in females <70 years of age, 2.4 times as high (OR of 2.4; 95% CI of 1.8 to 3.3) in females 70-79 years of age but did not increase (OR of 1.1; 95% CI of 0.6 to 2.1) in females ≥ 80 years of age. Excess mortality following a hip fracture may continue for up to 10 years in females <70 years of age (> 1 to < 5 years. OR of 1.9; 95% CI of 1.1 to 3.2 and > 5 to <10 years. OR of 3.2; 95% CI of 1.0 to 10.2).[1072]
- Tran and colleagues report that for women over 50 the hazard ratio (of excess mortality) of any fragility fracture is 1.51 (95% CI 1.31 – 1.75), 2.13 (95% CI 1.58 – 2.87) for hip fractures, 1.82 (95% CI 1.28 – 2.57) for vertebral fractures and 1.38 (95% CI 1.18 – 1.62) for non-hip, non-vertebral fractures.[1073]
- A study from Ontario calculated the risk of death in 101,773 individuals ≥ 66 years of age with an index fragility fracture sustained between January 1, 2011 and March 31, 2015 and compared this with matched controls.[1074] Compared to the 1-year absolute risk of death observed in the non-fracture cohort (5.4%), all index fracture types are associated with an increased risk of death with the exception of wrist fractures (see Table 4).

Table 4: Risk of Death Following an Incident Fracture
By Index Fracture Site

Index Fracture Type	# of Fractures	Mortality at 1-Year Post-Index Fracture #	%
Hip	26,963	6,625	24.6%
Vertebral	6,595	1,183	17.9%
Wrist	16,467	718	4.4%
Humerus	11,756	1,159	9.9%
Multiple	3,299	608	18.4%
Other	36,693	4,319	11.8%
Total	**101,773**	**14,612**	**14.4%**

[1071] Haentjens P, Magaziner J, Colón-Emeric C et al. Meta-analysis: excess mortality after hip fracture among older women and men. *Annals of Internal Medicine.* 2010; 152(6): 380-90.
[1072] LeBlanc E, Hillier T, Pedula K et al. Hip fracture and increased short-term but not long-term mortality in healthy older women. *JAMA Archives of Internal Medicine*. 2011; 171(20):1831-7.
[1073] Tran T, Bliuc D, van Geel T et al. Population-wide impact of non-hip non-vertebral fractures on mortality. *Journal of Bone and Mineral Research*. 2017; 32(9): 1802-10.
[1074] Brown J, Adachi J, Schemitsch E et al. Mortality in older adults following a fragility fracture: Real-world retrospective matched-cohort study in Ontario. *BMC Musculoskeletal Disorders*. 2021; 22(103:

- Based on the same study from Ontario, the higher risk of death increases with age and is maintained for at least three years after the index fracture.[1075] Table 5 summarizes these results for females.

Table 5: Risk of Death Following an Incident Frcature
In Females by Age Cohort and Time Since the Fracture

	Fracture Cohort			*Non-Fracture Cohort*			Absolute Risk Difference
	%	95% CI		%	95% CI		
			Within 1 Year				
66-70	3.5%	3.2%	3.8%	1.0%	0.8%	1.2%	2.5%
71-75	5.2%	4.8%	5.6%	1.7%	1.4%	1.9%	3.5%
76-80	7.8%	7.3%	8.3%	2.9%	2.7%	3.3%	4.9%
81-85	11.6%	11.1%	12.2%	4.8%	4.5%	5.2%	6.8%
86+	23.6%	22.9%	24.2%	10.0%	9.6%	10.4%	13.6%
Ages ≥66	**12.5%**	**12.2%**	**12.7%**	**5.1%**	**4.9%**	**5.2%**	**7.4%**
			Within 2 Years				
66-70	5.3%	4.9%	5.8%	2.1%	1.8%	2.3%	3.2%
71-75	8.3%	7.7%	8.8%	3.3%	3.0%	3.7%	5.0%
76-80	12.4%	11.8%	13.1%	5.9%	5.5%	6.4%	6.5%
81-85	18.5%	17.8%	19.2%	9.9%	9.4%	10.4%	8.6%
86+	34.9%	34.1%	35.6%	19.2%	18.7%	19.8%	15.7%
Ages ≥66	**19.0%**	**18.7%**	**19.3%**	**9.9%**	**9.7%**	**10.1%**	**9.1%**
			Within 3 Years				
66-70	7.3%	6.8%	7.8%	3.3%	3.0%	3.7%	4.0%
71-75	11.4%	10.8%	12.0%	5.1%	4.7%	5.5%	6.3%
76-80	17.7%	16.9%	18.4%	9.4%	8.9%	10.0%	8.3%
81-85	25.8%	25.0%	26.6%	15.3%	14.7%	15.9%	10.5%
86+	45.8%	44.9%	46.6%	27.7%	27.0%	28.4%	18.1%
Ages ≥66	**25.6%**	**25.2%**	**26.0%**	**14.8%**	**14.5%**	**15.0%**	**10.8%**

[1075] Brown J, Adachi J, Schemitsch E et al. Mortality in older adults following a fragility fracture: Real-world retrospective matched-cohort study in Ontario. *BMC Musculoskeletal Disorders*. 2021; 22(103:

- For modelling purposes, we calculated the excess risk of death attributable to each type of fragility fracture (see Table 4). For example, the 1-year absolute risk of death observed in the non-fracture Ontario cohort was 5.4% while the 1-year risk of death following a hip fracture was 24.6%. The excess risk of death attributable to the hip fracture would thus be 3.55 times that of the non-fracture cohort (24.6% - 5.4% = 19.2%; 19.2% / 5.4% = 3.55). The excess risk of death attributable to a vertebral, wrist, humerus, multiple and other fracture are 2.32/0.0/0.83/2.41/1.18, respectively. The excess risk of death attributable to each fracture type was then applied to the annual mortality % observed in the BC birth cohort of 20,000 females to estimate that 1,100 deaths are attributable to fragility fractures between the ages of 65 and 90 in the BC birth cohort (see Table 6).

Table 6: Screening for Fragility Fractures

Estimating the Number of Excess Deaths Attributable to Fragility Fractures

Females Ages ≥ 65 In a BC Birth Cohort of 40,000

			Deaths in Community-dwelling Elderly		**Number of Fragilty Fractures**							**Excess Deaths Attributable to Fragilty Fractures**						
Age	# in Cohort	# in Private Dwelling	#	%	Hip	Vertebral	Wrist	Humerus	Multiple	Other	**Total**	Hip	Vertebral	Wrist	Humerus	Multiple	Other	**Total**
65	18,489	18,330			19	9	79	19	13	92	**232**							
66	18,375	18,188	142	0.78%	24	11	79	21	15	96	**246**	0.5	0.2	0.0	0.1	0.2	0.8	**2**
67	18,250	18,036	152	0.84%	29	13	79	22	17	99	**259**	0.7	0.2	0.0	0.1	0.3	1.0	**2**
68	18,113	17,873	163	0.91%	34	15	79	23	18	103	**272**	0.9	0.3	0.0	0.2	0.4	1.1	**3**
69	17,963	17,698	176	0.99%	39	16	79	24	20	106	**284**	1.2	0.3	0.0	0.2	0.4	1.2	**3**
70	17,799	17,508	189	1.08%	43	18	79	25	21	109	**296**	1.5	0.4	0.0	0.2	0.5	1.4	**4**
71	17,619	17,304	204	1.18%	48	20	79	27	23	112	**307**	1.8	0.5	0.0	0.2	0.6	1.5	**5**
72	17,421	17,083	221	1.29%	52	21	79	28	24	115	**318**	2.2	0.6	0.0	0.3	0.7	1.7	**5**
73	17,204	16,794	289	1.72%	56	22	78	28	25	117	**327**	3.2	0.8	0.0	0.4	1.0	2.3	**8**
74	16,966	16,486	308	1.87%	60	24	77	29	26	118	**335**	3.7	1.0	0.0	0.4	1.1	2.6	**9**
75	16,704	16,158	328	2.03%	63	25	76	30	27	120	**342**	4.3	1.1	0.0	0.5	1.3	2.8	**10**
76	16,417	15,807	351	2.22%	78	28	78	32	30	133	**379**	5.0	1.3	0.0	0.5	1.5	3.1	**11**
77	16,102	15,432	375	2.43%	92	31	79	34	33	145	**413**	6.7	1.6	0.0	0.6	1.8	3.8	**15**
78	15,757	14,897	535	3.59%	104	33	79	35	36	155	**441**	11.7	2.5	0.0	1.0	2.9	6.1	**24**
79	15,378	14,341	557	3.88%	115	35	78	36	38	163	**465**	14.3	3.0	0.0	1.1	3.4	7.1	**29**
80	14,963	13,761	580	4.21%	124	36	78	37	40	170	**485**	17.1	3.4	0.0	1.3	3.8	8.1	**34**
81	14,510	13,157	604	4.59%	132	38	77	38	41	176	**501**	20.2	3.9	0.0	1.4	4.4	9.2	**39**
82	14,016	12,528	629	5.02%	138	38	76	38	42	180	**512**	23.5	4.4	0.0	1.6	5.0	10.4	**45**
83	13,478	11,450	1,078	9.42%	138	38	71	37	41	175	**500**	46.3	8.4	0.0	3.0	9.5	19.9	**87**
84	12,895	10,383	1,067	10.28%	136	36	66	35	40	169	**483**	50.4	9.0	0.0	3.1	10.2	21.3	**94**
85	12,264	9,332	1,051	11.27%	132	35	61	33	38	161	**460**	54.4	9.5	0.0	3.3	10.8	22.5	**100**
86	11,585	8,302	1,030	12.41%	132	32	55	31	38	155	**444**	58.0	10.0	0.0	3.4	11.4	23.6	**106**
87	10,859	7,300	1,002	13.72%	129	30	49	28	37	147	**420**	64.3	10.3	0.0	3.5	12.5	25.2	**116**
88	10,086	6,462	838	12.97%	126	27	44	25	36	139	**398**	59.5	8.9	0.0	3.0	11.5	22.5	**105**
89	9,271	5,620	842	14.97%	120	25	39	23	34	129	**369**	67.0	9.5	0.0	3.1	12.9	24.6	**117**
90	8,417	4,796	824	17.18%	111	22	34	20	31	117	**335**	73.0	9.9	0.0	3.2	14.0	26.2	**126**
			13,534		**2,272**	**678**	**1,829**	**758**	**783**	**3,502**	**9,822**	**591**	**101**	**0**	**36**	**122**	**250**	**1,100**

- Based on the average life expectancy of females at the time of their death, an estimated 8.3 years of life would be lost per death due to a fragility fracture for a total of 9,143 life years lost attributable to fragility fractures in the BC birth cohort (see Table 7).

Table 7: Screening for Fragility Fractures

Estimating the Life Years Lost Attributable to Fragility Fractures

Females Ages ≥ 65 In a BC Birth Cohort of 40,000

				Deaths								Life Years Lost						
Age	# in Cohort	# in Private Dwelling	In Cohort	Hip	Vertebral	Wrist	Humerus	Multiple	Other	**Total**	**LE**	Hip	Vertebral	Wrist	Humerus	Multiple	Other	**Total**
65	18,489	18,330																
66	18,375	18,188	142	0.5	0.2	0	0.1	0.2	0.8	**1.9**	22.0	12	4	0	3	5	19	**42**
67	18,250	18,036	152	0.7	0.2	0	0.1	0.3	1.0	**2.3**	21.2	15	5	0	3	6	20	**50**
68	18,113	17,873	163	0.9	0.3	0	0.2	0.4	1.1	**2.8**	20.3	19	6	0	3	7	22	**57**
69	17,963	17,698	176	1.2	0.3	0	0.2	0.4	1.2	**3.4**	19.5	23	7	0	4	8	23	**65**
70	17,799	17,508	189	1.5	0.4	0	0.2	0.5	1.4	**4.0**	18.7	28	8	0	4	10	25	**74**
71	17,619	17,304	204	1.8	0.5	0	0.2	0.6	1.5	**4.7**	17.9	32	9	0	4	11	27	**84**
72	17,421	17,083	221	2.2	0.6	0	0.3	0.7	1.7	**5.5**	17.1	37	10	0	5	12	29	**93**
73	17,204	16,794	289	3.2	0.8	0	0.4	1.0	2.3	**7.7**	16.3	52	14	0	6	16	38	**126**
74	16,966	16,486	308	3.7	1.0	0	0.4	1.1	2.6	**8.8**	15.5	57	15	0	7	18	40	**137**
75	16,704	16,158	328	4.3	1.1	0	0.5	1.3	2.8	**10**	14.7	63	16	0	7	19	42	**148**
76	16,417	15,807	351	5.0	1.3	0	0.5	1.5	3.1	**11**	14.0	69	18	0	8	20	44	**159**
77	16,102	15,432	375	6.7	1.6	0	0.6	1.8	3.8	**15**	13.2	89	21	0	9	24	50	**192**
78	15,757	14,897	535	12	2.5	0	1.0	2.9	6.1	**24**	12.5	146	32	0	13	36	77	**304**
79	15,378	14,341	557	14	3.0	0	1.1	3.4	7.1	**29**	11.8	169	35	0	13	40	84	**340**
80	14,963	13,761	580	17	3.4	0	1.3	3.8	8.1	**34**	11.1	191	38	0	14	43	90	**376**
81	14,510	13,157	604	20	3.9	0	1.4	4.4	9.2	**39**	10.5	211	40	0	15	46	96	**409**
82	14,016	12,528	629	24	4.4	0	1.6	5.0	10	**45**	9.8	231	43	0	15	49	102	**440**
83	13,478	11,450	1,078	46	8.4	0	3.0	10	20	**87**	9.2	425	77	0	27	88	183	**800**
84	12,895	10,383	1,067	50	9.0	0	3.1	10	21	**94**	8.6	432	77	0	27	87	182	**806**
85	12,264	9,332	1,051	54	10	0	3.3	11	23	**100**	8.0	434	76	0	26	86	180	**803**
86	11,585	8,302	1,030	58	10	0	3.4	11	24	**106**	7.4	431	74	0	25	84	175	**791**
87	10,859	7,300	1,002	64	10	0	3.5	13	25	**116**	6.9	443	71	0	24	86	173	**798**
88	10,086	6,462	838	60	9	0	3.0	12	23	**105**	6.4	380	57	0	19	73	144	**673**
89	9,271	5,620	842	67	10	0	3.1	13	25	**117**	5.9	395	56	0	18	76	145	**691**
90	8,417	4,796	824	73	10	0	3.2	14	26	**126**	5.4	397	54	0	17	76	142	**687**
			13,534	**591**	**101**	**0**	**36**	**122**	**250**	**1,100**	**8.3**	**4,783**	**862**	**0**	**317**	**1,027**	**2,154**	**9,143**

LE = life expectancy

Quality of Life Associated with Fragility Fractures

- "Years of life lost can be directly quantified by measuring the difference between the individual's age at death as a consequence of the fracture, and the mean age of death for their country, adjusted for sex. However, it is more difficult and less objective to quantify the pain, disturbance of physical function, decreased mobility and social interaction commonly associated with fractures, yet these make an important contribution to the morbidity and costs of fractures to both individuals and society."[1076]
- Based on a systematic review and meta-analysis, Si and co-authors found a 22.4% decrement in QoL in the first year following a hip fracture, declining to 13.2% in

[1076] Abimanyi-Ochom J, Watts J, Borgstrom F et al. Changes in quality of life associated with fragility fractures: Australian arm of the International Cost and Utility Related to Osteoporotic Fractures Study (AusICUROS). *Osteoporosis International*. 2015; 26: 1781-90.

subsequent years. A 27.6% decrement in QoL was observed in the first year following a vertebral fracture, also declining to 13.2% in subsequent years.[1077]

- Based on an Australian study, hip/wrist/vertebral/humerus/ankle/'other' fractures are associated with a 26/11/20/17/24/21%, respectively, decrement in QoL in the 12 months following the fracture. At 18 months post-fracture, individuals with wrist, humerus, ankle and 'other' fracture had returned to a pre-fracture QoL but the QoL in individuals with a hip or vertebral fractures fracture remained 13% and 11% lower than pre-fracture levels.[1078]
- Based on data from 11 countries, Svedbom et al calculated a 34% reduction in QoL in the first year following a hip fracture. They estimated a QoL decrement of 12% in year 2 and an 11% decrement in subsequent years. For vertebral fractures, they calculated a 27% reduction in year 1, 13% reduction in year 2 and a 13% reduction in subsequent years.[1079]
- Research from Ontario provides an assessment of QoL in the **three years** following a fragility fracture. At one-month post-fracture the QoL was reduced by 30-41% with the QoL decrement remaining at between 21-28% at 36 months post-fracture (see Table 8).[1080] This study included community-dwelling elderly as well as elderly in long-term care.

Table 8: QoL Decrement Following a Fragility Fracture
By Frcature Type and Months Since the Incident Fracture

Fracture Type	Number of Months Since the Fracture						
	1	3	6	12	18	24	36
Hip	39%	29%	28%	25%	25%	26%	28%
Vertebral	31%	22%	19%	18%	21%	24%	23%
Wrist	30%	15%	16%	18%	21%	22%	21%
Humerus	37%	21%	20%	20%	19%	21%	22%
Multiple	41%	25%	21%	21%	21%	24%	28%
Other	31%	19%	18%	18%	19%	20%	22%

- Research in Canada suggests that there is a statistically significant deficit in QoL in community-dwelling females ages 50+ **five years** after a fracture of the hip (18.2%, 95% CI of 10.9% to 26.7%), vertebra (7.3%, 95% CI of 1.2% to 13.4%) or rib (6.1%, 95% CI of 1.2% to 12.2%) but not after a fracture of the pelvis, forearm or 'other' fracture.[1081]
- At **ten years** of follow-up in this Canadian cohort, a fracture of the hip (19.4%, 95% CI of 12.2% to 26.7%), vertebra (8.5%, 95% CI of 2.4% to 14.6%) or rib (9.7%, 95%

[1077] Si L, Winzenberg T, de Graaff B et al. A systematic review and meta-analysis of utility-based quality of life for osteoporosis-related conditions. *Osteoporosis International*. 2014; 25: 1987-97.
[1078] Abimanyi-Ochom J, Watts J, Borgstrom F et al. Changes in quality of life associated with fragility fractures: Australian arm of the International Cost and Utility Related to Osteoporotic Fractures Study (AusICUROS). *Osteoporosis International*. 2015; 26: 1781-90.
[1079] Svedbom A, Borgstom F, Hernlund E et al. Quality of life for up to 18 months after low-energy hip, vertebral and distal forearm fractures – results from the ICUROS. *Osteoporosis International*. 2018; 29(3): 557-66.
[1080] Tarride J, Burke N, Leslie W et al. Loss of health related quality of life following low-trauma fractures in the elderly. *BMC Geriatrics*. 2016; 16(84).
[1081] Papaioannou A, Kennedy C, Ioannidis G et al. The impact of incident fractures on health-related quality of life: 5 years of data from the Canadian Multicentre Osteoporosis Study. *Osteoporosis International*. 2009; 20: 703-14.

CI of 3.6% to 14.6%) continued to be associated with a statistically significant reduction in QoL.[1082]

- For modelling purposes, we assumed the decrement in QoL by fracture type and time since the fracture as indicated in Table 9, based primarily on research from Australia[1083] and Canada.[1084,1085]

Table 9: QoL Decrement Following a Fragility Fracture
By Fracture Type and Years Since the Incident Fracture

Fracture Type	Number of Years Since the Fracture				
	1	2	3	4	≥ 5
Hip	26.0%	19.4%	19.4%	19.4%	19.4%
Vertebral	20.0%	11.0%	10.0%	9.0%	8.5%
Wrist	11.0%				
Humerus	17.0%				
Multiple	21.0%				
Other	21.0%				

[1082] Borhan S, Papaioannou A, Gaji-Veljanoski O et al. Incident fragility fractures have a long-term negative impact on health-related quality of life of older people: The Canadian Multicentre Osteoporosis Study. *Journal of Bone and Mineral Health.* 2019; 34(5): 838-48.
[1083] Abimanyi-Ochom J, Watts J, Borgstrom F et al. Changes in quality of life associated with fragility fractures: Australian arm of the International Cost and Utility Related to Osteoporotic Fractures Study (AusICUROS). *Osteoporosis International*. 2015; 26: 1781-90.
[1084] Papaioannou A, Kennedy C, Ioannidis G et al. The impact of incident fractures on health-related quality of life: 5 years of data from the Canadian Multicentre Osteoporosis Study. *Osteoporosis International*. 2009; 20: 703-14.
[1085] Borhan S, Papaioannou A, Gaji-Veljanoski O et al. Incident fragility fractures have a long-term negative impact on health-related quality of life of older people: The Canadian Multicentre Osteoporosis Study. *Journal of Bone and Mineral Health.* 2019; 34(5): 838-48.

- Applying the QoL decrement in Table 9 to fragility fracture survivors in the BC birth cohort results in 5,863 QALYs lost, with the majority (4,009 or 68%) of these QALYs lost in survivors of hip fractures (see Table 10).

Table 10: Screening for Fragility Fractures

Quality Adjusted Life Years Lost for Individuals Living with Fracture

Females Ages ≥ 65 In a BC Birth Cohort of 40,000

	Number Living with Fractures								*Quality Adjusted Life Years Lost Due to Fragility Fractures*						
Age	Hip	Vertebral	Wrist	Humerus	Multiple	Other	**Total**	**LE**	Hip	Vertebral	Wrist	Humerus	Multiple	Other	**Total**
65	19	9	79	19	13	92	**232**	23	86	20	9	3	3	19	**140**
66	24	11	79	20	15	95	**244**	22	102	22	9	3	3	20	**160**
67	28	13	79	22	16	99	**257**	21	118	25	9	4	3	21	**180**
68	33	14	79	23	18	102	**269**	20	132	27	9	4	4	21	**197**
69	37	16	79	24	19	105	**281**	20	144	29	9	4	4	22	**212**
70	42	18	79	25	21	108	**292**	19	154	31	9	4	4	23	**225**
71	46	19	79	26	22	110	**303**	18	162	32	9	4	5	23	**235**
72	50	20	79	27	23	113	**312**	17	168	33	9	5	5	24	**243**
73	53	22	78	28	24	114	**319**	16	170	33	9	5	5	24	**246**
74	56	23	77	29	25	116	**326**	15	172	34	8	5	5	24	**248**
75	59	24	76	30	26	117	**332**	15	172	34	8	5	5	25	**249**
76	73	27	78	31	29	130	**367**	14	202	36	9	5	6	27	**285**
77	85	29	79	33	32	141	**399**	13	224	37	9	6	7	30	**312**
78	92	30	79	34	33	149	**417**	13	230	37	9	6	7	31	**319**
79	100	32	78	35	35	156	**436**	12	236	37	9	6	7	33	**328**
80	107	33	78	36	36	162	**451**	11	238	36	9	6	8	34	**330**
81	112	34	77	36	37	166	**462**	10	234	35	8	6	8	35	**327**
82	115	34	76	37	37	169	**467**	10	226	34	8	6	8	36	**318**
83	92	29	71	34	32	155	**413**	9	170	28	8	6	7	33	**250**
84	85	27	66	32	30	148	**389**	9	148	24	7	5	6	31	**222**
85	77	25	61	30	27	139	**360**	8	125	21	7	5	6	29	**193**
86	74	22	55	27	26	132	**337**	7	112	18	6	5	6	28	**173**
87	65	19	49	24	24	122	**304**	7	91	14	5	4	5	26	**146**
88	66	18	44	22	24	117	**293**	6	87	13	5	4	5	25	**138**
89	53	15	39	20	21	105	**252**	6	64	10	4	3	4	22	**108**
90	38	12	34	17	17	91	**208**	5	42	8	4	3	4	19	**79**
Total	**1,681**	**577**	**1,829**	**722**	**661**	**3,252**	**8,721**		**4,009**	**708**	**201**	**123**	**139**	**683**	**5,863**

LE = Life Expectancy

The Intervention

Fracture Risk Assessment Tool (FRAX)

- The CTFPHC recommends a two-step assessment process, with the initial application of the Canadian clinical Fracture Risk Assessment Tool (FRAX) without bone mineral density (BMD) measurement. The FRAX result should be used to facilitate shared decision-making about the possible benefits and harms of preventive pharmacotherapy. The CTFPHC recommends this screening once every eight years.[1086]
- Based on a convenience survey of 79 family physicians, the CTFPHC has estimated that calculating FRAX, informing the patient of her risk, engaging in shared decision-making to inform if she would consider preventive medication and wants a BMD to help her decide would take 6.9 minutes.[1087,1088]
- The CTFPHC estimated that 30.1% of females aged 65-69 years, 36.2% of females aged 70-74 years, 41.4% of females aged 75-79 years and 45.6% of females aged 80-84 years would be at a high risk of a fracture and would receive a BMD measurement.[1089]
- A high risk of fracture is indicated by a 10-year probability of a major osteoporosis related fracture of ≥ 20% as calculated with the FRAX.[1090]

Bone Mineral Density Measurement

- After the assessment with FRAX followed by a discussion with the patient, if preventive pharmacotherapy is being considered, clinicians should request BMD measurement using dual-energy x-ray absorptiometry (DXA) of the femoral neck, and re-estimate fracture risk by adding the BMD T-score into FRAX.
- The CTFPHC estimated that ordering a BMD after risk calculation with FRAX would take 2.2 minutes and that a discussion post-BMD to decide on whether or not to prescribe preventive medication would take 8.2 minutes.[1091,1092]

Harms of Screening

- The CTFPHC notes that screening may lead to unintended consequences, including labelling and stigma.[1093]

[1086] Theriault G, Limburg H, Klarenbach S et al. Recommendation on screening for primary prevention of fragility fractures. *CMAJ*. 2023; 195: E639-49
[1087] Grad R, Reynolds D, Antao V et al. Screening for primary prevention of fragility fractures: How much time does it take? *Canadian Family Physician*. 2023; 69: 537-41.
[1088] CTFPHC. How was this calculation made? Available online at https://canadiantaskforce.ca/how-was-this-calculation-made/. Accessed January 2024.
[1089] CTFPHC. How was this calculation made? Available online at https://canadiantaskforce.ca/how-was-this-calculation-made/. Accessed January 2024.
[1090] Gates M, Pillay J, Nuspl M et al. Screening for the primary prevention of fragility fractures among adults aged 40 years and older in primary care: Systematic reviews of the effects and acceptability of screening and treatment, and the accuracy of risk prediction tools. *BMC Systematic Reviews*. 2023; 12(51):
[1091] Grad R, Reynolds D, Antao V et al. Screening for primary prevention of fragility fractures: How much time does it take? *Canadian Family Physician*. 2023; 69: 537-41.
[1092] CTFPHC. How was this calculation made? Available online at https://canadiantaskforce.ca/how-was-this-calculation-made/. Accessed January 2024.
[1093] Theriault G, Limburg H, Klarenbach S et al. Recommendation on screening for primary prevention of fragility fractures. *CMAJ*. 2023; 195: E639-49

- The research evidence supporting this appears to be largely based on qualitative interview studies involving 10-17 elderly females.
- Some of these studies suggest that a diagnosis of osteoporosis may be associated with uncertainty, worry and restricted physical activities.[1094,1095,1096]
- Others, however, suggest that the interviewees were "resilient and optimistic individuals…that carried out a number of positive coping strategies to manage health-related anxiety."[1097]
- A study of 15 women by Hansen et al found that "women handle (a diagnosis of) osteoporosis in different ways. This is very much influenced by positive or negative experiences of the diagnosis process and seems to affect the acceptance of the diagnosis and living with osteoporosis in general."[1098] These same 15 women were followed for a period of a year and the researchers found that "'moving on' with a chronic illness or a condition is a complex process of learning, finding meaning and the redefining of self - a unique journey for each person depending upon their particular situation and context."[1099]
- A 2016 systematic review of this qualitative literature included 34 international studies exploring the experiences of 773 participants (89% female). The authors concluded that their "review demonstrates contrasting feeling; on the one hand, osteoporosis is invisible and fragility fractures do not accord with the lived experience of symptoms that they could observe or feel; conversely, others interpreted the diagnosis as inhabiting a body that could be easily damaged with little or no provocation. The process can be accompanied by overwhelming uncertainty. We see how patients might not fully understand tests, risk or how to decide what action to take. This overwhelming uncertainty is underpinned by a person's relationship with their healthcare provider."[1100]

Pharmacotherapy

- Uptake of pharmacotherapy in individuals at high risk of a fragility fracture is less than ideal. The proportion of patients who receive an osteoporosis medication prescription following their diagnosis (or following a fragility fracture), ranges from

[1094] Hvas L, Reventlow S, Jensen H et al. Awareness of risk of osteoporosis may cause uncertainty and worry in menopausal women. *Scandinavian Journal of Public Health*. 2005; 33: 203-7.
[1095] Reventlow S, Hvas L, Malterud K. Making the invisible body visible. Bone scans, osteoporosis and women's bodily experiences. *Social Science & Medicine*. 2006; 62(11): 2720-31.
[1096] Reventlow S. Perceived risk of osteoporosis: restricted physical activities? Qualitative interview study with women in their sixties. *Scandinavian Journal of Primary Health Care*. 2007; 25: 160-5.
[1097] Weston J, Norris E, Clark E. The invisible disease: Making sense of an osteoporosis diagnosis in older age. *Qualitative Health Research*. 2011; 21(12): 1692-1704.
[1098] Hansen C, Konradsen H, Abrahamsen B et al. Women's experiences of their osteoporosis diagnosis at the time of diagnosis and 6 months later: A phenomenological hermeneutic study. *International Journal of Qualitative Studies in Health and Well-Being*. 2014; 9: 22438.
[1099] Hansen C, Abrahamsen B, Konradsen H et al. Women's lived experiences of learning to live with osteoporosis: A longitudinal qualitative study. *BMC Women's Health*. 2017; 17(17).
[1100] Barker K, Toye F, Lowe C. A qualitative systematic review of patient's experience of osteoporosis using meta-ethnography. *Archives of Osteoporosis.* 2016; 11: 33.

27% – 66%.[1101,1102,1103] The study suggesting 66%[1104] is by far the largest (n=27,736 versus 85 and 117 in the other two studies) so for modelling purposes we assumed that 66% of individuals at high risk of a fragility fracture would initiate pharmacotherapy.

- Bisphosphonates have been shown effective in building back bone mineral density and were the most frequently studied medication referenced by the USPSTF[1105] and the CTFPHC.[1106]
- The 2018 review for the USPSTF found that bisphosphonates significantly reduce vertebral fractures (RR of 0.57, 95% CI, 0.41-0.78) and nonvertebral fractures (RR of 0.84, 95% CI, 0.76-0.92) but not hip fractures (RR of 0.70, 95% CI, 0.44-1.11).[1107]
- The 2023 review for the CTFPHC found that a median of two years of treatment with bisphosphonates (alendronate, risedronate, zoledronic acid) in females ≥65 years of age results in the following absolute risk reduction (ARD):[1108]
    - Hip fractures - ARD of 5.3 fewer in 1,000 (95% CI of 8.3 to 1.6 fewer). The average risk for this population was estimated to be 20 / 1,000.
    - Clinical vertebral fractures - ARD of 12.8 fewer in 1,000 (95% CI of 17.9 to 5.0 fewer). The average risk for this population was estimated to be 27 / 1,000.
    - All clinical fragility fractures - ARD of 33.6 fewer in 1,000 (95% CI of 46.0 to 19.8 fewer). The average risk for this population was estimated to be 202 / 1,000.
    - No change in the risk of all-cause mortality
- The *Clinical Practice Guidelines for Management of Osteoporosis and Fracture Prevention in Canada: 2023 Update* recommends that "for females who meet criteria for initiation of pharmacotherapy, we recommend bisphosphonates (alendronate, risedronate or zoledronic acid). Strong recommendation; high-certainty evidence."[1109]
- The *Clinical Practice Guidelines for Management of Osteoporosis and Fracture Prevention in Canada: 2023 Update* also recommends that "for people on bisphosphonates, we suggest initial therapy for a duration of 3-6 years. Six years of

[1101] Billington E, Feasel A, Kline G. At odds about the odds: Women's choices to accept osteoporosis medications do not closely agree with physician-set treatment thresholds. *Journal of General Internal Medicine*. 2019; 35(1): 276-82.
[1102] Yu J, Brenneman S, Sazonov V et al. Reasons for not initiating osteoporosis therapy among a managed care population. *Patient Preference and Adherence*. 2015; 9: 821-30.
[1103] Keshishian A, Boystov N, Burge R et al. Examining the effect of medication adherence on risk of subsequent fracture among women with a fragility fracture in the U.S. Medicare Population. *Journal of Managed Care & Specialty Pharmacy*. 2017; 23(11): 1178-90.
[1104] Ibid.
[1105] Curry SJ, Krist AH, Owens DK et al. Screening for osteoporosis to prevent fractures: US Preventive Services Task Force recommendation statement. *Journal of the American Medical Association.* 2018; 319(24): 2521-31.
[1106] Gates M, Pillay J, Nuspl M et al. Screening for the primary prevention of fragility fractures among adults aged 40 years and older in primary care: Systematic reviews of the effects and acceptability of screening and treatment, and the accuracy of risk prediction tools. *BMC Systematic Reviews*. 2023; 12(51):
[1107] Curry SJ, Krist AH, Owens DK et al. Screening for osteoporosis to prevent fractures: US Preventive Services Task Force recommendation statement. *Journal of the American Medical Association.* 2018; 319(24): 2521-31.
[1108] Gates M, Pillay J, Nuspl M et al. Screening for the primary prevention of fragility fractures among adults aged 40 years and older in primary care: Systematic reviews of the effects and acceptability of screening and treatment, and the accuracy of risk prediction tools. *BMC Systematic Reviews*. 2023; 12(51):
[1109] Morin S, Feldman S, Funnell L et al. Clinical practice guidelines for management of osteoporosis and fracture prevention in Canada: 2023 update. *CMAJ*. 2023; 195(39): E1333-48.

therapy is appropriate for individuals with a history of hip, vertebral or multiple nonvertebral fractures, or new or ongoing risk factor(s) for accelerated bone loss or fracture. Conditional recommendation; low-certainty evidence."[1110]

- Recommended dosages for alendronate are 70 mg weekly or 10 mg daily (oral), risedronate 35 mg weekly or 150 mg monthly or 5 mg daily (oral), zoledronic acid 5 mg annually (intravenous).[1111]
- In Ontario, the weekly dose of alendronate and risedronate are the most commonly prescribed bisphosphonates, with 71% of new patients starting on alendronate in 2015 and 28% starting on risedronate.[1112,1113]

Compliance with Pharmacotherapy

- Outside of a clinical trial (i.e. in the real world), persistence / adherence / compliance with pharmacotherapy may be substantially lower than that achieved in clinical trials. Persistence can be defined as "the accumulation of time from initiation to discontinuation of therapy", while adherence / compliance can be defined as "the extent to which a patient acts in accordance with the prescribed interval and dose as well as dosing regimen." [1114]
- Persistence and compliance with bisphosphonate pharmacotherapy over the long-term is critical in achieving a reduced risk of fracture.[1115]
- Studies have shown that up to 50% of patients discontinue oral bisphosphonates during the first year of treatment,[1116] and approximately 30–50% of patients do not take their medication as directed.[1117]
- Research in Canada suggests that approximately 20-40% of patients discontinue bisphosphonate pharmacotherapy within one year and 30-50% within two years.[1118,1119,1120,1121]
- Compliance is often measured by calculating the medication possession ratio (MPR) or the proportion of days covered (PDC). MPR is calculated based on the number of

[1110] Morin S, Feldman S, Funnell L et al. Clinical practice guidelines for management of osteoporosis and fracture prevention in Canada: 2023 update. *CMAJ*. 2023; 195(39): E1333-48.
[1111] Morin S, Feldman S, Funnell L et al. Clinical practice guidelines for management of osteoporosis and fracture prevention in Canada: 2023 update. *CMAJ*. 2023; 195(39): E1333-48.
[1112] Cadarette S, Carney G, Baek D et al. Osteoporosis medication prescribing in British Columbia and Ontario: Impact of public drug coverage. *Osteoporosis International*. 2012; 28: 1475-80.
[1113] Hayes K, Ban J, Athanasiadis G et al. Time trends in oral bisphosphonate initiation in Ontario, Canada over 20 years reflect drug policy and healthcare delivery changes. *Osteoporosis International*. 2019; 30: 2311-19.
[1114] Fatoye F, Smith P, Gebrye T et al. Real-world persistence and adherence with oral bisphosphonates for osteoporosis: A systematic review. *BMJ Open*. 2019; 9: e027049.
[1115] Fatoye F, Smith P, Gebrye T et al. Real-world persistence and adherence with oral bisphosphonates for osteoporosis: A systematic review. *BMJ Open*. 2019; 9: e027049.
[1116] Cramer J, Gold D, Silverman S et al. A systematic review of persistence and compliance with bisphosphonates for osteoporosis. *Osteoporosis International*. 2007; 18: 1023-31.
[1117] Cramer J, Amonkar M, Hebborn A et al. Compliance and persistence with bisphosphonate dosing regimens among women with postmenopausal osteoporosis. *Current Medical Research and Opinion*. 2005; 21(9): 1453-60.
[1118] Papaioannou A, Ioannidis G, Adachi J et al. Adherence to bisphosphonates and hormone replacement therapy in a tertiary care setting of patients in the CANDOO database. *Osteoporosis International*. 2003; 14: 808–13.
[1119] Jones T, Petrella R, Crilly R. 'Determinants of persistence with weekly bisphosphonates in patients with osteoporosis.' *The Journal of Rheumatology*. 2008; 35: 1865-73.
[1120] Burden A, Paterson J, Solomon D, et al. Bisphosphonate prescribing, persistence and cumulative exposure in Ontario, Canada. *Osteoporosis International*. 2012; 23: 1075-82.
[1121] Burden A, Paterson J, Gruneir A et al. Adherence to osteoporosis pharmacotherapy is underestimated using days supply values in electronic pharmacy claims data. *Pharmacoepidemiology and Drug Safety*. 2015; 24: 67-74.

days' supply of medication divided by the length of the follow-up period. An MPR or PDC of >80% is usually considered to be a sufficiently high compliance rate to realize the drug's benefits. Research in Canada suggests that between 54-58% of patients are considered to be compliant with oral bisphosphonate pharmacotherapy (e.g. alendronate, risedronate).[1122,1123,1124]

- In a study of 19,987 (mostly [97%]) females ages 65 and older), Patrick et al. calculated that 36.5% of the study cohort took their medication between 80% and 100% of the time during the 300-day medication study compliance period.[1125] A further 31.8% of the cohort were in the 0-19% compliance group, 11.3% were in the 20-39% compliance group, 8.8% were in the 40-59% compliance group and 11.5% in the 60-79% compliance group.
- It was in the high compliance group (80-100%) that Patrick et al. found a statistically significant 5-year reduction of 23% (95% CI of 8% to 36%) in hip fractures, 26% (95% CI of 12% to 38%) reduction in vertebral fractures and a 20% (95% CI of 9% to 29%) reduction in other non-hip fractures when compared to the group with poor or no compliance. The only other compliance group that saw a significant reduction in hip fractures was the 60-79% group (24%, 95% CI of 1% to 42%).[1126]
- A systematic review found that persistence with alendronate and risedronate weekly treatment was comparable but that annual intravenous treatment with zoledronic acid improved persistence by 27% (HR = 0.73; 95% CI of 0.61 to 0.88).[1127]

Harms of Pharmacotherapy

- The 2023 review for the CTFPHC found that the risk of serious adverse events (e.g. gastrointestinal adverse events such as cancers, perforations, ulcers and bleeds and cardiovascular adverse events such as stoke and myocardial infarction) are not increased with the use of bisphosphonates. Furthermore, the risk of non-serious adverse events (e.g. multiple influenza-like symptoms, arthritis and arthralgia and myalgia) are not increased with the use of bisphosphonates with the possible exception of zoledronic acid.[1128]

Monitoring

- The *Clinical Practice Guidelines for Management of Osteoporosis and Fracture Prevention in Canada: 2023 Update* suggests that good practice includes "regular

[1122] Blouin J, Dragomir A, Fredette M et al. Comparison of direct health care costs related to the pharmacological treatment of osteoporosis and to the management of osteoporotic fractures among compliant and noncompliant users of alendronate and risedronate: A population-based study. *Osteoporosis International*. 2009; 20: 1571-81.
[1123] Sampalis J, Adachi J, Rampakakis E et al. Long-term impact of adherence to oral bisphosphonates on osteoporotic fracture incidence. *Journal of Bone and Mineral Research*. 2012; 27: 202-10.
[1124] Burden A, Paterson J, Gruneir A et al. Adherence to osteoporosis pharmacotherapy is underestimated using days supply values in electronic pharmacy claims data. *Pharmacoepidemiology and Drug Safety*. 2015; 24: 67-74.
[1125] Patrick A, Brookhart M, Losina E et al. The complex relation between bisphosphonate adherence and fracture reduction. *The Journal of Clinical Endocrinology & Metabolism*. 2010; 95(7): 3251-9.
[1126] Patrick A, Brookhart M, Losina E et al. The complex relation between bisphosphonate adherence and fracture reduction. *The Journal of Clinical Endocrinology & Metabolism*. 2010; 95(7): 3251-9.
[1127] Bastounis A, Langley T, Davis S et al. Comparing medication adherence in patients receiving bisphosphonates for preventing fragility fracture: A comprehensive systematic review and network meta-analysis. *Osteoporosis International*. 2022; 33: 1223-33.
[1128] Gates M, Pillay J, Nuspl M et al. Screening for the primary prevention of fragility fractures among adults aged 40 years and older in primary care: Systematic reviews of the effects and acceptability of screening and treatment, and the accuracy of risk prediction tools. *BMC Systematic Reviews*. 2023; 12(51):

clinical assessment for new fractures and new or active risk factors such as falls, as well as adherence to therapy, tolerability and adverse effects."[1129]

Fragility Fractures, Deaths and Quality of Life with Screening / Intervention

Fragility Fractures Avoided

- To estimate the number of fragility fractures avoided with screening / intervention in a BC birth cohort of 40,000 (20,000 females), we have made the following assumptions:
    - Screening would be up-to-date in 57.8% of community-dwelling elderly.[1130]
    - The proportion of the population screened who would be at high risk of a fragility fracture would be 30.1% of females aged 65-69 years, 36.2% of females aged 70-74 years, 41.4% of females aged 75-79 years and 45.6% of females aged 80-84 years.[1131]
    - 66% of patients at high risk would begin oral bisphosphonate pharmacotherapy[1132] and 56% of those would achieve a high level of compliance.[1133,1134,1135] In a sensitivity analysis, we will assume that the 66% would receive annual intravenous treatment with zoledronic acid which would lead to a high level of compliance in 71.1% of patients (or 27% higher than the 56%) over the average 4.5 years that the medication is taken.[1136]
    - With a high level of compliance with bisphosphonate pharmacotherapy, hip fractures would be reduced by 26.5% (95% CI 8.0% to 41.5%), vertebral fractures by 47.4% (95% CI 18.5% to 66.3%) and all other fractures would be reduced by 16.6% (95% CI 9.8% to 22.8%).[1137]
- Based on these assumptions, screening for primary prevention of fragility fractures in a BC birth cohort of 40,000 would be associated with a reduction of 183 fragility fractures (see Table 11).
- The data in Table 11 should be read as follows: at age 65, there are 18,330 females living in private dwellings. Screening for fragility fractures would be up-to-date in

[1129] Morin S, Feldman S, Funnell L et al. Clinical practice guidelines for management of osteoporosis and fracture prevention in Canada: 2023 update. *CMAJ*. 2023; 195(39): E1333-48.
[1130] Amarnath A, Franks P, Robbins J et al. Underuse and Overuse of Osteoporosis Screening in a Regional Health System: a Retrospective Cohort Study. *Journal of General Internal Medicine*. 2015; 12(30): 1733-40.
[1131] CTFPHC. How was this calculation made? Available online at https://canadiantaskforce.ca/how-was-this-calculation-made/. Accessed January 2024.
[1132] Keshishian A, Boystov N, Burge R et al. Examining the effect of medication adherence on risk of subsequent fracture among women with a fragility fracture in the U.S. Medicare Population. *Journal of Managed Care & Specialty Pharmacy*. 2017; 23(11): 1178-90.
[1133] Blouin J, Dragomir A, Fredette M et al. Comparison of direct health care costs related to the pharmacological treatment of osteoporosis and to the management of osteoporotic fractures among compliant and noncompliant users of alendronate and risedronate: A population-based study. *Osteoporosis International*. 2009; 20: 1571-81.
[1134] Sampalis J, Adachi J, Rampakakis E et al. Long-term impact of adherence to oral bisphosphonates on osteoporotic fracture incidence. *Journal of Bone and Mineral Research*. 2012; 27: 202-10.
[1135] Burden A, Paterson J, Gruneir A et al. Adherence to osteoporosis pharmacotherapy is underestimated using days supply values in electronic pharmacy claims data. *Pharmacoepidemiology and Drug Safety*. 2015; 24: 67-74.
[1136] Bastounis A, Langley T, Davis S et al. Comparing medication adherence in patients receiving bisphosphonates for preventing fragility fracture: A comprehensive systematic review and network meta-analysis. *Osteoporosis International*. 2022; 33: 1223-33.
[1137] Gates M, Pillay J, Nuspl M et al. Screening for the primary prevention of fragility fractures among adults aged 40 years and older in primary care: Systematic reviews of the effects and acceptability of screening and treatment, and the accuracy of risk prediction tools. *BMC Systematic Reviews*. 2023; 12(51):

57.8% (10,595) of these females. Of the 10,595, 30.1% (3,189) would be at high risk of fragility fractures. Of the 3,189, 66% (2,105) would start oral bisphosphonate pharmacotherapy. Of the 2,105, 56% (1,179) would achieve a high level of compliance with bisphosphonate pharmacotherapy. Without bisphosphonate pharmacotherapy, the risk of a hip fracture would be 104/100,000 person-years (see Table 3), suggesting that 1.23 hip fractures would occur that year in these 1,179 individuals. But, because they are on bisphosphonate pharmacotherapy, their risk of a hip fracture would be reduced by 26.5%, or 0.32 of the 1.23 projected hip fractures.

Table 11: Estimated Number of Fragility Fractures

Community-Dwelling Females Ages ≥65

With Screening / Intervention

In a BC Birth Cohort of 40,000

							Fragility Fractures Avoided						
Age	# in Private Dwelling	# (57.8%) with Up-to-Date Screening	% at High Risk	# at High Risk	**Start Medication** 66.0%	**Compliance with Medication** 56.0%	Hip	Vertebral	Wrist	Humerus	Multiple	All Other	**Total**
65	18,330	10,595	30.1%	3,189	2,105	1,179	0.3	0.3	0.8	0.2	0.1	1.0	**3**
66	18,188	10,513	30.1%	3,164	2,088	1,170	0.4	0.3	0.8	0.2	0.2	1.0	**3**
67	18,036	10,425	30.1%	3,138	2,071	1,160	0.5	0.4	0.8	0.2	0.2	1.1	**3**
68	17,873	10,331	30.1%	3,110	2,052	1,149	0.6	0.4	0.8	0.2	0.2	1.1	**3**
69	17,698	10,229	30.1%	3,079	2,032	1,138	0.7	0.5	0.8	0.3	0.2	1.1	**4**
70	17,508	10,120	36.2%	3,663	2,418	1,354	0.9	0.7	1.0	0.3	0.3	1.4	**5**
71	17,304	10,002	36.2%	3,621	2,390	1,338	1.0	0.7	1.0	0.3	0.3	1.4	**5**
72	17,083	9,874	36.2%	3,574	2,359	1,321	1.1	0.8	1.0	0.4	0.3	1.5	**5**
73	16,794	9,707	36.2%	3,514	2,319	1,299	1.1	0.8	1.0	0.4	0.3	1.5	**5**
74	16,486	9,529	36.2%	3,449	2,277	1,275	1.2	0.9	1.0	0.4	0.3	1.5	**5**
75	16,158	9,339	41.4%	3,866	2,552	1,429	1.5	1.0	1.1	0.4	0.4	1.8	**6**
76	15,807	9,136	41.4%	3,782	2,496	1,398	1.8	1.2	1.1	0.5	0.4	2.0	**7**
77	15,432	8,920	41.4%	3,693	2,437	1,365	2.2	1.3	1.2	0.5	0.5	2.1	**8**
78	14,897	8,611	41.4%	3,565	2,353	1,318	2.4	1.4	1.2	0.5	0.5	2.3	**8**
79	14,341	8,289	41.4%	3,432	2,265	1,268	2.7	1.5	1.2	0.5	0.6	2.4	**9**
80	13,761	7,954	45.6%	3,627	2,394	1,341	3.2	1.7	1.3	0.6	0.6	2.8	**10**
81	13,157	7,605	45.6%	3,468	2,289	1,282	3.4	1.7	1.2	0.6	0.7	2.8	**11**
82	12,528	7,241	45.6%	3,302	2,179	1,220	3.6	1.8	1.2	0.6	0.7	2.9	**11**
83	11,450	6,618	45.6%	3,018	1,992	1,115	3.6	1.7	1.2	0.6	0.7	2.8	**11**
84	10,383	6,001	45.6%	2,737	1,806	1,011	3.5	1.7	1.1	0.6	0.6	2.7	**10**
85	9,332	5,394	45.6%	2,460	1,623	909	3.4	1.6	1.0	0.5	0.6	2.6	**10**
86	8,302	4,798	45.6%	2,188	1,444	809	3.4	1.5	0.9	0.5	0.6	2.5	**9**
87	7,300	4,219	45.6%	1,924	1,270	711	3.3	1.4	0.8	0.4	0.6	2.4	**9**
88	6,462	3,735	45.6%	1,703	1,124	629	3.3	1.3	0.7	0.4	0.6	2.3	**8**
89	5,620	3,248	45.6%	1,481	978	547	3.1	1.1	0.6	0.4	0.5	2.1	**8**
90	4,796	2,772	45.6%	1,264	834	467	2.9	1.0	0.5	0.3	0.5	1.9	**7**
Total							**55**	**29**	**26**	**11**	**12**	**51**	**183**

Deaths Attributable to Fragility Fractures Avoided

- We then used the same approach as taken previously (see Table 6) to estimate that the 183 fragility fractures avoided with screening / intervention (see Table 11) would be associated with 26 deaths avoided (see Table 12).
- Furthermore, we used the same approach as taken previously (see Table 7) to estimate the number of life years lost attributable to the 26 deaths. On average, each death would be associated with 8.1 LYL for a total of 212 LYL (see Table 13).

Table 12: Estimated Number of Deaths Attributable to Fragility Fractures

Community-Dwelling Females Ages ≥65

With Screening / Intervention

In a BC Birth Cohort of 40,000

Age	# in Private Dwelling	Number of Fragilty Fractures Avoided							Deaths Avoided Attributable to Fragilty Fractures						
		Hip	Vertebral	Wrist	Humerus	Multiple	Other	**Total**	Hip	Vertebral	Wrist	Humerus	Multiple	Other	**Total**
65	18,330	0.3	0.3	0.8	0.2	0.1	1.0	**3**							
66	18,188	0.4	0.3	0.8	0.2	0.2	1.0	**3**	0.01	0.01	0.00	0.00	0.00	0.01	**0.0**
67	18,036	0.5	0.4	0.8	0.2	0.2	1.1	**3**	0.01	0.01	0.00	0.00	0.00	0.01	**0.0**
68	17,873	0.6	0.4	0.8	0.2	0.2	1.1	**3**	0.02	0.01	0.00	0.00	0.00	0.01	**0.0**
69	17,698	0.7	0.5	0.8	0.3	0.2	1.1	**4**	0.02	0.01	0.00	0.00	0.00	0.01	**0.1**
70	17,508	0.9	0.7	1.0	0.3	0.3	1.4	**5**	0.03	0.01	0.00	0.00	0.01	0.01	**0.1**
71	17,304	1.0	0.7	1.0	0.3	0.3	1.4	**5**	0.04	0.02	0.00	0.00	0.01	0.02	**0.1**
72	17,083	1.1	0.8	1.0	0.4	0.3	1.5	**5**	0.04	0.02	0.00	0.00	0.01	0.02	**0.1**
73	16,794	1.1	0.8	1.0	0.4	0.3	1.5	**5**	0.07	0.03	0.00	0.01	0.01	0.03	**0.1**
74	16,486	1.2	0.9	1.0	0.4	0.3	1.5	**5**	0.08	0.04	0.00	0.01	0.01	0.03	**0.2**
75	16,158	1.5	1.0	1.1	0.4	0.4	1.8	**6**	0.09	0.04	0.00	0.01	0.02	0.04	**0.2**
76	15,807	1.8	1.2	1.1	0.5	0.4	2.0	**7**	0.12	0.05	0.00	0.01	0.02	0.05	**0.2**
77	15,432	2.2	1.3	1.2	0.5	0.5	2.1	**8**	0.16	0.07	0.00	0.01	0.03	0.06	**0.3**
78	14,897	2.4	1.4	1.2	0.5	0.5	2.3	**8**	0.27	0.11	0.00	0.01	0.04	0.09	**0.5**
79	14,341	2.7	1.5	1.2	0.5	0.6	2.4	**9**	0.34	0.12	0.00	0.02	0.05	0.10	**0.6**
80	13,761	3.2	1.7	1.3	0.6	0.6	2.8	**10**	0.40	0.14	0.00	0.02	0.06	0.12	**0.7**
81	13,157	3.4	1.7	1.2	0.6	0.7	2.8	**11**	0.52	0.18	0.00	0.02	0.07	0.15	**0.9**
82	12,528	3.6	1.8	1.2	0.6	0.7	2.9	**11**	0.61	0.20	0.00	0.03	0.08	0.17	**1.1**
83	11,450	3.6	1.7	1.2	0.6	0.7	2.8	**11**	1.19	0.39	0.00	0.05	0.15	0.32	**2.1**
84	10,383	3.5	1.7	1.1	0.6	0.6	2.7	**10**	1.30	0.42	0.00	0.05	0.17	0.34	**2.3**
85	9,332	3.4	1.6	1.0	0.5	0.6	2.6	**10**	1.40	0.44	0.00	0.05	0.18	0.36	**2.4**
86	8,302	3.4	1.5	0.9	0.5	0.6	2.5	**9**	1.50	0.46	0.00	0.06	0.18	0.38	**2.6**
87	7,300	3.3	1.4	0.8	0.4	0.6	2.4	**9**	1.66	0.48	0.00	0.06	0.20	0.41	**2.8**
88	6,462	3.3	1.3	0.7	0.4	0.6	2.3	**8**	1.54	0.41	0.00	0.05	0.19	0.36	**2.5**
89	5,620	3.1	1.1	0.6	0.4	0.5	2.1	**8**	1.73	0.44	0.00	0.05	0.21	0.40	**2.8**
90	4,796	2.9	1.0	0.5	0.3	0.5	1.9	**7**	1.88	0.46	0.00	0.05	0.23	0.42	**3.0**
		55	**29**	**26**	**11**	**12**	**51**	**183**	**15.0**	**4.6**	**0.0**	**0.6**	**1.9**	**3.9**	**26.0**

Table 13: Estimated Number of Life Years Lost Attributable to Fragility Fractures

Community-Dwelling Females Ages ≥65

With Screening / Intervention

In a BC Birth Cohort of 40,000

Age	# in Private Dwelling	Deaths Avoided Attributable to Fragilty Fractures							LE	Life Years Lost						
		Hip	Vertebral	Wrist	Humerus	Multiple	Other	**Total**		Hip	Vertebral	Wrist	Humerus	Multiple	Other	**Total**
65	18,330															
66	18,188	0.01	0.01	0.00	0.00	0.00	0.01	**0.0**	22.0	0.2	0.1	0.0	0.0	0.1	0.2	**0.6**
67	18,036	0.01	0.01	0.00	0.00	0.00	0.01	**0.0**	21.2	0.3	0.1	0.0	0.0	0.1	0.2	**0.7**
68	17,873	0.02	0.01	0.00	0.00	0.00	0.01	**0.0**	20.3	0.3	0.2	0.0	0.0	0.1	0.2	**0.8**
69	17,698	0.02	0.01	0.00	0.00	0.00	0.01	**0.1**	19.5	0.4	0.2	0.0	0.0	0.1	0.3	**1.0**
70	17,508	0.03	0.01	0.00	0.00	0.01	0.01	**0.1**	18.7	0.5	0.2	0.0	0.0	0.1	0.3	**1.1**
71	17,304	0.04	0.02	0.00	0.00	0.01	0.02	**0.1**	17.9	0.7	0.3	0.0	0.1	0.1	0.3	**1.5**
72	17,083	0.04	0.02	0.00	0.00	0.01	0.02	**0.1**	17.1	0.8	0.4	0.0	0.1	0.2	0.4	**1.7**
73	16,794	0.07	0.03	0.00	0.01	0.01	0.03	**0.1**	16.3	1.1	0.5	0.0	0.1	0.2	0.5	**2.3**
74	16,486	0.08	0.04	0.00	0.01	0.01	0.03	**0.2**	15.5	1.2	0.6	0.0	0.1	0.2	0.5	**2.6**
75	16,158	0.09	0.04	0.00	0.01	0.02	0.04	**0.2**	14.7	1.3	0.6	0.0	0.1	0.2	0.5	**2.8**
76	15,807	0.12	0.05	0.00	0.01	0.02	0.05	**0.2**	14.0	1.6	0.8	0.0	0.1	0.3	0.6	**3.4**
77	15,432	0.16	0.07	0.00	0.01	0.03	0.06	**0.3**	13.2	2.1	0.9	0.0	0.1	0.3	0.7	**4.2**
78	14,897	0.27	0.11	0.00	0.01	0.04	0.09	**0.5**	12.5	3.4	1.3	0.0	0.2	0.5	1.1	**7**
79	14,341	0.34	0.12	0.00	0.02	0.05	0.10	**0.6**	11.8	4.0	1.5	0.0	0.2	0.6	1.2	**7**
80	13,761	0.40	0.14	0.00	0.02	0.06	0.12	**0.7**	11.1	4.5	1.6	0.0	0.2	0.6	1.3	**8**
81	13,157	0.52	0.18	0.00	0.02	0.07	0.15	**0.9**	10.5	5.5	1.9	0.0	0.2	0.7	1.6	**10**
82	12,528	0.61	0.20	0.00	0.03	0.08	0.17	**1.1**	9.8	6.0	2.0	0.0	0.2	0.8	1.7	**11**
83	11,450	1.19	0.39	0.00	0.05	0.15	0.32	**2.1**	9.2	11.0	3.6	0.0	0.4	1.4	3.0	**19**
84	10,383	1.30	0.42	0.00	0.05	0.17	0.34	**2.3**	8.6	11.2	3.6	0.0	0.4	1.4	3.0	**20**
85	9,332	1.40	0.44	0.00	0.05	0.18	0.36	**2.4**	8.0	11.2	3.5	0.0	0.4	1.4	2.9	**19**
86	8,302	1.50	0.46	0.00	0.06	0.18	0.38	**2.6**	7.4	11.1	3.4	0.0	0.4	1.4	2.8	**19**
87	7,300	1.66	0.48	0.00	0.06	0.20	0.41	**2.8**	6.9	11.4	3.3	0.0	0.4	1.4	2.8	**19**
88	6,462	1.54	0.41	0.00	0.05	0.19	0.36	**2.5**	6.4	9.8	2.6	0.0	0.3	1.2	2.3	**16**
89	5,620	1.73	0.44	0.00	0.05	0.21	0.40	**2.8**	5.9	10.2	2.6	0.0	0.3	1.2	2.4	**17**
90	4,796	1.88	0.46	0.00	0.05	0.23	0.42	**3.0**	5.4	10.2	2.5	0.0	0.3	1.2	2.3	**17**
		15.0	**4.6**	**0.0**	**0.6**	**1.9**	**3.9**	**26.0**	**8.1**	**120**	**38**	**0**	**5**	**16**	**33**	**212**

LE = life expectancy

QALYs Gained Due to Fragility Fractures Avoided

- As noted above, the 183 fragility fractures avoided would be associated with 26 deaths, leaving 157 living with their fragility fracture. For these 153 individuals, we used the same approach as taken previously (see Table 10) to calculate that living with these fragility fractures would result in 137 QALYs lost, with the majority (92 or 67%) of these QALYs lost in survivors of hip fractures (see Table 14).

Table 14: Estimated Number of QALYs Lost Attributable to Fragility Fractures

Community-Dwelling Females Ages ≥65

With Screening / Intervention

In a BC Birth Cohort of 40,000

	Number Living with Fractures								***Quality Adjusted Life Years Lost Due to Fragility Fractures***						
Age	Hip	Vertebral	Wrist	Humerus	Multiple	Other	**Total**	**LE**	Hip	Vertebral	Wrist	Humerus	Multiple	Other	**Total**
65	0.3	0.3	0.8	0.2	0.1	1.0	**3**	23	1.5	0.6	0.1	0.0	0.0	0.2	**2**
66	0.4	0.3	0.8	0.2	0.2	1.0	**3**	22	1.7	0.7	0.1	0.0	0.0	0.2	**3**
67	0.5	0.4	0.8	0.2	0.2	1.1	**3**	21	2.0	0.8	0.1	0.0	0.0	0.2	**3**
68	0.6	0.4	0.8	0.2	0.2	1.1	**3**	20	2.3	0.8	0.1	0.0	0.0	0.2	**3**
69	0.6	0.5	0.8	0.3	0.2	1.1	**4**	20	2.5	0.9	0.1	0.0	0.0	0.2	**4**
70	0.9	0.6	1.0	0.3	0.3	1.4	**5**	19	3.2	1.1	0.1	0.1	0.1	0.3	**5**
71	0.9	0.7	1.0	0.3	0.3	1.4	**5**	18	3.3	1.2	0.1	0.1	0.1	0.3	**5**
72	1.0	0.8	1.0	0.4	0.3	1.5	**5**	17	3.4	1.2	0.1	0.1	0.1	0.3	**5**
73	1.1	0.8	1.0	0.4	0.3	1.5	**5**	16	3.5	1.2	0.1	0.1	0.1	0.3	**5**
74	1.1	0.8	1.0	0.4	0.3	1.5	**5**	15	3.5	1.2	0.1	0.1	0.1	0.3	**5**
75	1.4	1.0	1.1	0.4	0.4	1.7	**6**	15	4.1	1.4	0.1	0.1	0.1	0.4	**6**
76	1.7	1.1	1.1	0.5	0.4	1.9	**7**	14	4.7	1.5	0.1	0.1	0.1	0.4	**7**
77	2.0	1.2	1.2	0.5	0.5	2.1	**7**	13	5.3	1.6	0.1	0.1	0.1	0.4	**8**
78	2.2	1.3	1.2	0.5	0.5	2.2	**8**	13	5.4	1.5	0.1	0.1	0.1	0.5	**8**
79	2.3	1.3	1.2	0.5	0.5	2.3	**8**	12	5.5	1.5	0.1	0.1	0.1	0.5	**8**
80	2.8	1.5	1.3	0.6	0.6	2.6	**9**	11	6.2	1.7	0.1	0.1	0.1	0.6	**9**
81	2.9	1.6	1.2	0.6	0.6	2.7	**10**	10	6.0	1.6	0.1	0.1	0.1	0.6	**9**
82	3.0	1.6	1.2	0.6	0.6	2.7	**10**	10	5.8	1.6	0.1	0.1	0.1	0.6	**8**
83	2.4	1.4	1.2	0.5	0.5	2.5	**8**	9	4.4	1.3	0.1	0.1	0.1	0.5	**7**
84	2.2	1.3	1.1	0.5	0.5	2.4	**8**	9	3.8	1.1	0.1	0.1	0.1	0.5	**6**
85	2.0	1.2	1.0	0.5	0.4	2.3	**7**	8	3.2	1.0	0.1	0.1	0.1	0.5	**5**
86	1.9	1.0	0.9	0.4	0.4	2.1	**7**	7	2.9	0.8	0.1	0.1	0.1	0.4	**4**
87	1.7	0.9	0.8	0.4	0.4	2.0	**6**	7	2.3	0.7	0.1	0.1	0.1	0.4	**4**
88	1.7	0.9	0.7	0.4	0.4	1.9	**6**	6	2.2	0.6	0.1	0.1	0.1	0.4	**3**
89	1.4	0.7	0.6	0.3	0.3	1.7	**5**	6	1.6	0.5	0.1	0.1	0.1	0.4	**3**
90	1.0	0.6	0.5	0.3	0.3	1.5	**4**	5	1.1	0.3	0.1	0.0	0.1	0.3	**2**
Total	**40**	**24**	**26**	**10**	**10**	**47**	**157**		**92**	**28**	**3**	**2**	**2**	**10**	**137**

LE = Life Expectancy

Based on the above approach and assumptions, the CPB associated with screening for, and treatment of, fragility fractures in community-dwelling females ages 65 and older is 348 QALYs (see Table 15, row *z*).

Table 15: CPB of Screening for Fragility Fractures in Women 65+
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
	In The Absence of Screening / Intervention		
a	Expected number of hip fractures	2,272	Table 3
b	Expected number of vertebral fractures	678	Table 3
c	Expected number of all other fractures	6,872	Table 3
d	Expected number of deaths attributable to hip fractures	591	Table 6
e	Expected number of deaths attributable to vertebral fractures	101	Table 6
f	Expected number of deaths attributable to all other fractures	408	Table 6
g	Expected number of LYL due to deaths attributable to hip fractures	4,783	Table 7
h	Expected number of LYL due to deaths attributable to vertebral fractures	862	Table 7
i	Expected number of LYL due to deaths attributable to all other fractures	3,498	Table 7
j	QALYs lost due to **living with** hip fractures	4,009	Table 10
k	QALYs lost due to **living with** vertebral fractures	708	Table 10
l	QALYs lost due to **living with** other fractures	1,146	Table 10
m	**Total QALYs Lost**	**15,006**	g+h+i+j+k+l
	With Screening / Intervention		
n	Number of hip fractures avoided	55	Table 11
o	Number of vertebral fractures avoided	29	Table 11
p	Number of all other fractures avoided	99	Table 11
q	Number of deaths attributable to hip fractures avoided	15	Table 12
r	Number of deaths attributable to vertebral fractures avoided	5	Table 12
s	Number of deaths attributable to all other fractures avoided	6	Table 12
t	Number of LYL due to deaths attributable to hip fractures avoided	120	Table 13
u	Number of LYL due to deaths attributable to vertebral fractures avoided	38	Table 13
v	Number of LYL due to deaths attributable to all other fractures avoided	54	Table 13
w	QALYs lost due to **living with** hip fractures	92	Table 14
x	QALYs lost due to **living with** vertebral fractures	28	Table 14
y	QALYs lost due to **living with** other fractures	16	Table 14
z	**Total QALYs gained due to screening (going from 0% to 57.8%)**	**348**	t+u+v+w+x+y

For the sensitivity analysis, we modified a number of major assumptions and recalculated the CPB as follows:

- Assume that the hip fracture reduction rate is reduced from 26.5% to 8.0%, the vertebral fracture reduction rate is reduced from 47.4% to 18.5% and the other fracture reduction rate is reduced from 16.6% to 9.8%: CPB = 131
- Assume that the hip fracture reduction rate is increased from 26.5% to 41.5%, the vertebral fracture reduction rate is increased from 47.4% to 66.3% and the other fracture reduction rate is increased from 16.6% to 22.8%: CPB = 521
- Assume that all patients receiving pharmacotherapy would be given an annual 5mg IV infusion of zoledronic acid rather than weekly alendronate or risedronate, resulting in the proportion of patients being in the high level of compliance group increasing from 56% to 71.1%: CPB = 442

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with screening of, and treatment for, fragility fractures in community-dwelling females ages 65 and older.

In modelling CE, we made the following assumptions:

Unit Costs

- The cost of each 10 minute primary care provider office visit is $35.97 (see Reference Document).
- The value of patient time is $37.16 per hour (see Reference Document).
- According to the BC Medical Services Plan Fee-For-Service Payment Analysis for 2016/17 – 2020/21, a single area bone density scan (fee item 8688) averaged $69.28 per scan in 2020/21. Adding a second area (fee item 8689) costs an additional $47.48 per scan. A second area scan occurred at a rate of approximately 99.4% of single area scans.[1138] The average cost of a bone scan is therefore $116.47 ($69.28 + (0.994 * $47.48).
- Based on data from Pacific Blue Cross,[1139] the generic equivalent to alendronate 70 mg weekly costs between $1.92 and $2.73 per pill (in Vancouver), with a mid-point of $2.33. The dispensing fee ranges from $4.49 - $13.99, with only a single dispensing fee below $10.00. We assume a dispensing fee at the midpoint of $10.00 - $13.99 (or $12.00) and assume a 3-month dose is dispensed each time. Annual costs would therefore be $169.16 ($2.33 * 52 + $12.00 * 4).
- Based on data from Pacific Blue Cross,[1140] the generic equivalent to risedronate 35 mg weekly costs between $1.81 and $3.18 per pill (in Vancouver), with a mid-point of $2.50. The dispensing fee ranges from $4.49 - $11.60, with only a single dispensing fee below $9.99. We assume a dispensing fee at the midpoint of $9.99 - $11.60 (or $10.80) and assume a 3-month dose is dispensed each time. Annual costs would therefore be $173.20 ($2.50 * 52 + $10.80 * 4).
- The cost for an annual 5mg IV infusion of zoledronic acid is estimated at $447.[1141] The cost of administering zoledronic acid intravenously has been estimated at $187 (2013 USD) per infusion,[1142] or $200 in 2022 CAD. The total annual cost of zoledronic acid would thus be $647 ($447 + $200).
- A 2016 Canadian study by Hopkins et al. estimated the annual costs of a fragility fracture to be $24,789 (in 2014 CAD or $33,128 in 2022 CAD).[1143] Costs included acute care, rehabilitation care, long term care, home care, outpatient physician

[1138] B.C. Ministry of Health, Health Sector Information, Analysis & Reporting Division. *MSP Fee-For-Service Payment Analysis 2016/2017 - 2020/2021*. 2021. Available at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msp_ffs_payment_analysis_20162017_to_20202021.pdf. Accessed January 2024.
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[1140] Pacific Blue Cross. *Pharmacy Compass*. 2023. Available online at https://www.pac.bluecross.ca/pharmacycompass. Accessed January 2024.
[1141] Coyle D. Cost-effectiveness of pharmaceutical treatments for osteoporosis consistent with the revised economic evaluation guidelines for Canada. *MDM Policy & Practice*. 2019; 4(1). doi:10.1177/2381468318818843.
[1142] Insinga R. Administration costs of denosumab and zoledronic acid for postmenopausal osteoporosis. *The American Journal of Pharmacy Benefits*. 2016; 8(3): e42-7.
[1143] Hopkins R, Burke N, Von Keyserlingk C et al. The current economic burden of illness of osteoporosis in Canada. *Osteoporosis International*. 2016; 27(10): 3023-32.

services, mobility devices, patient time costs and caregiver costs. The costs by fragility fracture type are as follows:

  - Hip - $63,649 in 2014 CAD / $78,491 in 2022 CAD
  - Wrist - $8,681 / $10,705
  - Vertebral - $26,960 / $33,247
  - Humerus - $15,862 / $19,561
  - Multiple - $54,145 / $66,771
  - All Other - $14,6419 / $18,055

- Nikotovic and colleagues calculated that direct health care costs utilized in the process of dying following a hip fracture were $34,873 (in 2010 CAD or $46,605 in 2022 CAD).[1144]

Costs of Screening / Intervention

- We model that 57.8%[1145] of females ≥ 65 year of age are screened using FRAX with this initial screening taking 6.9 minutes.[1146,1147]
- The screening would identify 30.1% of females aged 65-69 years, 36.2% of females aged 70-74 years, 41.4% of females aged 75-79 years and 45.6% of females aged ≥80 years to be at high risk and these high risk patients would go on to receive a BMD measurement.[1148]
- Ordering a BMD after risk calculation with FRAX would take 2.2 minutes and a discussion post-BMD to decide on whether or not to prescribe preventive medication would take 8.2 minutes.[1149,1150]
- For those not identified as high risk on FRAX, screening would take 70% of a primary care provider visit. For those identified as high risk on FRAX, screening and ordering a BMD would require a full primary care provider visit followed by a second primary care provider visit to discuss results and initiate pharmacotherapy.
- We model one additional visit to a primary care provider for monitoring medication for those with low compliance and two **annual** visits to a primary care provider for a period of 4.5 years for monitoring medication for those with high compliance.
- 66% of patients at high risk would initiate oral bisphosphonate pharmacotherapy (once weekly alendronate or risedronate) and 56% would achieve a high level of

[1144] Nikitovic M, Wodchis W, Krahn M et al. Direct health-care costs attributable to hip fractures among seniors: A matched cohort study.
[1145] Amarnath ALD, Franks P, Robbins JA et al. Underuse and Overuse of Osteoporosis Screening in a Regional Health System: a Retrospective Cohort Study. *Journal of General Internal Medicine*. 2015; 12(30): 1733-40.
[1146] Grad R, Reynolds D, Antao V et al. Screening for primary prevention of fragility fractures: How much time does it take? *Canadian Family Physician*. 2023; 69: 537-41.
[1147] CTFPHC. How was this calculation made? Available online at https://canadiantaskforce.ca/how-was-this-calculation-made/. Accessed January 2024.
[1148] CTFPHC. How was this calculation made? Available online at https://canadiantaskforce.ca/how-was-this-calculation-made/. Accessed January 2024.
[1149] Grad R, Reynolds D, Antao V et al. Screening for primary prevention of fragility fractures: How much time does it take? *Canadian Family Physician*. 2023; 69: 537-41.
[1150] CTFPHC. How was this calculation made? Available online at https://canadiantaskforce.ca/how-was-this-calculation-made/. Accessed January 2024.

compliance with 4.5 years oral bisphosphonate pharmacotherapy.[1151,1152,1153] Those who are not at high compliance would still utilize some drugs while not gaining the benefits of those drugs. We have estimated that the 44% not at high compliance would use approximately 30% of the drugs used by those in high compliance.[1154]

- The annual cost of pharmacotherapy is estimated at $171.18 based on the midpoint between the annual costs for the generic equivalents to alendronate and risedronate.
- An estimated two hours of patient time is required for each visit to a primary care provider and to receive a BMD measurement.
- Based on these assumptions, the estimated cost of screening and intervention for fragility fractures in community-dwelling females ages 65 and older in a BC birth cohort of 40,000 (20,000 females) is $14.0 million (see Table 16).

[1151] Blouin J, Dragomir A, Fredette M et al. Comparison of direct health care costs related to the pharmacological treatment of osteoporosis and to the management of osteoporotic fractures among compliant and noncompliant users of alendronate and risedronate: A population-based study. *Osteoporosis International*. 2009; 20: 1571-81.
[1152] Sampalis J, Adachi J, Rampakakis E et al. Long-term impact of adherence to oral bisphosphonates on osteoporotic fracture incidence. *Journal of Bone and Mineral Research*. 2012; 27: 202-10.
[1153] Burden A, Paterson J, Gruneir A et al. Adherence to osteoporosis pharmacotherapy is underestimated using days supply values in electronic pharmacy claims data. *Pharmacoepidemiology and Drug Safety*. 2015; 24: 67-74.
[1154] Patrick A, Brookhart M, Losina E et al. The complex relation between bisphosphonate adherence and fracture reduction. *The Journal of Clinical Endocrinology & Metabolism*. 2010; 95(7): 3251-9.

Table 16: Estimated Cost of Screening and Intervention

Community-Dwelling Females Ages ≥65

In a BC Birth Cohort of 40,000

Age	# in Private Dwelling	#(57.8%) with Up-to-Date Screening	# of FRAX Screens	Cost of FRAX Screening		% at High Risk	# at High Risk	# of Bone Density Scans	Cost of BMD Follow-up			Accept Medication	Compliance with Medication		Cost of Medication		Cost of Follow-up		Total Cost
				PCP	Patient				PCP	BMD	Patient	66.0%	High 56.0%	Low 44.0%	High	Low	PCP	Patient	
65	18,330	10,595	10,595	$301,174	$622,276	30.1%	3,189	3,189	$114,708	$371,421	$474,010	2,105	1,179	926	$201,761	$47,558	$118,103	$244,020	**$2,495,031**
66	18,188	10,513				30.1%									$201,761		$84,792	$175,194	**$461,747**
67	18,036	10,425				30.1%									$201,761		$84,792	$175,194	**$461,747**
68	17,873	10,331				30.1%									$201,761		$84,792	$175,194	**$461,747**
69	17,698	10,229				30.1%									$100,880		$42,396	$87,597	**$230,873**
70	17,508	10,120				36.2%													
71	17,304	10,002				36.2%													
72	17,083	9,874				36.2%													
73	16,794	9,707	9,707	$282,325	$583,330	36.2%	3,514	3,514	$126,393	$409,258	$522,299	2,319	1,299	1,020	$222,315	$52,403	$121,496	$251,032	**$2,570,851**
74	16,486	9,529				36.2%									$222,315		$84,792	$175,194	**$482,301**
75	16,158	9,339				41.4%									$222,315		$84,792	$175,194	**$482,301**
76	15,807	9,136				41.4%									$222,315		$84,792	$175,194	**$482,301**
77	15,432	8,920				41.4%									$111,157		$42,396	$87,597	**$241,150**
78	14,897	8,611				41.4%													
79	14,341	8,289				41.4%													
80	13,761	7,954				45.6%													
81	13,157	7,605	7,605	$228,901	$472,947	45.6%	3,468	3,468	$124,736	$403,891	$515,449	2,289	1,282	1,007	$219,399	$51,716	$121,015	$250,037	**$2,388,090**
82	12,528	7,241				45.6%									$219,399		$84,792	$175,194	**$479,385**
83	11,450	6,618				45.6%									$219,399		$84,792	$175,194	**$479,385**
84	10,383	6,001				45.6%									$219,399		$84,792	$175,194	**$479,385**
85	9,332	5,394				45.6%									$109,700		$42,396	$87,597	**$239,693**
86	8,302	4,798				45.6%													
87	7,300	4,219				45.6%													
88	6,462	3,735				45.6%													
89	5,620	3,248	3,248	$97,776	$202,021	45.6%	1,481	1,481	$53,281	$172,523	$220,176	978	547	430	$93,717	$22,090	$100,265	$207,164	**$1,169,013**
90	4,796	2,772				45.6%									$93,717		$84,792	$175,194	**$353,703**
Total			**31,155**	**$910,176**	**$1,880,574**			**11,652**	**$419,118**	**$1,357,093**	**$1,731,934**				**$3,083,071**	**$173,767**	**$1,435,986**	**$2,966,986**	**$13,958,704**

Costs Avoided

- The prevention of fragility fractures is associated with medical costs avoided. For modeling purposes, we have assumed that fragility fractures are associated with the following costs avoided:
    - Hip - $78,491
    - Wrist - $10,705
    - Vertebral - $33,247
    - Humerus - $19,561
    - Multiple - $66,771
    - All Other - $18,055
- Furthermore, we have assumed that each death avoided is associated with $46,605 in medical costs avoided.
- Based on these assumptions, total medical costs avoided associated with screening and intervention for fragility fractures in community-dwelling females ages 65 and older in a BC birth cohort of 40,000 (20,000 females) is $8.7 million (see Table 17).

Table 17: Estimated Costs Avoided with Screening and Intervention

Community-Dwelling Females Ages ≥65

In a BC Birth Cohort of 40,000

	Number of Fragilty Fractures Avoided							Costs	Deaths Avoided Attributable to Fragilty Fractures						Costs	Total Costs
Age	Hip	Vertebral	Wrist	Humerus	Multiple	Other	**Total**	**Avoided**	Hip	Vertebral	Humerus	Multiple	Other	**Total**	**Avoided**	**Avoided**
65	0.3	0.3	0.8	0.2	0.1	1.0	**2.8**	$75,324								**$75,324**
66	0.4	0.3	0.8	0.2	0.2	1.0	**3.0**	$86,104	0.01	0.01	0.00	0.00	0.01	**0.03**	$1,267	**$87,371**
67	0.5	0.4	0.8	0.2	0.2	1.1	**3.2**	$96,651	0.01	0.01	0.00	0.00	0.01	**0.03**	$1,581	**$98,231**
68	0.6	0.4	0.8	0.2	0.2	1.1	**3.4**	$106,940	0.02	0.01	0.00	0.00	0.01	**0.04**	$1,936	**$108,876**
69	0.7	0.5	0.8	0.3	0.2	1.1	**3.6**	$116,945	0.02	0.01	0.00	0.00	0.01	**0.05**	$2,339	**$119,284**
70	0.9	0.7	1.0	0.3	0.3	1.4	**4.6**	$152,293	0.03	0.01	0.00	0.01	0.01	**0.06**	$2,799	**$155,092**
71	1.0	0.7	1.0	0.3	0.3	1.4	**4.8**	$163,514	0.04	0.02	0.00	0.01	0.02	**0.09**	$3,998	**$167,512**
72	1.1	0.8	1.0	0.4	0.3	1.5	**5.0**	$174,259	0.04	0.02	0.00	0.01	0.02	**0.10**	$4,712	**$178,971**
73	1.1	0.8	1.0	0.4	0.3	1.5	**5.2**	$183,924	0.07	0.03	0.01	0.01	0.03	**0.14**	$6,704	**$190,628**
74	1.2	0.9	1.0	0.4	0.3	1.5	**5.3**	$192,936	0.08	0.04	0.01	0.01	0.03	**0.16**	$7,689	**$200,625**
75	1.5	1.0	1.1	0.4	0.4	1.8	**6.3**	$230,138	0.09	0.04	0.01	0.02	0.04	**0.19**	$8,789	**$238,927**
76	1.8	1.2	1.1	0.5	0.4	2.0	**7.0**	$268,707	0.12	0.05	0.01	0.02	0.05	**0.25**	$11,470	**$280,177**
77	2.2	1.3	1.2	0.5	0.5	2.1	**7.7**	$304,866	0.16	0.07	0.01	0.03	0.06	**0.31**	$14,677	**$319,544**
78	2.4	1.4	1.2	0.5	0.5	2.3	**8.3**	$335,363	0.27	0.11	0.01	0.04	0.09	**0.53**	$24,622	**$359,986**
79	2.7	1.5	1.2	0.5	0.6	2.4	**8.8**	$362,357	0.34	0.12	0.02	0.05	0.10	**0.63**	$29,317	**$391,674**
80	3.2	1.7	1.3	0.6	0.6	2.8	**10.1**	$424,756	0.40	0.14	0.02	0.06	0.12	**0.74**	$34,402	**$459,158**
81	3.4	1.7	1.2	0.6	0.7	2.8	**10.5**	$446,056	0.52	0.18	0.02	0.07	0.15	**0.94**	$43,951	**$490,007**
82	3.6	1.8	1.2	0.6	0.7	2.9	**10.8**	$462,762	0.61	0.20	0.03	0.08	0.17	**1.08**	$50,507	**$513,269**
83	3.6	1.7	1.2	0.6	0.7	2.8	**10.6**	$457,699	1.19	0.39	0.05	0.15	0.32	**2.11**	$98,287	**$555,986**
84	3.5	1.7	1.1	0.6	0.6	2.7	**10.2**	$446,563	1.30	0.42	0.05	0.17	0.34	**2.28**	$106,140	**$552,702**
85	3.4	1.6	1.0	0.5	0.6	2.6	**9.8**	$429,675	1.40	0.44	0.05	0.18	0.36	**2.44**	$113,542	**$543,217**
86	3.4	1.5	0.9	0.5	0.6	2.5	**9.4**	$422,885	1.50	0.46	0.06	0.18	0.38	**2.58**	$120,330	**$543,215**
87	3.3	1.4	0.8	0.4	0.6	2.4	**8.9**	$407,586	1.66	0.48	0.06	0.20	0.41	**2.80**	$130,656	**$538,242**
88	3.3	1.3	0.7	0.4	0.6	2.3	**8.5**	$392,413	1.54	0.41	0.05	0.19	0.36	**2.55**	$118,781	**$511,194**
89	3.1	1.1	0.6	0.4	0.5	2.1	**7.9**	$368,812	1.73	0.44	0.05	0.21	0.40	**2.83**	$131,776	**$500,588**
90	2.9	1.0	0.5	0.3	0.5	1.9	**7.1**	$338,223	1.88	0.46	0.05	0.23	0.42	**3.04**	$141,846	**$480,069**
Total	**55**	**29**	**26**	**11**	**12**	**51**	**183**	**$7,447,750**	**15.0**	**4.6**	**0.6**	**1.9**	**3.9**	**26.0**	**$1,212,117**	**$8,659,868**

Cost-effectiveness

Based on the above assumptions, the CE associated with screening and intervention for fragility fractures in community-dwelling females ages 65 and older in a BC birth cohort of 40,000 is $18,832/QALY (see Table 18, row *v*).

Table 18: Cost Effectiveness of Screening for Fragility Fractures in Females 65+
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
	Cost of Screening and Intervention		
a	Cost of FRAX screening - PCP	$910,176	Table 16
b	Cost of FRAX screening - Patient	$1,880,574	Table 16
c	Cost of BMD follow-up - PCP	$419,118	Table 16
d	Cost of BMD follow-up - BMD	$1,357,093	Table 16
e	Cost of BMD follow-up - Patient	$1,731,934	Table 16
f	Cost of medication	$3,256,838	Table 16
g	Cost of follow-up - PCP	$1,435,986	Table 16
h	Cost of follow-up - Patient	$2,966,986	Table 16
i	Subtotal - Healthcare system costs	$7,379,210	+ a + c + d + f + g
j	Subtotal - Patient costs	$6,579,494	+ b + e + h
k	**Total Costs**	**$13,958,704**	+ i + j
	Potential Costs Avoided		
l	Number of fragility fractures avoided	183	Table 17
m	Costs avoided due to fragility fractures avoided	-$7,447,750	Table 17
n	Deaths avoided attributable to fragilty fractures	26	Table 17
o	Costs avoided due to deaths avoided	-$1,212,117	Table 17
p	**Total Costs Avoided**	**-$8,659,868**	+ m + o
q	**Net cost of intervention**	**$5,298,837**	+ k + p
r	QALYs gained	348	Table 15
s	Cost effectiveness (CE) of intervention, $/QALY	$15,205	+ q / r
t	Net Cost of Intervention (1.5% Discount)	$5,179,979	Calculated
u	Net QALYs Gained (1.5% Discount)	275	Calculated
v	Cost Effectiveness (CE) of Intervention, $/QALY (1.5% Discount)	**$18,832**	Calculated

For the sensitivity analysis, we modified a number of major assumptions and recalculated the CE as follows:

- Assume that the hip fracture reduction rate is reduced from 26.5% to 8.0%, the vertebral fracture reduction rate is reduced from 47.4% to 18.5% and the other fracture reduction rate is reduced from 16.6% to 9.8%: **CE = $89,847**
- Assume that the hip fracture reduction rate is increased from 26.5% to 41.5%, the vertebral fracture reduction rate is increased from 47.4% to 66.3% and the other fracture reduction rate is increased from 16.6% to 22.8%: **CE = $4,502**
- Assume that all patients receiving pharmacotherapy would be given an annual 5mg IV infusion of zoledronic acid rather than weekly alendronate or risedronate, resulting in the proportion of patients being in the high level of compliance group increasing from 56% to 71.1%: CE = $41,248 (total medication costs [row f] increase from $3.3 to $15.2 million)

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening for, and treatment of, osteoporosis in females ages 65 and older in order to prevent fractures is estimated to be 275 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $18,832 per QALY (see Table 19).

Table 19: Screening for Fragility Fractures in Females 65+ in a BC Birth Cohort of 40,000

Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume No Current Service			
1.5% Discount Rate	**275**	104	411
3% Discount Rate	218	82	326
0% Discount Rate	348	131	521
CE ($/QALY) ***including*** patient time costs			
1.5% Discount Rate	**$18,832**	$4,502	$89,847
3% Discount Rate	$23,107	$7,361	$101,314
0% Discount Rate	$15,205	$2,077	$80,130
CE ($/QALY) ***excluding*** patient time costs			
1.5% Discount Rate	Cost saving	Cost saving	$35,024
3% Discount Rate	$371	Cost saving	$40,870
0% Discount Rate	Cost saving	Cost saving	$30,049

United States Preventive Services Task Force Recommendations[1155]

The USPSTF recommends 1-time screening for AAA with ultrasonography in men aged 65 to 75 years who have ever smoked. (B recommendation).

Canadian Task Force on Preventive Health Care Recommendations[1156]

We recommend one-time screening with ultrasonography for AAA of men aged 65 to 80 years (weak recommendation; moderate quality of evidence).

We recommend not screening men older than 80 years of age for AAA (weak recommendation; low quality of evidence).

The Canadian Task force acknowledged "evidence showing increased risk of AAA among smokers" but did not make a separate recommendation on screening this population "because there is no evidence on outcomes of screening smokers for AAA."[1157]

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with screening for abdominal aortic aneurysms in males ages 65 to 75 who have ever smoked.

An abdominal aortic aneurysm is conventionally diagnosed when the diameter of the aorta below the kidneys is 30 mm (3.0 cm) or greater.[1158]

The USPSTF considers an "ever-smoker" someone who has smoked at least 100 cigarettes in their lifetime.[1159]

Unless otherwise noted, we apply these conventions and definitions in our modelling.

In modelling CPB, we made the following assumptions:

- The single screen recommended by the USPSTF is conducted at age 65.
- Jacomelli and colleagues report that the National Health Service in England's AAA screening programme had mean uptake across the country of 78.1%, but varied regionally between 61.7 – 85.8%.[1160] We use 85.8% as the best in the world screening rate for AAA.

[1155] LeFevre ML. Screening for abdominal aortic aneurysm: US Preventive Services Task Force recommendation statement. *Annals of Internal Medicine.* 2014; 161(4): 281-90.
[1156] Singh H, Dickinson JA, Lewin G et al. Recommendations on screening for abdominal aortic aneurysm in primary care. *Canadian Medical Association Journal*. 2017; 189(36): E1137-E45.
[1157] Singh H, Dickinson JA, Lewin G et al. Recommendations on screening for abdominal aortic aneurysm in primary care. *Canadian Medical Association Journal*. 2017; 189(36): E1137-E45.
[1158] Sakalihasan N, Limet R and Defawe OD. Abdominal aortic aneurysm. *The Lancet*. 2005; 365(9470): 1577-89.
[1159] LeFevre ML. Screening for abdominal aortic aneurysm: US Preventive Services Task Force recommendation statement. *Annals of Internal Medicine.* 2014; 161(4): 281-90.
[1160] Jacomelli J, Summers L, Stevenson A et al. Impact of the first 5 years of a national abdominal aortic aneurysm screening programme. *British Journal of Surgery*. 2016; 103(9): 1125-31.

- The large, population-based randomized controlled trials (RCTs) used by the USPSTF in making their recommendation found an abdominal aortic aneurysm (AAA) in 4.0 – 7.7% of male screening participants.[1161]
- Citing more recent epidemiologic evidence from Europe and New Zealand, the USPSTF acknowledged a "substantial decrease in AAA prevalence in men aged 65 years or older in the past 2 decades"[1162] and referenced a study by Svensjö et al. citing an AAA prevalence rate of 1.7% in Sweden.[1163]
- In the UK, the AAA prevalence rate in 65-year old men has decreased from 5.0% in 1991 to 1.3% in 2015.[1164] In Denmark, the prevalence rate in 65-year old men was 2.6% during 2008-2011.[1165]

- For modelling purposes we use an AAA prevalence rate in 65-year old men of 2.35% (Table 5, row *e*). Using 2.35% prevalence in our model brings the model results with screening reasonably close to actual BC results. The 2.35% prevalence rate used is between the values reported for the UK and Denmark.

- The USPSTF rated the quality of the population-based randomized controlled trials (RCTs) used by the USPSTF in making their recommendation. The USPSTF considered the Multicentre Aneurysm Screening Study (MASS) and the Viborg AAA studies as "good-quality", and the Chichester and Western Australia AAA studies as "fair-quality".[1166] Neither good-quality study included men over the age of 74. On the other hand, both fair-quality studies included older men up to ages 80 (Chichester) and 83 (Western Australia).
- The prevalence of AAA increases with increasing age.[1167]
- In the MASS study, 4.9% of screened men were diagnosed with AAA and the total AAA-related death rate was 109 per 100,000 person years in the control group.[1168] In the Viborg study, 4.0% of screened men were diagnosed with AAA and the total AAA-related death rate was 87 per 100,000 person years in the control group.[1169]
- Based on 25 years of experience with an ultrasound screening program for AAA in the UK, Oliver-Williams and colleagues report that while the "prevalence of screen-

[1161] LeFevre ML. Screening for abdominal aortic aneurysm: US Preventive Services Task Force recommendation statement. *Annals of Internal Medicine.* 2014; 161(4): 281-90.
[1162] Guirguis-Blake JM, Beil TL, Senger CA et al. Ultrasonography screening for abdominal aortic aneurysms: a systematic evidence review for the US Preventive Services Task Force. *Annals of Internal Medicine.* 2014; 160(5): 321-9.
[1163] Svensjö S, Björck M, Gürtelschmid M et al. Low prevalence of abdominal aortic aneurysm among 65-year-old Swedish men indicates a change in the epidemiology of the disease. *Circulation*. 2011; 124(10): 1118-23.
[1164] Oliver-Williams C, Sweeting MJ, Turton G et al. Lessons learned about prevalence and growth rates of abdominal aortic aneurysms from a 25-year ultrasound population screening programme. *British Journal of Surgery*. 2018; 105(1): 68-74.
[1165] Grøndal N, Søgaard R and Lindholt JS. Baseline prevalence of abdominal aortic aneurysm, peripheral arterial disease and hypertension in men aged 65–74 years from a population screening study (VIVA trial). *British Journal of Surgery*. 2015; 102(8): 902-6.
[1166] Guirguis-Blake JM, Beil TL, Senger CA et al. Ultrasonography screening for abdominal aortic aneurysms: a systematic evidence review for the US Preventive Services Task Force. *Annals of Internal Medicine.* 2014; 160(5): 321-9.
[1167] Grøndal N, Søgaard R and Lindholt JS. Baseline prevalence of abdominal aortic aneurysm, peripheral arterial disease and hypertension in men aged 65–74 years from a population screening study (VIVA trial). *British Journal of Surgery*. 2015; 102(8): 902-6.
[1168] Thompson S, Ashton H, Gao L et al. Final follow-up of the Multicentre Aneurysm Screening Study (MASS) randomized trial of abdominal aortic aneurysm screening. *British Journal of Surgery*. 2012; 99(12): 1649-56.
[1169] Lindholt JS, Sørensen J, Søgaard R et al. Long-term benefit and cost-effectiveness analysis of screening for abdominal aortic aneurysms from a randomized controlled trial. *British Journal of Surgery*. 2010; 97(6): 826-34.

detected small and medium AAAs has decreased over the past 25 years, …growth rates have remained similar. Men with a subaneurysmal aorta at age 65 years have a substantial risk of developing a large AAA by the age of 80 years."[1170]

- For modelling purposes, we assume that the death rate / 100,000 person years of 98.0 observed in the control groups of the MASS and Viborg studies would be reduced linearly to 51.7 / 100,000 person years due to the lower estimated prevalence of AAA (2.35%) used in our model (see Table 1).

Table 1: Screening for Abdominal Aortic Aneurysm Men Ages 65+
Adjusted Study Results Based on Lower AAA Prevalence

Study	USPSTF Study Rating	Study Prevalence of AAA	Study Death Rate in Control Group per 100,000 person years	Model Prevalence of AAA	Adjusted Death Rate per 100,000 person years
MASS (Thompson et al., 2012)	Good	4.9%	109	2.35%	52.3
Viborg (Lindholt et al.)	Good	4.0%	87	2.35%	51.1
Average of Good Quality Studies			**98.0**		**51.7**

- As early as 1998, Semmens et al. reported a decline in AAA-related emergency and elective procedures in Western Australia, ahead of similar results being reported in Europe and theorized that this may be due to "significant changes in the health of the Australian community" including "the success of the anti-smoking movement".[1171]
- In Sweden, Johansson and colleagues observed that AAA mortality declined from 36 to 10 deaths per 100,000 for men aged 65-74 between the early 2000s and 2015.[1172] They note, however, that only an estimated 30% of this reduction was associated with the introduction of screening for AAA and that 70% is due to other factors, most notably a reduction in smoking. Between 1970 and 2010, the prevalence of smoking in Sweden decreased from 44% to 15%.[1173]
- In a 2018 systematic review and meta-analysis of tobacco smoking and AAA, Aune and colleagues report that the relative risk of AAA in current smokers is 4.87 (95% CI 3.93 – 6.02) and in former smokers is 2.10 (95% CI 1.76 – 2.50) compared to never smokers.[1174]
- The Canadian Tobacco, Alcohol and Drugs Survey, 2017 indicated that 16.8% (95% CI 11.6 – 22.0%) of **men 45+ in BC** are current smokers, 36.3% (95% CI 29.6 – 43.0%) are former smokers and 47% (95% CI 39.6 – 54.3) have never smoked.[1175]

[1170] Oliver-Williams C, Sweeting MJ, Turton G et al. Lessons learned about prevalence and growth rates of abdominal aortic aneurysms from a 25-year ultrasound population screening programme. *British Journal of Surgery*. 2018; 105(1): 68-74.
[1171] Semmens J, Norman P, Lawrence-Brown M et al. Population-based record linkage study of the incidence of abdominal aortic aneurysm in Western Australia in 1985–1994. *British Journal of Surgery.* 1998; 85(5): 648-52.
[1172] Johansson M, Zahl PH, Siersma V et al. Benefits and harms of screening men for abdominal aortic aneurysm in Sweden: a registry-based cohort study. *The Lancet*. 2018; 391(10138): 2441-7.
[1173] Johansson M, Zahl PH, Siersma V et al. Benefits and harms of screening men for abdominal aortic aneurysm in Sweden: a registry-based cohort study. *The Lancet*. 2018; 391(10138): 2441-7.
[1174] Aune D, Schlesinger S, Norat T et al. Tobacco smoking and the risk of abdominal aortic aneurysm: a systematic review and meta-analysis of prospective studies. *Scientific Reports.* 2018; 8(1): 14786.
[1175] Government of Canada. *Canadian Tobacco, Alcohol and Drugs (CTADS) Survey: 2017 Detailed Tables.* 2017. Available at https://www.canada.ca/en/health-canada/services/canadian-tobacco-alcohol-drugs-survey/2017-summary/2017-detailed-tables.html#t2. Accessed January 2019.

- Based on Canadian Community Health Survey data from 2014, 12.9% of BC men ages **65-69** are daily or occasional smokers.[1176]

- For modelling purposes, we assume that 12.9% of men 65 years of age are current smokers (Table 5, row *d*), 47% are never smokers (Table 5, row *b*) and the balance (40.1%) are former smokers (Table 5, row *c*).

- In Table 2 we combine the estimated AAA-related death rate for the population as a whole (51.7 / 100,000 person years, see Table 1), the proportion of 65 year old BC men by smoking category and the relative risk of AAA for current-smokers, former-smokers and never-smokers. At the same time, we calculated the prevalence of AAA in each group, using our model prevalence of 2.35% for the whole population (Table 5, row *e*).

- The results suggest a prevalence of 1.21% (Table 5, row *f*) and an AAA-related death rate of 26.6 / 100,000 in never-smokers, a prevalence of 2.54% (Table 5, row *g*) and an AAA-related death rate of 55.9 / 100,000 in former-smokers and a prevalence of 5.90% (Table 5, row *h*) and an AAA-related death rate of 129.7 / 100,000 in current-smokers.

Table 2: Screening for Abdominal Aortic Aneurysm Men 65+
AAA Prevalence and Death Rates by Smoking Category

	Total	Never-Smoker	Former-Smoker	Current-Smoker
Proportion of Population	1.00	0.470	0.401	0.129
Relative Risk of AAA		1.00	2.10	4.87
Prevalence of AAA	2.35%	1.21%	2.54%	5.90%
Death Rate per 100,000	51.7	26.6	55.9	129.7

- Howard et al. report the incidence of acute AAA events to be 55 / 100,000 per year in 65-74 year olds and 112 / 100,000 per year in 75-84 year olds. Of these acute AAA events, 59.2% were fatal within 30 days.[1177] This works out to AAA-related death rates of 32.6 (55 * 0.592) and 66.3 (112 * 0.592) / 100,000 for 65-74 and 75-84 year olds respectively.

- Howard and colleagues also report that 22.3% of incident AAA-events took place in 65 – 74 year olds, with only 13.1% of AAA-related deaths occurring in this age group.[1178]

- We adjust the rates for age groups from 65 – 74 and 75 – 84 to reflect that 86.9% of AAA-related deaths are in the 75+ age group, while ensuring the total population rates still reflect what was calculated in Table 2. The deaths and life-years lost in a cohort of BC men 65+ due to AAA is shown in Table 3. We model AAA screening at age 65 through to age 84, in keeping with the average life expectancy of 19.5 years for a 65 year old male from the BC Life Table.

[1176] Based on the Statistics Canada's Canadian Community Health Survey 2014 Public Use Microdata File. All computations, use and interpretation of these data are entirely that of H. Krueger & Associates Inc.
[1177] Howard D, Banerjee A, Fairhead J et al. Age-specific incidence, risk factors and outcome of acute abdominal aortic aneurysms in a defined population. *British Journal of Surgery*. 2015; 102(8): 907-15.
[1178] Howard D, Banerjee A, Fairhead J et al. Age-specific incidence, risk factors and outcome of acute abdominal aortic aneurysms in a defined population. *British Journal of Surgery*. 2015; 102(8): 907-15.

- AAA is usually asymptomatic prior to rupture,[1179] therefore reduced quality of life in those living with AAA is not presented in Table 3 or considered in our model.
- Table 3 indicates that, in our birth cohort, we would expect 36 AAA-related deaths in male never-smokers (Table 5, row *p*), 65 AAA-related deaths in former-smokers (Table 5, row *q*) and 48 AAA-related deaths in current-smokers (Table 5, row *r*). These 149 AAA-related deaths represent 2.05% of the total 7,289 deaths in the cohort between the ages of 65 and 84. Research from other jurisdictions suggests an AAA-related death rate of between 1-2% of total deaths.[1180,1181] These 149 deaths would result in the loss of 1,555 (377 + 675 + 503) QALYs in our cohort.
- BC Vital Statistics annual reports provide a detailed listing (by ICD-10 code) of annual deaths by age and sex. ICD-10 code I71 is for deaths due to "aortic aneurysm & dissection." If we combine deaths due to ICD-10 code I71 from the 2013[1182], 2014[1183] and 2015[1184] BC Vital Statistics annual reports, 0.78% of deaths in males 65 – 79 and 0.72% of deaths in males 80 and over were attributed to ICD-10 code I71. In males over 65, 0.74% of deaths were attributed to ICD-10 code I71. This proportion of deaths attributable to ICD-10 code I71 is considerably lower than our modelled estimate of 2.05%. Using cause of death data from vital statistics can be somewhat challenging as research has indicted that at least 15% of all deaths are miscoded in vital statistics data in the US and Canada.[1185] It is possible, therefore, that the 0.74% is an underrepresentation of the actual proportion of deaths due to AAA in BC males 65 years of age and older due to AAA.

[1179] Kapila V, Jetty P, Doug Wooster M et al. 2018 Screening for abdominal aortic aneurysms in Canada: review and position statement from the Canadian Society of Vascular Surgery. Available at https://canadianvascular.ca/resources/Documents/Clinical-Guidelines/FINAL-2018-CSVS-Screening-Recommendations.pdf. Accessed January 2019.
[1180] Howard D, Banerjee A, Fairhead J et al. Age-specific incidence, risk factors and outcome of acute abdominal aortic aneurysms in a defined population. *British Journal of Surgery*. 2015; 102(8): 907-15.
[1181] Sandiford P, Mosquera D and Bramley D. Trends in incidence and mortality from abdominal aortic aneurysm in New Zealand. *British Journal of Surgery*. 2011; 98(5): 645-51.
[1182] BC Vital Statistics Agency. *Annual Report 2013. Selected Vital Statistics and Health Status Indicators.* 2015. Available at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2013/pdf/annual-report-2013.pdf. Accessed February 2019.
[1183] BC Vital Statistics Agency. *Annual Report 2014. Selected Vital Statistics and Health Status Indicators.* 2015. Available at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2014/pdf/annual-report-2014.pdf. Accessed February 2019.
[1184] BC Vital Statistics Agency. *Annual Report 2015. Selected Vital Statistics and Health Status Indicators.* 2015. Available at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2015/pdf/annual-report-2015.pdf. Accessed February 2019.
[1185] Naghavi M, Makela S, Foreman K. Research Algorithms for enhancing public health utility of national causes-of-death data. *Population Health Metrics*. 2010; 8: 9.

Table 3: Screening for Abdominal Aortic Aneurysm in Men 65+
Deaths and Life Years Lost Due to Abdominal Aortic Aneurysm
In a BC Birth Cohort of 40,000

		Never Smokers			*Former Smokers*			*Current Smokers*					*Life Years Lost Due to Death*		
Age	# in Cohort	Proportion of Population	AAA-Related Deaths per 100,000 person years	AAA-Related Deaths	Proportion of Population	AAA-Related Deaths per 100,000 person years	AAA-Related Deaths	Proportion of Population	AAA-Related Deaths per 100,000 person years	AAA-Related Deaths	AAA-Deaths in **Ever Smokers**	Life Expectancy	*Never Smokers*	*Former Smokers*	*Current Smokers*
65	17,208	47.0%	6.1	0.5	40.1%	12.9	0.9	12.9%	29.8	0.7	1.5	19.5	9.7	17.3	12.9
66	17,024	47.0%	6.1	0.5	40.1%	12.9	0.9	12.9%	29.8	0.7	1.5	18.7	9.2	16.4	12.2
67	16,826	47.0%	6.1	0.5	40.1%	12.9	0.9	12.9%	29.8	0.6	1.5	17.9	8.7	15.5	11.6
68	16,612	47.0%	6.1	0.5	40.1%	12.9	0.9	12.9%	29.8	0.6	1.5	17.1	8.2	14.6	10.9
69	16,381	47.0%	6.1	0.5	40.1%	12.9	0.8	12.9%	29.8	0.6	1.5	16.4	7.7	13.8	10.3
70	16,132	47.0%	6.1	0.5	40.1%	12.9	0.8	12.9%	29.8	0.6	1.5	15.6	7.2	13.0	9.7
71	15,863	47.0%	6.1	0.5	40.1%	12.9	0.8	12.9%	29.8	0.6	1.4	14.9	6.8	12.2	9.1
72	15,573	47.0%	6.1	0.4	40.1%	12.9	0.8	12.9%	29.8	0.6	1.4	14.2	6.4	11.4	8.5
73	15,260	47.0%	6.1	0.4	40.1%	12.9	0.8	12.9%	29.8	0.6	1.4	13.5	5.9	10.6	7.9
74	14,923	47.0%	6.1	0.4	40.1%	12.9	0.8	12.9%	29.8	0.6	1.3	12.8	5.5	9.8	7.3
75	14,560	47.0%	53.9	3.7	40.1%	113.1	6.6	12.9%	262.3	4.9	11.5	12.1	44.6	79.9	59.6
76	14,170	47.0%	53.9	3.6	40.1%	113.1	6.4	12.9%	262.3	4.8	11.2	11.5	41.3	73.9	55.1
77	13,751	47.0%	53.9	3.5	40.1%	113.1	6.2	12.9%	262.3	4.7	10.9	10.8	37.6	67.4	50.3
78	13,301	47.0%	53.9	3.4	40.1%	113.1	6.0	12.9%	262.3	4.5	10.5	10.2	34.3	61.5	45.9
79	12,820	47.0%	53.9	3.2	40.1%	113.1	5.8	12.9%	262.3	4.3	10.2	9.6	31.2	55.8	41.6
80	12,306	47.0%	53.9	3.1	40.1%	113.1	5.6	12.9%	262.3	4.2	9.7	9.0	28.0	50.2	37.5
81	11,759	47.0%	53.9	3.0	40.1%	113.1	5.3	12.9%	262.3	4.0	9.3	8.4	25.0	44.8	33.4
82	11,179	47.0%	53.9	2.8	40.1%	113.1	5.1	12.9%	262.3	3.8	8.9	7.9	22.4	40.1	29.9
83	10,565	47.0%	53.9	2.7	40.1%	113.1	4.8	12.9%	262.3	3.6	8.4	7.4	19.8	35.5	26.5
84	9,919	47.0%	53.9	2.5	40.1%	113.1	4.5	12.9%	262.3	3.4	7.9	6.9	17.3	31.0	23.2
Total			**26.6**	**36**		**55.9**	**65**		**129.7**	**48**	**113**		**377**	**675**	**503**

- There are three primary AAA-related modes of death considered by the randomized controlled trials: death as a result of AAA rupture before receiving emergency surgery at a hospital, death as a result of AAA rupture after receiving emergency surgery, and death due to complications following elective surgery.
- Only one good quality USPSTF referenced study reported on rates of elective and emergency surgery in the control and screening intervention groups; the Viborg study reported by Lindholt and colleagues.[1186] They report an elective surgery rate of 70 / 100,000 and an emergency surgery rate of 70 / 100,000 in the control population at a reported AAA prevalence of 4.0%.
- We model that these rates would be reduced linearly to 41 / 100,000 person years (Table 5, row *v*) and 41 / 100,000 person years (Table 5, row *ac*) for elective and emergency procedures respectively due to the lower estimated prevalence of AAA (2.35%) used in our model (see Table 4).

Table 4: Screening for Abdominal Aortic Aneurysm Men Ages 65+
Adjusted Surgery Rates Based on Lower AAA Prevalence[1]

Variable	Study Prevalence of AAA	Incidence per 100,000 person years	Model Prevalence of AAA	Adjusted Incidence per 100,000 person years
Elective Operations, Control	4.0%	70	2.35%	41
Acute Operation, with Rupture, Control	4.0%	57	2.35%	33
Acute Operation, **without** rupture, Control	4.0%	13	2.35%	8
Total for Acute Operations, Control	4.0%	70	2.35%	41

[1] Source: Lindholt et al. (2010)

[1186] Lindholt J, Juul S, Fasting H et al. Screening for abdominal aortic aneurysms: single centre randomised controlled trial. *BMJ*. 2005; 330: 750.

- Guirguis-Blake and colleagues conducted a pooled analysis of RCTs reporting 13-15 year follow up results and calculated the following relative risks in the screening group: [1187]
    - RR of elective operations for AAA: 2.15 (95% CI, 1.89 – 2.44)
    - RR of emergency operations for AAA: 0.52 (95% CI, 0.40 – 0.66)
    - RR of AAA-related mortality: 0.58 (95% CI, 0.39 – 0.88)

- We model the RR after the pooled analysis by Guirguis-Blake et al. with a relative risk of elective operations of 2.15 (Table 5, row *al*), a relative risk of emergency operations of 0.52 (Table 5, row *au*), and an overall relative risk of AAA-related death of 0.58 in the screening group (Table 5, row *az*).

- There are a number of cases of asymptomatic AAA that could be found without screening. This number ranges from 7 - 25% in economic analyses and studies reporting this variable.[1188,1189,1190,1191,1192]

- For modelling purposes we use the mid-point between 7% and 25% (13%) and vary this from 7 – 25% in our sensitivity analysis (Table 5, row *ak*).

- Reporting on the years 2003 – 2004 for Canada, Forbes et al. reported that 8.9% of elective AAA-repair was carried out by endovascular surgery, with the balance being open surgery.[1193]
- Jetty and Husereau reported on Canadian trends from 2004 – 2009 and reported that endovascular aneurysm repair (EVAR) rates rose from 11.5% to 35.5% in Canada during that time. They also report substantial regional differences in elective endovascular repair rates, from a low of 15.8% in Manitoba to a high of 45.0% in BC in 2009. BC's rate increased each year from 7.5% in 2005 to 45.0% in 2009.[1194]
- Of the 1,958 surgeries for AAA in BC between 2013/14 and 2017/18, 1,142 were EVAR (58%) and 816 were open (42%).[1195]

[1187] Guirguis-Blake J, Beil T, Sun X et al. Primary Care Screening for Abdominal Aortic Aneurysm: A Systematic Evidence Review for the US Preventive Services Task Force. Evidence Synthesis No. 109. 2014: Available at https://www.ncbi.nlm.nih.gov/books/NBK184793/. Accessed January 2019.
[1188] Montreuil B and Brophy J. Screening for abdominal aortic aneurysms in men: a Canadian perspective using Monte Carlo–based estimates. *Canadian Journal of Surgery*. 2008; 51(1): 23.
[1189] Silverstein MD, Pitts SR, Chaikof EL et al. Abdominal aortic aneurysm (AAA): cost-effectiveness of screening, surveillance of intermediate-sized AAA, and management of symptomatic AAA. *Baylor University Medical Center Proceedings*. 2005; 18(4): 345-67.
[1190] Wanhainen A, Lundkvist J, Bergqvist D et al. Cost-effectiveness of different screening strategies for abdominal aortic aneurysm. *Journal of Vascular Surgery.* 2005; 41(5): 741-51.
[1191] Wanhainen A, Hultgren R, Linné A et al. Outcome of the Swedish nationwide abdominal aortic aneurysm screening program. *Circulation.* 2016; 134(16): 1141-8.
[1192] Howard D, Banerjee A, Fairhead J et al. Age-specific incidence, risk factors and outcome of acute abdominal aortic aneurysms in a defined population. *British Journal of Surgery*. 2015; 102(8): 907-15.
[1193] Forbes TL, Lawlor DK, DeRose G et al. National audit of the recent utilization of endovascular abdominal aortic aneurysm repair in Canada: 2003 to 2004. *Journal of Vascular Surgery.* 2005; 42(3): 410-4.
[1194] Jetty P and Husereau D. Trends in the utilization of endovascular therapy for elective and ruptured abdominal aortic aneurysm procedures in Canada. *Journal of Vascular Surgery.* 2012; 56(6): 1518-26.
[1195] Aciemme (Sam) Ospan, Senior Manager, Lifetime Prevention Schedule, Healthy Living and Health Promotion Branch, BC Ministry of Health. June 3, 2019. Personal communication.

- Recent evidence from the UK and Sweden also indicate a rate for elective EVAR of 59%. [1196,1197]

- We model an EVAR rate of 58% in BC (Table 5, rows *x* & *ap*).

- The USPSTF referenced two key studies comparing early open surgery with surveillance in their analysis of the harms of screening.[1198] One study was conducted in the UK (UKSAT)[1199] and the other in the US (ADAM).[1200]

- Greenhalgh and colleagues reported a 30-day mortality rate of 5.8% in patients receiving open surgery in the UK Small Aneurysm Trial (UKSAT). The authors acknowledge that this rate was "about half the national in-hospital mortality rate for elective repair" of AAA. [1201] This study was conducted at a time when endovascular surgery was "still under development".

- Lederle and colleagues reported a 30-day mortality rate of 2.0% in patients receiving open surgery in the Aneurysm Detection and Management (ADAM) study.[1202]

- Thompson and colleagues reported a 30-day mortality of 1.8% and 4.6% for elective endovascular and elective open AAA surgeries respectively (MASS study in UK).[1203]

- Several studies published since the USPSTF recommendation in 2014 have reported on elective surgery mortalities. A study of Medicare beneficiaries in the US reported a perioperative (within 30-days of surgery) mortality rate of 1.6% for endovascular repair of AAA and 5.2% for open repair. The mean age was 75.6 for those receiving surgery and the data used was from 2001 - 2008.[1204]

- More recent European studies report ranges of 0.3% – 0.7% and 0.9% – 1.3% for 30-day mortality following endovascular repair and open surgery respectively.[1205,1206] Neither study explicitly states the mean age of patients receiving surgery, but

[1196] Jacomelli J, Summers L, Stevenson A et al. Impact of the first 5 years of a national abdominal aortic aneurysm screening programme. *British Journal of Surgery*. 2016; 103(9): 1125-31.
[1197] Wanhainen A, Hultgren R, Linné A et al. Outcome of the Swedish nationwide abdominal aortic aneurysm screening program. *Circulation.* 2016; 134(16): 1141-8.
[1198] Guirguis-Blake JM, Beil TL, Senger CA et al. Ultrasonography screening for abdominal aortic aneurysms: a systematic evidence review for the US Preventive Services Task Force. *Annals of Internal Medicine.* 2014; 160(5): 321-9.
[1199] Greenhalgh R, Brady A, Brown L et al. Mortality results for randomised controlled trial of early elective surgery or ultrasonographic surveillance for small abdominal aortic aneurysms. The UK Small Aneurysm Trial Participants. *The Lancet.* 1998; 352: 1649-55.
[1200] Lederle FA, Wilson SE, Johnson GR et al. Immediate repair compared with surveillance of small abdominal aortic aneurysms. *New England Journal of Medicine*. 2002; 346(19): 1437-44.
[1201] Greenhalgh R, Brady A, Brown L et al. Mortality results for randomised controlled trial of early elective surgery or ultrasonographic surveillance for small abdominal aortic aneurysms. The UK Small Aneurysm Trial Participants. *The Lancet.* 1998; 352: 1649-55.
[1202] Lederle FA, Wilson SE, Johnson GR et al. Immediate repair compared with surveillance of small abdominal aortic aneurysms. *New England Journal of Medicine*. 2002; 346(19): 1437-44.
[1203] Thompson S, Ashton H, Gao L et al. Final follow-up of the Multicentre Aneurysm Screening Study (MASS) randomized trial of abdominal aortic aneurysm screening. *British Journal of Surgery*. 2012; 99(12): 1649-56.
[1204] Schermerhorn ML, Buck DB, O'malley AJ et al. Long-term outcomes of abdominal aortic aneurysm in the Medicare population. *New England Journal of Medicine*. 2015; 373(4): 328-38.
[1205] Jacomelli J, Summers L, Stevenson A et al. Impact of the first 5 years of a national abdominal aortic aneurysm screening programme. *British Journal of Surgery*. 2016; 103(9): 1125-31.
[1206] Wanhainen A, Hultgren R, Linné A et al. Outcome of the Swedish nationwide abdominal aortic aneurysm screening program. *Circulation.* 2016; 134(16): 1141-8.

Jacomelli et al.[1207] report on screening of 65 year-old men and Wanhainen et al.[1208] on 65 – 74 year old men, so it can be inferred that their results are taken from a younger cohort than is reported by Schermerhorn and colleagues.[1209]

- In a report using Ontario data de Mestral and colleagues report a 90-day mortality rate following endovascular repair of 1.6%.[1210]
- Reporting on outcomes of open repair of AAA in Ontario, Dubois and colleagues report a 30-day mortality for open repair of 3%.[1211]

- We model a 30-day mortality of 1.0% and 3.0% for elective endovascular and open surgery respectively (Table 5, rows *z* & *aa* and *ar* & *as*).

- In their evidence synthesis for the USPSTF, Guirguis-Blake and colleagues report an estimate of 41% mortality (either in hospital or 30-day) associated with emergency surgery for AAA.[1212]

- We model an emergency surgery 30-day mortality of 41% (Table 5, row *ae* & *ax*).

Based on these assumptions, the CPB associated with screening for abdominal aortic aneurysms in males aged 65 who have ever smoked is 495 QALYs (see Table 5, row *bk*).

Comparison to Actual BC Data

Analysis from the discharge abstract database in BC from 2013/14 – 2017/18 indicates that 77.8 / 100,000 men over 65 years old had elective AAA surgery and 24.8 / 100,000 men over 65 years old had emergency and / or ruptured AAA surgery, a ratio of 3.14. [1213] Our model calculates these rates at 88.4 /100,000 and 21.4 / 100,000 respectively, a difference of approximately 14% from the actuals in both cases. With no screening (i.e. in the control group), the Viborg study reported the same rates of elective and emergency surgery (see Table 4). If there was no screening in BC, we might expect a similar ratio as the unscreened population in the Viborg study. The fact that there are more than three times as many elective as emergency surgeries in BC suggests that BC physicians are already opportunistically screening their patients in the province. In the fully screened population analysed by the USPSTF, [1214] the ratio of elective to emergency surgeries was 4.13, indicating that while

[1207] Jacomelli J, Summers L, Stevenson A et al. Impact of the first 5 years of a national abdominal aortic aneurysm screening programme. *British Journal of Surgery*. 2016; 103(9): 1125-31.

[1208] Wanhainen A, Hultgren R, Linné A et al. Outcome of the Swedish nationwide abdominal aortic aneurysm screening program. *Circulation.* 2016; 134(16): 1141-8.

[1209] Schermerhorn ML, Buck DB, O'malley AJ et al. Long-term outcomes of abdominal aortic aneurysm in the Medicare population. *New England Journal of Medicine*. 2015; 373(4): 328-38.

[1210] de Mestral C, Croxford R, Eisenberg N et al. The impact of compliance with imaging follow-up on mortality after endovascular abdominal aortic aneurysm repair: a population based cohort study. *European Journal of Vascular and Endovascular Surgery*. 2017; 54(3): 315-23.

[1211] Dubois L, Shariff S, Jenkyn KB et al. PC010 Higher Surgeon Annual Volume, but Not Years of Experience, Leads to Reduced Rates of Perioperative Complications and Reoperations Following Open AAA Repair. *Journal of Vascular Surgery.* 2017; 65(6): 143S-4S.

[1212] Guirguis-Blake J, Beil T, Sun X et al. Primary Care Screening for Abdominal Aortic Aneurysm: A Systematic Evidence Review for the US Preventive Services Task Force. Evidence Synthesis No. 109. 2014: Available at https://www.ncbi.nlm.nih.gov/books/NBK184793/. Accessed January 2019.

[1213] Aciemme (Sam) Ospan, Senior Manager, Lifetime Prevention Schedule, Healthy Living and Health Promotion Branch, BC Ministry of Health. June 3, 2019. Personal communication.

[1214] Guirguis-Blake J, Beil T, Sun X et al. Primary Care Screening for Abdominal Aortic Aneurysm: A Systematic Evidence Review for the US Preventive Services Task Force. Evidence Synthesis No. 109. 2014: Available at https://www.ncbi.nlm.nih.gov/books/NBK184793/. Accessed January 2019.

opportunistic screening is occurring in BC, it has not yet reached a level in which the majority of eligible males (we model a 'best-in-the –world' rate of 85.8%[1215]) are screened.

Table 5: CPB of Abdominal Aortic Aneurysm Screening in Ever-Smoking Men 65+ In a BC Birth Cohort of 40,000			
Row Label	**Variable**	**Base Case**	**Data Source**
	Deaths and Life-Years Lost due to AAA in an Unscreened Cohort		
a	Number of 65-year old men in cohort	17,208	BC Life Table
b	Proportion of population, *never-smokers*	47.0%	√
c	Proportion of population, *former smokers*	40.1%	√
d	Proportion of population, *current smokers*	12.9%	√
e	Prevalence of AAA in population	2.35%	√
f	Prevalence of AAA in *never-smokers*	1.21%	Table 2
g	Prevalence of AAA in *former smokers*	2.54%	Table 2
h	Prevalence of AAA in *current smokers*	5.90%	Table 2
i	Life years for cohort from 65 - 84	286,132	Table 3
j	Life years, ever-smokers for cohort from 65 - 84	151,650	= i * (c + d)
k	Number with AAA in cohort at age 65, *never-smokers*	98	=a * b * f
l	Number with AAA in cohort at age 65, *former smokers*	176	=a * c * g
m	Number with AAA in cohort at age 65, *current smokers*	131	=a * d * h
n	Number of AAA-related deaths over cohort lifetime	149	Table 3
o	Fraction of those with AAA dying over cohort lifetime, total population	36.9%	= n / (k + l + m)
p	Number of deaths over cohort lifetime, **never-smokers**	**36**	= k * o
q	Number of deaths over cohort lifetime, **former smokers**	**65**	= l * o
r	Number of deaths over cohort lifetime, **current smokers**	**48**	= m * o
s	Life years lost over cohort lifetime, **never-smokers**	**377**	Table 3
t	Life years lost over cohort lifetime, **former smokers**	**675**	Table 3
u	Life years lost over cohort lifetime, **current smokers**	**503**	Table 3
	AAA-related deaths in an Unscreened Cohort of *Ever-Smokers*		
v	Rate of elective surgery per 100,000, unscreened population	41	Table 4
w	Number of elective surgeries in cohort	62	= (v / 100,000) * j
x	Proportion of elective surgeries that are endovascular	58%	√
y	Proportion of elective surgeries that are open	42%	= (1 - ag)
z	30-day mortality for elective endovascular AAA surgery	1.0%	√
aa	30-day mortality for elective open AAA surgery	3.0%	√
ab	Number of deaths associated with **elective surgeries**	**1.1**	= w * ((x * z) + (y * aa))
ac	Rate of emergency surgery per 100,000, unscreened population	41	Table 4
ad	Number of emergency surgeries in cohort	62	= (ac / 100,000) * j
ae	Death rate, emergency surgery	41%	√
af	Number of deaths associated with **emergency surgeries**	**25.6**	= ad * ae
ag	Number of deaths **prior to arriving at hospital for surgery**	**86.3**	= (q + r) - ab - af

[1215] Jacomelli J, Summers L, Stevenson A et al. Impact of the first 5 years of a national abdominal aortic aneurysm screening programme. *British Journal of Surgery*. 2016; 103(9): 1125-31.

Table 5: CPB of Abdominal Aortic Aneurysm Screening in Ever-Smoking Men 65+ In a BC Birth Cohort of 40,000			
Row Label	**Variable**	**Base Case**	**Data Source**
	AAA-related deaths in a Screened Cohort of *Ever-Smokers*		
ah	Number targeted for screening, base case: **ever-smokers** (current + former)	9,120	= a * (c + d)
ai	Screening Rate	85.8%	√
aj	Total Number screened	7,825	= v * w
ak	Proportion of AAA opportunistically detected without screening	13%	√
al	Relative risk of elective surgery, screened vs. unscreened population	2.15	√
am	Rate of elective surgery per 100,000, screened population	88.4	= al * v
an	Number of elective surgeries in cohort	134	= ((am / 100,000) * j)
ao	Number of elective surgeries in cohort, due to screening alone	62	= an * (1 - ak)
ap	Proportion of elective surgeries that are endovascular	58%	= x
aq	Proportion of elective surgeries that are open	42%	= y
ar	30-day mortality for elective endovascular AAA surgery	1.0%	= z
as	30-day mortality for elective open AAA surgery	3.0%	= aa
at	Number of deaths associated with **elective surgeries**	**2.5**	= an * ((ap * ar) + (aq * as))
au	Relative risk of emergency surgery, screened vs. unscreened population	0.52	√
av	Rate of emergency surgery per 100,000, unscreened population	21.4	= au *ac
aw	Number of emergency surgeries in cohort	32	= (au / 100,000) * j
ax	Death rate, emergency surgery	41%	√
ay	Number of deaths associated with **emergency surgeries**	**13.3**	= aw * ax
az	Relative risk of AAA-related death, overall, screened vs. unscreened population	0.58	√
ba	AAA-related deaths in screened cohort	66	= (q + r) * az
bb	Number of deaths **prior to arriving at hospital for surgery**	**49.8**	= ba - ay - at
	Difference in AAA-related deaths in a Screened vs. Unscreened Cohort of *Ever-Smokers*		
bc	Deaths due to elective surgeries, screened vs. unscreened	1.3	= at - ab
bd	Deaths due to emergency surgeries, screened vs. unscreened	-12.3	= ay - af
bf	Deaths prior to hospital arrival, screened vs. unscreened	-36.5	= bb - ag
bg	**Difference in total AAA-related deaths, screened vs. unscreened**	**-47.5**	= bc + bd + bf
bh	Total AAA-related deaths in unscreened cohort	113	= q + r
bi	Fraction of deaths avoided as a result of screening	42%	= (-bg) / bh
	Difference in Life Years, Screened vs. Unscreened Cohort of *Ever-Smokers*		
bj	Life years lost due to **death from** AAA in unscreened ever-smoking group	1178	Table 3
bk	QALYs saved by screening	495	= bi * bj

√ = Estimates from the literature

For the sensitivity analysis, we modified the relative risk assumptions and recalculated the CPB as follows:

- Assume that the relative risk of overall death is increased from 0.58 to 0.88 (Table 5, row *az*), the relative risk of elective surgery in screened individuals is *decreased* from 2.15 to 1.89 (Table 5, row *al*) and the relative risk of emergency surgery is increased from 0.52 to 0.66 (Table 5, row *au)*: **CPB = 141**
- Assume that the relative risk of overall death is decreased from 0.58 to 0.39 (Table 5, row az), the relative risk of elective surgery in screened individuals is *increased* from 2.15 to 2.44 (Table 5, row al) and the relative risk of emergency surgery is decreased from 0.52 to 0.40 (Table 5, row au): **CPB = 719**
- Offer screening to all 65 year old males, rather than to just 65 year old male ever-smokers (Table 5, rows *b*, *c* and *d*): CPB = 653

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with screening for abdominal aortic aneurysms in males ages 65 to 75 who have ever smoked

In modelling CE, we made the following assumptions:

- The single screen recommended by the USPSTF is conducted at age 65.
- The screen targets only the population of ever-smokers (i.e. current and former smokers). We assess the benefits of screening the whole population in our sensitivity analysis.
- For modelling purposes, we assume that 12.9% of men 65 years of age are current smokers (Table 6, row *d*) and 40.1% are former smokers (Table 6, row *c*).
- We assume that all 65 year old males will have at least one visit to their GP each year.
- We model a best-in-world screening acceptance rate of 85.8% (Table 6, row *e*).[1216]
- The cost of each 10 minute primary care provider office visit is $35.97 (Reference Document) (Table 6, row *g)*
- The value of patient time (based on 2 hours, including travel time) for each visit to a primary care office and for abdominal ultrasound screening is $74.32 (Reference Document) (Table 6, row *h*).
- The proportion of each office visit attributable to recommending screening is 50% (Reference Document) (Table 6, row *i*).
- The average service fee cost of an abdominal B-scan (ultrasound – fee item 8648) in BC in 2021 was $110.36 (Table 6, row *k*).[1217]
- Visser reported elective endovascular surgery costs at €20,767 (2003) or $41,113 (2022 CAD), with those costs rising to €23,588 (2003) or $46,697 (2022 CAD) if one-year follow-up costs were included.[1218]
- Matsumura and colleagues reported elective endovascular surgery costs between $34,800 – 38,900 USD (2008) or $37,797 – $42,250 (2022 CAD), depending on which device was used in the surgery.[1219]
- Similarly, in their cost-effectiveness analysis, Svensjo and colleagues use an elective endovascular surgery cost of €24,493 (2012), with that cost rising to €29,758 if post-

[1216] Jacomelli J, Summers L, Stevenson A et al. Impact of the first 5 years of a national abdominal aortic aneurysm screening programme. *British Journal of Surgery*. 2016; 103(9): 1125-31.
[1217] B.C. Ministry of Health, Health Sector Information, Analysis & Reporting Division. *MSP Fee-For-Service Payment Analysis 2016/2017 - 2020/2021*. 2021. Available at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msp_ffs_payment_analysis_20162017_to_20202021.pdf. Accessed September 2023.
[1218] Visser JJ, van Sambeek MR, Hunink MM et al. Acute abdominal aortic aneurysms: cost analysis of endovascular repair and open surgery in hemodynamically stable patients with 1-year follow-up. *Radiology*. 2006; 240(3): 681-9.
[1219] Matsumura JS, Stroupe KT, Lederle FA et al. Costs of repair of abdominal aortic aneurysm with different devices in a multicenter randomized trial. *Journal of Vascular Surgery*. 2015; 61(1): 59-65.

operative costs were included as well.[1220] Converted to 2022 CAD the amounts are $44,875 and $54,521 respectively.

- For elective endovascular surgery, Burgers and colleagues reported surgery costs of €14,690 (2013) or $25,260 (2022 CAD).[1221]

- Elective endovascular surgery costs, adjusted to 2022 CAD, range between $25,260 (Burgers et al.) and $54,521 (Svensjö et al.). We model elective endovascular AAA-repair surgery costs at $39,891 (the mid-point of this) and vary this to $25,260 and $54,521 in our sensitivity analysis (Table 6, row *s*).

- We noted previously that we assume a 30-day mortality of 1.0% and 3.0% for elective endovascular and open surgery respectively. This early mortality advantage associated with EVAR erodes over time, with no survival advantage after 4 to 5 years of follow-up.[1222,1223,1224]

- Based on 15 years of follow-up results from the UK EVAR trial, graft-related re-interventions remained higher in patients with endovascular repair compared with open repair. Overall, any graft-related re-intervention occurred in 26% of EVAR vs. 12% of open patients. Serious graft-related re-interventions occurred in 22% of EVAR vs. 9% of open patients while life-threatening re-interventions occurred in 14% of EVAR vs. 7% of open patients. The authors note that "there is no time to assume that it is safe to discontinue surveillance in patients who have had EVAR".[1225]

- Studies assessing the long-term cost-effectiveness of EVAR vs. open surgery that take into account the changing survival profile following EVAR and open surgery, as well as differential graft-related intervention rates, have found no differences in cost-effectiveness. Epstein and colleagues "did not find that EVAR is cost-effective compared with open repair in the long term in trials conducted in European centres."[1226] Lederle and co-authors conclude that, based on follow-up of 9 years, "survival, quality of life, costs and cost-effectiveness did not differ between elective open and endovascular repair of AAA."[1227] Cost-effectiveness studies with a follow-up period of less than 4 years, on the other hand, find EVAR to be cost-effective

[1220] Svensjö S, Mani K, Björck M et al. Screening for abdominal aortic aneurysm in 65-year-old men remains cost-effective with contemporary epidemiology and management. *European Journal of Vascular and Endovascular Surgery*. 2014; 47(4): 357-65.
[1221] Burgers L, Vahl A, Severens J et al. Cost-effectiveness of elective endovascular aneurysm repair versus open surgical repair of abdominal aortic aneurysms. *European Journal of Vascular and Endovascular Surgery*. 2016; 52(1): 29-40.
[1222] Patel R, Sweeting MJ, Powell JT et al. Endovascular versus open repair of abdominal aortic aneurysm in 15-years' follow-up of the UK endovascular aneurysm repair trial 1 (EVAR trial 1): a randomised controlled trial. *The Lancet*. 2016; 388(10058): 2366-74.
[1223] Deery SE and Schermerhorn ML. Open versus endovascular abdominal aortic aneurysm repair in Medicare beneficiaries. *Surgery*. 2017; 162(4): 721-31.
[1224] Powell JT, Sweeting MJ, Ulug P et al. Meta-analysis of individual-patient data from EVAR-1, DREAM, OVER and ACE trials comparing outcomes of endovascular or open repair for abdominal aortic aneurysm over 5 years. *British Journal of Surgery*. 2017; 104(3): 166-78.
[1225] Patel R, Sweeting MJ, Powell JT et al. Endovascular versus open repair of abdominal aortic aneurysm in 15-years' follow-up of the UK endovascular aneurysm repair trial 1 (EVAR trial 1): a randomised controlled trial. *The Lancet*. 2016; 388(10058): 2366-74.
[1226] Epstein D, Sculpher M, Powell J et al. Long-term cost-effectiveness analysis of endovascular versus open repair for abdominal aortic aneurysm based on four randomized clinical trials. *British Journal of Surgery*. 2014; 101(6): 623-31.
[1227] Lederle FA, Stroupe KT, Kyriakides TC et al. Long-term cost-effectiveness in the veterans affairs open vs endovascular repair study of aortic abdominal aneurysm: A randomized clinical trial. *JAMA Surgery.* 2016; 151(12): 1139-44.

compared with open surgery, largely due to the early survival advantages associated with EVAR.[1228]

- Because of this long term convergence in the benefits and costs between EVAR and open surgery, we have not taken into account the longer-term benefits or costs of EVAR or open surgery in our modelling.
- Visser reported elective open surgery costs at €35,470 (2003) or $70,220 (2022 CAD), with those costs rising to €36,448 (2003) or $72,157 (2022 CAD) if one-year follow-up costs were included.[1229]
- Matsumura and colleagues reported elective open surgery costs between $38,900 – $45,100 (2008 USD) or $42,250 – $48,984 (2022 CAD), depending on which device was used in the surgery.[1230]
- Similarly, in their cost-effectiveness analysis, Svensjo and colleagues use an elective open surgery cost of €30,099 (2012), with that cost rising to €35,615 if post-operative costs were included as well.[1231] Converted to 2022 CAD the amounts are $55,146 and $65,252 respectively.
- For elective open surgery, Burgers and colleagues reported surgery costs of €16,399 (2013) or $28,199 (2022 CAD).[1232]
- In papers not reporting on the specific type of elective surgery, the elective surgery costs ranged from $15,489 - $48,847 (2022 CAD).[1233,1234,1235,1236,1237,1238,1239,1240]

[1228] IMPROVE Trial Investigators. Comparative clinical effectiveness and cost-effectiveness of endovascular strategy v open repair for ruptured abdominal aortic aneurysm: three year results of the IMPROVE randomised trial. *British Medical Journal.* 2017; 359: j4859.
[1229] Visser JJ, van Sambeek MR, Hunink MM et al. Acute abdominal aortic aneurysms: cost analysis of endovascular repair and open surgery in hemodynamically stable patients with 1-year follow-up. *Radiology*. 2006; 240(3): 681-9.
[1230] Matsumura JS, Stroupe KT, Lederle FA et al. Costs of repair of abdominal aortic aneurysm with different devices in a multicenter randomized trial. *Journal of Vascular Surgery.* 2015; 61(1): 59-65.
[1231] Svensjö S, Mani K, Björck M et al. Screening for abdominal aortic aneurysm in 65-year-old men remains cost-effective with contemporary epidemiology and management. *European Journal of Vascular and Endovascular Surgery*. 2014; 47(4): 357-65.
[1232] Burgers L, Vahl A, Severens J et al. Cost-effectiveness of elective endovascular aneurysm repair versus open surgical repair of abdominal aortic aneurysms. *European Journal of Vascular and Endovascular Surgery*. 2016; 52(1): 29-40.
[1233] Lindholt JS, Sørensen J, Søgaard R et al. Long-term benefit and cost-effectiveness analysis of screening for abdominal aortic aneurysms from a randomized controlled trial. *British Journal of Surgery*. 2010; 97(6): 826-34.
[1234] Thompson S, Ashton H, Gao L et al. Screening men for abdominal aortic aneurysm: 10 year mortality and cost-effectiveness results from the randomised Multicentre Aneurysm Screening Study. *British Medical Journal.* 2009; 338: b2307.
[1235] Chew HF, You C, Brown MG et al. Mortality, morbidity, and costs of ruptured and elective abdominal aortic aneurysm repairs in Nova Scotia, Canada. *Annals of Vascular Surgery.* 2003; 17(2): 171-9.
[1236] Brox AC, Filion KB, Zhang X et al. In-hospital cost of abdominal aortic aneurysm repair in Canada and the United States. *Archives of Internal Medicine.* 2003; 163(20): 2500-4.
[1237] Wanhainen A, Lundkvist J, Bergqvist D et al. Cost-effectiveness of different screening strategies for abdominal aortic aneurysm. *Journal of Vascular Surgery.* 2005; 41(5): 741-51.
[1238] Silverstein MD, Pitts SR, Chaikof EL et al. Abdominal aortic aneurysm (AAA): cost-effectiveness of screening, surveillance of intermediate-sized AAA, and management of symptomatic AAA. *Baylor University Medical Center Proceedings*. 2005; 18(4): 345-67.
[1239] Montreuil B and Brophy J. Screening for abdominal aortic aneurysms in men: a Canadian perspective using Monte Carlo–based estimates. *Canadian Journal of Surgery*. 2008; 51(1): 23.
[1240] Giardina S, Pane B, Spinella G et al. An economic evaluation of an abdominal aortic aneurysm screening program in Italy. *Journal of Vascular Surgery.* 2011; 54(4): 938-46.

- Elective open surgery costs, adjusted to 2022 CAD, range between $28,199 (Burgers et al.) and $72,157 (Visser et al.). We model elective open AAA-repair surgery costs at $50,178 (open surgery mid-point) and vary this to $28,199 and $72,157 in our sensitivity analysis (Table 6, row *t*).

- Chew and colleagues reported that emergency AAA-repair surgery costs in Nova Scotia were $18,899 (1998 CAD), including overhead. This is equivalent to $30,733 (2022 CAD).[1241]
- In a Swedish cost analysis, Wanhainen and colleagues used €32,183 (2003) for emergency AAA-repair with rupture or $55,354 (2022 CAD).[1242]
- In a model of US costs, Silverstein and colleagues used $60,000 (2003) USD to account for emergency surgery and emergency care costs. Adjusted to 2022 CAD, this comes to $74,425.[1243]
- Montreuil and colleagues conducted a Monte Carlo analysis of screening Canadian men for AAA and used $35,982 (2005 CAD) for emergency AAA-repair surgery costs, equivalent to $48,630 (2022 CAD).[1244]
- Lindholt and colleagues reported an emergency AAA-repair surgery cost of €35,928 (2007) in Denmark or $69,876 (2022 CAD).[1245]
- Reporting on the cost-effectiveness of screening using the MASS results, Thompson and colleagues used an emergency AAA-repair cost of £14,825 (2008) or $32,831 (2022 CAD).[1246]
- Giardina and colleagues report an emergency AAA-repair cost of €15,602 (2009) in Italy, or $30,364 (2022 CAD).[1247]

- Emergency AAA-repair surgery costs, adjusted to 2022 CAD, range between $30,364 (Giardina et al.) and $74,425 (Silverstein et al.). We model the cost of emergency surgery as $46,853 (mid-point of emergency surgery range) and vary this from $30,364 to $74,425 in our sensitivity analysis (Table 6, row *ao*).

- Chew et al. reported a mean length of stay in Nova Scotia of 19.57 days in hospital for emergency surgery survivors and 9.22 days in hospital for emergency surgery patients who died.[1248] We model accordingly (Table 6, rows *aq* & *ar*)

[1241] Chew HF, You C, Brown MG et al. Mortality, morbidity, and costs of ruptured and elective abdominal aortic aneurysm repairs in Nova Scotia, Canada. *Annals of Vascular Surgery.* 2003; 17(2): 171-9.
[1242] Wanhainen A, Lundkvist J, Bergqvist D et al. Cost-effectiveness of different screening strategies for abdominal aortic aneurysm. *Journal of Vascular Surgery.* 2005; 41(5): 741-51.
[1243] Silverstein MD, Pitts SR, Chaikof EL et al. Abdominal aortic aneurysm (AAA): cost-effectiveness of screening, surveillance of intermediate-sized AAA, and management of symptomatic AAA. *Baylor University Medical Center Proceedings*. 2005; 18(4): 345-67.
[1244] Montreuil B and Brophy J. Screening for abdominal aortic aneurysms in men: a Canadian perspective using Monte Carlo–based estimates. *Canadian Journal of Surgery*. 2008; 51(1): 23.
[1245] Lindholt JS, Sørensen J, Søgaard R et al. Long-term benefit and cost-effectiveness analysis of screening for abdominal aortic aneurysms from a randomized controlled trial. *British Journal of Surgery*. 2010; 97(6): 826-34.
[1246] Thompson S, Ashton H, Gao L et al. Screening men for abdominal aortic aneurysm: 10 year mortality and cost-effectiveness results from the randomised Multicentre Aneurysm Screening Study. *British Medical Journal.* 2009; 338: b2307.
[1247] Giardina S, Pane B, Spinella G et al. An economic evaluation of an abdominal aortic aneurysm screening program in Italy. *Journal of Vascular Surgery.* 2011; 54(4): 938-46.
[1248] Chew HF, You C, Brown MG et al. Mortality, morbidity, and costs of ruptured and elective abdominal aortic aneurysm repairs in Nova Scotia, Canada. *Annals of Vascular Surgery.* 2003; 17(2): 171-9.

- The Canadian Society for Vascular Surgery (CSVS) and HealthLinkBC agree that hospital stays for elective endovascular AAA-repair surgery will range between 1 – 3 days.[1249,1250]
- The Canadian Society for Vascular Surgery suggests that elective open AAA-repair surgery will require 5 – 7 days in hospital.[1251]
- Analysis from the discharge abstract database in BC from 2013/14 – 2017/18 indicates the average length of stay for elective endovascular AAA repair in BC is no less than 4 days, while the average length of stay for elective open AAA repair is 10 days.[1252]
- HealthLinkBC states that patients will typically fully recover 4 weeks after *endovascular* AAA-repair surgery and suggests planning to take 1 - 2 weeks off work.[1253] The CSVS reports a full recovery time between 2 – 4 weeks.[1254]
- HealthLinkBC states that patients will typically resume "usual activities" 4 – 6 weeks after *open* AAA-repair surgery and that full recovery will take 2 – 3 months.[1255] The CSVS reports a full recovery time between 1 – 3 months.[1256]

- For the purposes of calculating patient time costs, we model 4 days and 10 days in hospital for elective endovascular and open AAA-repair surgeries respectively (Table 6, rows *v* & *w*). We model time off work at 10 days (midpoint of 1 – 2 weeks) and 35 days (midpoint of 4 – 6 weeks) for endovascular and open AAA-repair surgeries respectively (Table 6, rows *x* & *y*). In our sensitivity analysis we range the days off work between 7 – 14 for endovascular and 28 – 42 for open surgery.

- Emergency ground transport in BC costs $848 for non-MSP beneficiaries.[1257] This can be considered the unsubsidized cost of emergency ground transportation.

- We model that the difference in the sum of emergency surgeries and deaths prior to hospitalization for AAA between the unscreened and screened cohort is equivalent to the number of avoided emergency transports (Table 6, row *ay*). These emergency transports each cost $530 (Table 6, row *az*).

Based on these assumptions, the CE associated with screening for abdominal aortic aneurysms in males ages 65 to 75 who have ever smoked is $9,300 / QALY (see Table 6, row *bg*).

[1249] Canadian Society for Vascular Surgery. *Abdominal Aortic Aneurysm.* 2018. Available at https://canadianvascular.ca/Abdominal-Aortic-Aneurysms. Accessed February 2019.
[1250] HealthLinkBC. *Endovascular Repair for Abdominal Aortic Aneurysm.* 2018. Available at https://www.healthlinkbc.ca/health-topics/abn3549#abn3550. Accessed February 2019.
[1251] Canadian Society for Vascular Surgery. *Abdominal Aortic Aneurysm.* 2018. Available at https://canadianvascular.ca/Abdominal-Aortic-Aneurysms. Accessed February 2019.
[1252] Aciemme (Sam) Ospan, Senior Manager, Lifetime Prevention Schedule, Healthy Living and Health Promotion Branch, BC Ministry of Health. June 3, 2019. Personal communication.
[1253] HealthLinkBC. *Endovascular Repair for Abdominal Aortic Aneurysm.* 2018. Available at https://www.healthlinkbc.ca/health-topics/abn3549#abn3550. Accessed February 2019.
[1254] Canadian Society for Vascular Surgery. *Abdominal Aortic Aneurysm.* 2018. Available at https://canadianvascular.ca/Abdominal-Aortic-Aneurysms. Accessed February 2019.
[1255] HealthLinkBC. *Open Repair Surgery for Abdominal Aortic Aneurysm.* 2018. Available at https://www.healthlinkbc.ca/health-topics/abn3540. Accessed February 2019
[1256] Canadian Society for Vascular Surgery. *Abdominal Aortic Aneurysm.* 2018. Available at https://canadianvascular.ca/Abdominal-Aortic-Aneurysms. Accessed February 2019.
[1257] Island Health. *Emergency Transport Fees*. 2023. Available at https://www.islandhealth.ca/patients-visitors/fees-payments/patient-transportation-fees. Accessed November 2023.

Table 6: Cost Effectiveness of Abdominal Aortic Aneurysm Screening in Ever-Smoking Men 65+ In a BC Birth Cohort of 40,000			
Row Label	Variable	Base case	Data Source
a	Number of 65-year old men in cohort	17,208	BC Life Table
b	Proportion who are former smokers	40.1%	√
c	Proportion who are current smokers	12.9%	√
d	Number targeted for screening	9,120	= a * (d + e)
e	Screening Rate	85.8%	√
f	Total Number screened	7,825	= f * g
g	Cost of 10 minute office visit	$35.97	Ref Doc
h	Value of patient time and travel for office visit	$74.32	Ref Doc
i	Portion of 10-minute office visit for screening	50%	Ref Doc
j	Cost of initial primary care visit for cohort	$431,519	= f * (g + h) * i
k	Cost of ultrasonic screening session	$110	√
l	Cost of ultrasonic screening for cohort	$1,445,190	= f * (h + k)
m	Number of elective surgeries in ever-smokers, unscreened	62	Table 5, row w
n	Number of elective surgeries in ever-smokers, screened	134	Table 5, row an
o	Rate of opportunistically detected AAA	13%	Table 5, row ak
p	Number of additional elective surgeries attributable to screening alone	62	= ((n - m) * (1 - o))
q	Proportion of surgeries that are endoscopic surgeries	58%	Table 5, row ap
r	Proportion of surgeries that are open surgeries	42%	= 1 - q
s	Cost per elective surgery, endoscopic AAA repair	$39,891	√
t	Cost per elective surgery, open AAA repair	$50,178	√
u	Cost of additional elective surgery due to screening	$2,756,748	= p * ((q * s) + (r * t))
v	Time in hospital, days, endovascular AAA repair	4	√
w	Time in hospital, days, open AAA repair	10	√
x	Recovery time, days, endovascular AAA repair	10	√
y	Recovery time, days, open AAA repair	35	√
z	Cost per day of patient time in hospital	$279	Ref Doc
aa	Patient time cost for additional elective AAA surgeries	$468,262.78	= p * ((q * (v + x)) + (r * (w + y)) * z
ab	Number of elective surgeries, endoscopic	36	= p * q
ac	Cost of CT Scan	$223.50	√
ad	Cost of office visit, 100% for AAA follow-up	$110	= g + h
ae	Average life expectancy of 65-year old man	20	BC Life Table
af	Estimated compliance with annual follow-up protocol	70%	√
ag	Cost of CT Scans	$113,825	= ab * ac * ae * af
ah	Cost of follow-up office visits	$56,169	= ab * ad * ae * af
ai	Lifetime failure rates of EVAR	10%	√
aj	Cost to correct EVAR failure with open surgery	$182,535	= ab * ai * t
ak	Total cost due to additional elective AAA surgery in cohort	$3,577,540	= u + aa + ag + ah + aj
al	Number of emergency surgeries in ever-smokers, unscreened	62.4	Table 5, row ad
am	Number of emergency surgeries in ever-smokers, screened	32.4	Table 5, row aw
an	Reduction in emergency surgeries in screened population	29.9	= al - am
ao	Cost of emergency surgery, AAA rupture repair	$52,395	√
ap	Cost reduction due to avoided surgery	$1,568,479	= an * ao
aq	Time in hospital, emergency AAA repair, survivors	19.57	√
ar	Time in hospital, emergency AAA repair, patients who die	9.22	√
as	Death rate, emergency surgery	41%	√
at	Average time in hospital, emergency AAA repair	15.3	= ((aq * (1 - as)) + (ar * as))
au	Patient time cost avoided due to avoided emergency surgery	$127,870	an * at * z
av	Total cost reduction due to avoided surgeries	$1,696,349	= ap + av
aw	Number of emergency surgeries and pre-hospital deaths, unscreened cohort	149	Table 5, row ad + Table 5, row ag
ax	Number of emergency surgeries and pre-hospital deaths, screened cohort	82	Table 5, row aw + Table 5, row bb
ay	Number of avoided emergency transports due to screening	66	= aw - ax
az	Average cost of emergency transport	$848	√
ba	Avoided emergency transportation cost	$56,348	= ay * az
bb	Net cost of intervention	$3,701,553	= j + l + ak - av - ba
bc	QALYs saved	495	Table 5, row bk
bd	Cost effectiveness (CE) of intervention, $/QALY	$7,479	= bb / bc
be	Net Cost of Intervention (1.5% Discount)	$3,874,550	Calculated
bf	Net QALYs Gained (1.5% Discount)	417	Calculated
bg	Cost Effectiveness (CE) of Intervention, $/QALY (1.5% Discount)	$9,300	= be / bf

√ = Estimates from the literature

For the sensitivity analysis, we modified a number of major assumptions and recalculated the CE as follows:

- Assume that the relative risk of overall death moves from 0.58 to 0.88 (Table 5, row *az*), the relative risk of elective surgery in screened individuals is *decreased* from 2.15 to 1.89 (Table 5, row *al*) and the relative risk of emergency surgery moves from 0.52 to 0.66 (Table 5, row *au)*: **CE = $29,687**
- Assume that the relative risk of overall death moves from 0.58 to 0.39 (Table 5, row *az*), the relative risk of elective surgery in screened individuals is *increased* from 2.15 to 2.44 (Table 5, row *al*) and the relative risk of emergency surgery moves from 0.52 to 0.40 (Table 5, row *au)*: **CE = $7,230**
- Assume the rate of opportunistically detected AAA in the population increases from 13% to 25% (Table 5, row *ak*): CE = $8,150
- Assume the rate of opportunistically detected AAA in the population decreases from 13% to 7% (Table 5, row *ak*): CE = $9,875
- Assume the cost of elective endovascular surgery increases from $39,891 to $54,521 (Table 6, row *s*), the cost of elective open endovascular surgery increases from $50,178 to $72,157 (Table 6, row *t*), and the cost of emergency AAA-repair surgery increases from $52,395 to $74,425 (Table 6, row *ao*): CE = $10,726
- Assume the cost of elective endovascular surgery decreases from $39,891 to $25,260 (Table 6, row *s*), the cost of elective open endovascular surgery decreases from $50,178 to $28,199 (Table 6, row *t*), and the cost of emergency AAA-repair surgery decreases from $52,395 to $30,364 (Table 6, row *ao*): CE = $7,873
- Assume that the time off work for elective endovascular surgery increases from 10 to 14 days (Table 6, row *x*) and the time off work for elective open surgery increases from 35 to 42 days (Table 6, row *y*): CE = $9,512
- Assume that the time off work for elective endovascular surgery decreases from 10 to 7 days (Table 6, row *x*) and the time off work for elective open surgery increases from 35 to 28 days (Table 6, row *y*): CE = $9,110
- Offer screening to all 65 year old males, rather than to just 65 year old male ever-smokers (Table 5, rows *b*, *c* and *d*): CE = $13,455

Summary

Ever-Smoking Males Ages 65 and Older

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening for, and treatment of, abdominal aortic aneurysm in ever-smoking males ages 65 and older is estimated to be 417 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $9,300 per QALY (see Table 7).

Table 7: Abdominal Aortic Aneurysm Screening in Ever-Smoking Men 65+ in a BC Birth Cohort of 40,000

Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume No Current Service			
1.5% Discount Rate	**417**	119	605
3% Discount Rate	353	101	513
0% Discount Rate	495	141	719
CE ($/QALY) ***including*** patient time costs			
1.5% Discount Rate	**$9,300**	$7,230	$29,687
3% Discount Rate	$11,317	$8,829	$35,788
0% Discount Rate	$7,479	$5,784	$24,193
CE ($/QALY) ***excluding*** patient time costs			
1.5% Discount Rate	$6,285	$4,993	$19,805
3% Discount Rate	$7,756	$6,187	$24,131
0% Discount Rate	$4,952	$3,911	$15,894

All Males Ages 65 and Older

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening for, and treatment of, abdominal aortic aneurysm in in all males ages 65 and older is estimated to be 550 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $13,455 per QALY (see Table 8).

Table 8: Abdominal Aortic Aneurysm Screening in Men 65+ in a BC Birth Cohort of 40,000

Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume No Current Service			
1.5% Discount Rate	**550**	157	799
3% Discount Rate	466	133	677
0% Discount Rate	653	187	949
CE ($/QALY) ***including*** patient time costs			
1.5% Discount Rate	**$13,455**	$10,489	$42,671
3% Discount Rate	$16,339	$12,775	$51,394
0% Discount Rate	$10,853	$8,423	$34,817
CE ($/QALY) ***excluding*** patient time costs			
1.5% Discount Rate	$9,145	$7,292	$28,542
3% Discount Rate	$11,248	$8,998	$34,727
0% Discount Rate	$7,240	$5,745	$22,952

Screening for Sexually Transmitted Infections and Blood Borne Pathogens

Human Immunodeficiency Virus

United States Preventive Services Task Force Recommendations (2013)

> *An estimated 1.2 million persons in the United States are currently living with HIV infection, and the annual incidence of the disease is approximately 50 000 cases. Since the first cases of AIDS were reported in 1981, more than 1.1 million persons have been diagnosed and nearly 595 000 have died from the condition.*
>
> *Approximately 20% to 25% of individuals living with HIV infection are unaware of their positive status.*
>
> *The USPSTF recommends that clinicians screen adolescents and adults aged 15 to 65 years for HIV infection. Younger adolescents and older adults who are at increased risk should also be screened. (A recommendation)*
>
> *The USPSTF recommends that clinicians screen all pregnant women for HIV, including those who present in labor who are untested and whose HIV status is unknown. (A recommendation)*[1258]

Canadian Task Force on Preventive Health Care Recommendations (2016)

The CTFPHC has reviewed the USPSTF guideline on screening for HIV infection and conclude that it "is a high-quality guideline, but the CTFPHC does not recommend its use in Canada. In the opinion of the CTFPHC, available evidence does not justify routinely screening all adult Canadians for HIV." Instead, the focus should be on screening high-risk groups and pregnant women.[1259]

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with screening adolescents and adults aged 15 to 65 years for HIV infection in a BC birth cohort of 40,000.

In modelling CPB, we made the following assumptions:

- The total number of individuals living with HIV infections in BC is estimated to be 12,100 (with a range from 9,700 to 14,500) (see Table 1).[1260]

[1258] Moyer VA. Screening for HIV: U.S. Preventive Services Task Force Recommendation Statement. *Annals of Internal Medicine*. 2013; 159(1): 51-60.
[1259] Canadian Task Force on Preventive Health Care. *HIV 2013 Critical Appraisal Report.* Available online at https://canadiantaskforce.ca/wp-content/uploads/2016/05/2013-hiv-en-ca-final.pdf. Accessed February 2018.
[1260] BC Centre for Disease Control. *HIV in British Columbia: Annual Surveillance Report 2015*. 2017. Available online at http://www.bccdc.ca/resource-gallery/Documents/Statistics%20and%20Research/Statistics%20and%20Reports/STI/HIV_Annual_Report_2015-FINAL.pdf. Accesed February 2018.

Table 1: Estimated Number of Prevalent HIV Infections In British Columbia by Exposure Category 2014

Exposure Category	Number	Range		% of Total
MSM	5,500	4,400	6,600	45%
MSM-PWID	385	270	500	3%
PWID	3,400	2,700	4,100	28%
HET (non-endemic)	2,220	1,740	2,700	18%
HET (endemic)	470	340	600	4%
Other	125	80	170	1%
All	12,100	9,700	14,500	

MSM - Men who have sex with men
PWID - People who inject drugs
HET (non-endemic) - Heterosexual contact with a person who is either HIV-infected or at risk for HIV or heterosexual as the only identified risk
HET (endemic) - Heterosexual contact and origin from a country where HIV is endemic
Other - Recipients of blood transfusion or clotting factor, perinatal, and occupational transmission

- 20% of HIV-infected men who have sex with men (MSM), 24% of HIV-infected injection drug users (IDU) and 34% of HIV-infected heterosexuals (HET) are unaware of their HIV status (Table 2, rows *c*, *f* & *i*).[1261]
- Adherence with universal screening was assumed to be 83% for MSM, 45% for HET and 60% for IDU (Table 2, rows *u*, *v* & *w*) (see Reference Document).
- 4.56% of HIV infected individuals die prematurely without early initiation of antiretroviral therapy (ART) (deferring initiation of ART to CD4 levels of 200 cells/µL). This can be reduced to 1.11% with early initiation of ART (Table 2, rows *y* & *z*).[1262]
- The average age at which undiagnosed HIV is detected is 40 (Table 2, row *bb*).[1263]
- The gain in quality of life associated with early detection and treatment of an HIV infection is 0.11 (Table 2, row *ee*).[1264]
- Antiretroviral therapy is a potent intervention for prevention of HIV in discordant couples. The RCT by Cohen, et al. found that just 1 of 28 transmissions occurred in a serodiscordant couple in which the infected partner received early initiation of antiretroviral therapy (a hazard ratio of 0.04; 95% CI from 0.01 to 0.27).[1265] The 2013 Cochrane review by Anglemyer and colleagues noted the RCT study by Cohen, et al. as well as nine observational studies. Results from the observational studies suggested that treating the HIV-infected partner in a serodiscordant couple reduces the risk of transmission by 64% (a relative risk of 0.36; 95% CI from 0.17 to

[1261] Public Health Agency of Canada. *Summary: Estimates of HIV Prevalence and Incidence in Canada, 2011*. 2011. Available at http://www.phac-aspc.gc.ca/aids-sida/publication/survreport/assets/pdf/estimat2011-eng.pdf. Accessed May 2014.
[1262] Siegfried N, Uthman OA and Rutherford GW. Optimal time for initiation of antiretroviral therapy in asymptomatic, HIV-infected, treatment-naive adults. *Cochrane Database of Systematic Reviews.* 2011.
[1263] Ibid.
[1264] Long EF, Brandeau ML and Owens DK. The cost-effectiveness and population outcomes of expanded HIV screening and antiretroviral treatment in the United States. *Annals of Internal Medicine*. 2010; 153(12): 778-89.
[1265] Cohen MS, Chen YQ, McCauley M et al. Prevention of HIV-1 infection with early antiretroviral therapy. *New England Journal of Medicine*. 2011; 365(6): 493-505.

0.75).[1266,1267] In BC, the expanded utilization of highly active antiretroviral therapy (HAART) between 1996 and 2012 is associated with a 66% decrease in new diagnoses of HIV.[1268] To incorporate this information into our model, we first calculated the rate per person year of HIV transmission in HIV-discordant couples if the HIV-positive partner is not treated with ART. This is based on the results from the control arms of the 1 RCT and 9 observational studies included in the Cochrane review by Anglemyer et al. (1,094 transmissions during 42,917 person-years, a transmission rate of 0.0255 per person-year, Table 2, row *gg*). We then assumed a 64% reduction in the transmission rate per person-year if the HIV-positive partner is treated with ART. This results in an annual transmission rate of 0.0092 per person-year (Table 2, row *hh*). In the sensitivity analysis we used results from the Cohen et al study (96% reduction) as the upper bounds and the 95% CI from the 9 observational studies reviewed by Anglemyer et al (RR of 0.75 or a 25% reduction) as the lower bounds.

- We assumed that the 16.58 infections avoided associated with screening and the early treatment with ART (Table 2, row *kk*) would lead to an additional 11.91 infections avoided (Table 2, row *nn*), due to second order transmission benefits.
- The difference in quality of life between avoided infection and symptomatic HIV treated with ART is 0.17 (Table 2, row *oo*).[1269]
- Other assumptions used in assessing the clinically preventable burden are detailed in the Reference Document.

Based on these assumptions, the calculation of CPB (Table 2, row *qq*) is 360 QALYs. This represents the potential CPB of moving from no screening to 45% in the heterosexual population, 60% in people who inject drugs and 83% in men who have sex with men.

[1266] Anglemyer A, Rutherford GW, Horvath T et al. Antiretroviral therapy for prevention of HIV transmission in HIV-discordant couples. *Cochrane Database of Systematic Reviews.* 2013.
[1267] Anglemyer A, Horvath T and Rutherford G. Antiretroviral therapy for prevention of HIV transmission in HIV-discordant couples. *Journal of the American Medical Association*. 2013; 310(15): 1619-20.
[1268] Montaner JS, Lima VD, Harrigan PR et al. Expansion of HAART coverage is associated with sustained decreases in HIV/AIDS morbidity, mortality and HIV transmission: the "HIV Treatment as Prevention" experience in a Canadian setting. *PLoS One*. 2014; 9(2): e87872.
[1269] Long EF, Brandeau ML and Owens DK. The cost-effectiveness and population outcomes of expanded HIV screening and antiretroviral treatment in the United States. *Annals of Internal Medicine*. 2010; 153(12): 778-89.

Table 2: CPB of Screening to Detect and Treat HIV in a BC Birth Cohort of 40,000			
Row Label	**Variable**	**Base Case**	**Data Source**
a	Prevalence of HIV Infections in B.C.	12,100	Table 1
b	Prevalence of HIV Infections in MSM	5,500	√
c	% Undiagnosed in MSM	20%	√
d	Undiagnosed HIV in MSM	1,100	= b*c
e	Prevalence of HIV Infections in PWID	3,785	√
f	% Undiagnosed in PWID	24%	√
g	Undiagnosed HIV in PWID	908	= e*f
h	Prevalence of HIV Infections in HET	2,690	√
i	% Undiagnosed in HET	34%	√
j	Undiagnosed HIV in HET	915	= h*i
k	Undiagnosed HIV in BC	2,923	= d+g+j
l	Diagnosed HIV in BC	9,177	= a-k
m	BC Population Ages 15-65	3,239,000	√
n	Prevalence / 100,000 Diagnosed HIV	283	=l/(m/100,000)
o	Prevalence / 100,000 Undiagnosed HIV	90	=k/(m/100,000)
p	Est. diagnosed HIV in BC birth cohort of 40,000	113	= n*0.4
q	Est. undiagnosed HIV in BC birth cohort of 40,000	36	= o*0.4
r	Est. undiagnosed HIV in BC birth cohort of 40,000 - MSM	14	= (d/k)*q
s	Est. undiagnosed HIV in BC birth cohort of 40,000 - PWID	11	= (g/k)*q
t	Est. undiagnosed HIV in BC birth cohort of 40,000 - HET	11	= (j/k)*q
u	Adherence with screening - MSM	83.0%	Ref Doc
v	Adherence with screening - PWID	60.0%	√
w	Adherence with screening - HET	45.0%	Ref Doc
x	Previously undiagnosed HIV infections detected by universal screening	23.09	=r*u+s*v+t*w
y	% early death without early initiation of antiretroviral therapy (ART)	4.56%	√
z	% early death with early initiation of ART	1.11%	√
aa	Early deaths avoided with early initiation of ART	0.80	=(x*y)-(x*z)
bb	Average age at which undiagnosed HIV infection detected	40	√
cc	Life expectancy of a 40 year-old	44	√
dd	QALYs gained - premature death avoided	35.0	=aa*cc
ee	Gain in QoL associated with early detection and treatment of HIV	0.11	√
ff	QALYs gained - early detection and treatment	112	=x*cc*ee
gg	HIV transmission in HIV-discordant couples, HIV positive partner **untreated** with ART - rate/person year	0.0255	√
hh	HIV transmission in HIV-discordant couples, HIV positive partner **treated** with ART - rate/person year	0.0092	√
ii	Potential HIV transmissions, HIV positive partner **untreated** with ART	25.91	=x*cc*gg
jj	Potential HIV transmissions, HIV positive partner **treated** with ART	9.33	=x*cc*hh
kk	Infections avoided per early detection associated with ART-first order	16.58	=ii-jj
ll	Potential HIV transmissions, HIV positive partner **untreated** with ART	18.60	=kk*gg*cc
mm	Potential HIV transmissions, HIV positive partner **treated** with ART	6.70	=kk*hh*cc
nn	Infections avoided per early detection associated with ART-second order	11.91	=ll-mm
oo	Difference in QoL associated with no infection vs. symptomatic infection treated with ART	0.17	√
pp	QALYs gained - infections avoided due to ART	213	=(kk+nn)*cc*oo
qq	Total QALYs gained, Utilization increasing from 0% to 45% for HET, 60% for PWID and 83% for MSM	360	=dd+ff+pp

√ = Estimates from the literature

We also modified several major assumptions and recalculated the CPB as follows:

- Assume the prevalence of individuals living with HIV infections in BC is decreased from 12,100 to 9,700 (Table 2, row *a*): CPB = 288.
- Assume the prevalence of individuals living with HIV infections in BC is increased from 12,100 to 14,500 (Table 2, row *a*): CPB = 431.
- Assume that the early initiation of antiretroviral therapy is associated with a 96% reduction (from 64%) in the transmission rate per person-year (Table 2, row *hh*): **CPB = 533.**
- Assume that the early initiation of antiretroviral therapy is associated with a 25% reduction (from 64%) in the transmission rate per person-year (Table 2, row *hh*): **CPB = 209**.

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with screening adolescents and adults aged 15 to 65 years for HIV infection in a BC birth cohort of 40,000.

In modelling CE, we made the following assumptions:

- **Number of screens** – We have assumed screening between the ages of 15-65 would occur every year in high risk populations and once every 5 years in low-risk populations.[1270] Long and colleagues estimated the high-risk population to be 2.85% of the total population ages 15-65 in the US[1271] and 1.62% in the UK.[1272] We assumed 2.85% for BC (Table 3, row *a*). In the sensitivity analysis, we adjusted screening once every five years in the low-risk population to once every 10 years and once per lifetime.
- **True / false positive screens** – The ratio of true to false positive test results is 1:1 (Table 3, row *i*).[1273]
- **Laboratory cost per screen** – The estimated cost per screen is $7 (with a range from $5 to $9). The estimated cost of confirming true / false positive results is $400 (with a range from $300 to $500).[1274] We increased these costs to 2022 CAD with an estimated cost per screen of $7.89 ($5.63 to $10.14) and the estimated cost of confirming true / false positive results of $451 ($338 to $563) (Table 3, rows *m* & *n*).
- **Cost of a counselling session** - We estimated the average cost of a counselling session associated with a true / false positive result to be $85.95, based on MSP fee item 13015 (*HIV/AIDS Primary Care Management – in or out of office – per half hour or major portion thereof*) (Table 3, row *o*).[1275]

[1270] Office of the Provincial Health Officer. *HIV Testing Guidelines for the Province of British Columbia* 2014. Available at http://www.bccdc.ca/NR/rdonlyres/B35EDEBD-98CA-48BB-AB7C-B18A357AC19D/0/HIV_GUIDE_051114.pdf. Accessed May 2014.

[1271] Long EF, Brandeau ML and Owens DK. The cost-effectiveness and population outcomes of expanded HIV screening and antiretroviral treatment in the United States. *Annals of Internal Medicine*. 2010; 153(12): 778-89.

[1272] Long EF, Mandalia R, Mandalia S et al. Expanded HIV testing in low-prevalence, high-income countries: a cost-effectiveness analysis for the United Kingdom. *PLoS One*. 2014; 9(4): e95735.

[1273] Dr. Mel Krajden, Associate Medical Director, BCCDC Public Health Microbiology and Reference Laboratory, BC Centre for Disease Control. Personal communication, March, 2014.

[1274] Ibid.

[1275] Medical Services Commission. *Payment Schedule*. 2022. Available online at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msc_payment_schedule_-_may_2022.pdf. Accesed November 2018.

- **Average annual cost of antiretrovirals for HIV** – Calculated based on an estimated average cost per day of treatment in Canada of $26.00 (in 2012 CAD)[1276] or $30.39 in 2022 CAD (Table 3, row *s*). Costs in BC may be as high as $47.00 per day (in 2005 CAD)[1277] or $63.52 in 2022 CAD. We have used this higher estimate in our sensitivity analysis.
- **Direct medical costs avoided** – The annual direct medical costs (excluding medications) associated with HIV/AIDS in Canada have been estimated by stage of infection at $1,684 for asymptomatic HIV, $2,534 for symptomatic HIV and $9,715 for AIDS (in 2009 CAD).[1278] We modelled avoided cost using the annual direct medical costs associated with symptomatic HIV, updated to 2022 CAD of $3,183 (Table 3, row *w*).
- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the estimated cost per QALY would be $18,930 (see Table 3, row *gg*).

[1276] Centre for Health Services and Policy Research. *The Canadian Rx Atlas: Third Edition*. 2013. Available at http://www.chspr.ubc.ca/sites/default/files/file_upload/publications/2013/RxAtlas/canadianrxatlas2013.pdf. Accessed November 2023.
[1277] Johnston KM, Levy AR, Lima VD et al. Expanding access to HAART: a cost-effective approach for treating and preventing HIV. *AIDS*. 2010; 24(12): 1929-35.
[1278] Kingston-Riechers, J. *The Economic Cost of HIV/AIDS in Canada*. Canadian AIDS Society, 2011. Available online at http://www.cdnaids.ca/files.nsf/pages/economiccostofhiv-aidsincanada/$file/Economic%20Cost%20of%20HIV-AIDS%20in%20Canada.pdf. Accessed July, 2014.

Table 3: CE of Screening to Detect and Treat HIV in a BC Birth Cohort of 40,000			
Row Label	**Variable**	**Base Case**	**Data Source**
a	Proportion of population high risk	2.85%	√
b	Proportion of population low risk	97.15%	=1-a
c	Screening rate in high risk populations	Annual	√
d	Screening rate in low risk populations	Every 5 years	√
e	Lifetime screens in high risk populations	44,883	Calculated
f	Lifetime screens in low risk populations	167,873	Calculated
g	Total screens	212,756	=e+f
h	# of true positive screens	23.09	Table 2, row x
i	Estimated # of false positive screens	23.09	=h
	Costs of screening and counseling		
j	Cost of 10-minute office visit	$35.97	Ref Doc
k	Value of patient time and travel for office visit	$74.32	Ref Doc
l	Proportion of office visit required	0.50	Assumed
m	Cost per screen	$7.89	√
n	Cost per true/false positive screen	$451	√
o	Cost per counselling session	$85.95	√
p	Cost of screening	$5,525,900	=(g*j*l)+(g*m)+(h+i)*n
q	Cost of counselling	$3,969	=(h+i)*o
r	Patient time costs	$7,906,031	= g*k*l
	Costs of antiretrovirals		
s	Cost per day of treatment	$30.39	√
t	Cost of antiretrovirals	$11,268,765	=Table 2, row x * Table 2, row cc *365 * s
	Costs avoided		
u	HIV infections avoided - treatment with ART	28.49	Table 2, row kk + Table 2, row nn
v	Cost of antiretrovirals avoided	-$13,902,488	= -u * Table 2, row cc*365*s
w	Annual direct medical costs (excluding medications) associated with symptomatic HIV	$3,183	√
x	Direct medical costs avoided	-$3,989,382	= -u * Table 2, row cc*w
	CE calculation		
y	Cost of screening and counseling (undiscounted)	$13,435,900	= p+q+r
z	Cost of antiretrovirals (undiscounted)	$11,268,765	= t
aa	Costs avoided (undiscounted)	-$17,891,869	= v+x
bb	QALYs saved (undiscounted)	360	Table 2, row qq
cc	Cost of screening and counseling (1.5% discount rate)	$9,854,484	Calculated
dd	Cost of antiretrovirals (1.5% discount rate)	$8,265,011	Calculated
ee	Costs avoided (1.5% discount rate)	-$13,122,690	Calculated
ff	QALYs saved (1.5% discount rate)	264	Calculated
gg	**CE ($/QALY saved)**	**$18,930**	=(cc+dd+ee)/ff

√ = Estimates from the literature

We also modified several major assumptions and recalculated the cost per QALY as follows:

- Assume the prevalence of individuals living with HIV infections in BC is decreased from 12,100 to 9,700 (Table 2, row *a*): CE = $28,150.
- Assume the prevalence of individuals living with HIV infections in BC is increased from 12,100 to 14,500 (Table 2, row *a*): CE = $12,763.
- Assume that the early initiation of antiretroviral therapy is associated with a 96% reduction (from 64%) in the transmission rate per person-year (Table 2, row *hh*): CE = Cost-saving.
- Assume that the early initiation of antiretroviral therapy is associated with a 25% reduction (from 64%) in the transmission rate per person-year (Table 2, row *hh*): **CE = $93,297.**
- Assume screening once every 10 years rather than once every 5 years in the low-risk population (Table 3, row *d*): CE = $4,137.
- Assume screening once per lifetime rather than once every 5 years in the low-risk population (Table 3, row *d*): CE = Cost-saving.
- Assume the cost of screening is reduced from $7.89 and $451 to $5.63 and $338 (Table 3, rows *m* & *n*): CE = $17,580.
- Assume the cost of screening is increased from $7.89 and $451 to $10.14 and $563 (Table 3, rows *m* & *n*): CE = $20,275.
- Assume the proportion of an office visit required is reduced from 0.50 to 0.33 (Table 3, row *l*): CE = $7,846.
- Assume the proportion of an office visit required is increased from 0.50 to 0.67 (Table 3, row *l*): CE = $30,015.
- Assume the average annual cost of antiretrovirals for HIV is increased from $26 to $47 per day (Table 3, row *s*): CE = $10,952.

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening adolescents and adults aged 15 to 65 years for HIV infection is estimated to be 264 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $18,930.

Table 4: Screening to Diagnose and Treat HIV Infections in a Birth Cohort of 40,000

Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
1.5% Discount Rate	**264**	153	391
3% Discount Rate	198	115	294
0% Discount Rate	360	209	533
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$18,930**	Cost-saving	$93,297
3% Discount Rate	$18,930	Cost-saving	$93,297
0% Discount Rate	$18,930	Cost-saving	$93,297
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	Cost-saving	Cost-saving	$55,453
3% Discount Rate	Cost-saving	Cost-saving	$55,453
0% Discount Rate	Cost-saving	Cost-saving	$55,453

Screening for Chlamydial / Gonococcal Infections – Evidence Update

Background

In 2014, we modelled screening for chlamydial and gonococcal infections for the Lifetime Prevention Schedule (LPS) based on the newly released 2014 recommendation from the U.S. Preventive Services Task Force (USPSTF). The USPSTF recommended screening for chlamydia and gonorrhea in sexually active females aged 24 years or younger and in older women who are at increased risk for infection (B recommendation).[1279]

Our modelling leaned heavily on the assumptions used by Hu and colleagues in their cost-effectiveness analysis.[1280] At the time, we noted that the modelling was highly sensitive to a number of key assumptions, a fact also recognized by Hu and colleagues.[1281] Furthermore, there was a significant debate about these key assumptions. For example, Hu and colleagues assumed that 30% of infections with chlamydia would lead to acute pelvic inflammatory disease (PID), with a range from 10-40%. Subsequent research suggested that the rate might be much lower, resulting in a change in the lower end of the range from 10% to just 0.43%.[1282,1283] Others indicated that we simply do not know very much about the natural progression from infection with either chlamydia or gonorrhea to PID.[1284]

This uncertainty surrounding key assumptions meant a large range in our model results, from $37,189 to $234,414 per quality-adjusted life year (QALY).[1285]

There was also substantial debate about whether screening is associated with any significant reduction in PID and its sequelae. In a landmark article published in the *New England Journal of Medicine* in 1996, Scholes et al. presented the results of a randomized controlled clinical trial in which they observed a significant reduction in PID in women screened for chlamydia (relative risk of 0.44; 95% CI of 0.20 to 0.90).[1286] The 2014 USPSTF recommendation leaned heavily on this study. Subsequent research, however, has not been able to replicate these results. The Prevention of Pelvic Infection (POPI) trial in the UK, also a randomized controlled trial, for example, found a non-significant reduction in PID associated with screening (relative risk of 0.65; 95% CI of 0.34 to 1.22).[1287]

[1279] LeFevre M. Screening for chlamydia and gonorrhea: US Preventive Services Task Force recommendation statement. *Annals of Internal Medicine*. 2014; 161(12): 902-10.

[1280] Hu D, Hook E and Goldie S. Screening for Chlamydia trachomatis in women 15 to 29 years of age: A cost-effectiveness analysis. *Annals of Internal Medicine*. 2004; 141(7): 501-13.

[1281] Hu D, Hook III E and Goldie S. The impact of natural history parameters on the cost-effectiveness of Chlamydia trachomatis screening strategies. *Sexually Transmitted Diseases*. 2006; 33(7): 428-36.

[1282] van Valkengoed I, Morré S, van den Brule A et al. Overestimation of complication rates in evaluations of Chlamydia trachomatis screening programmes - implications for cost-effectiveness analyses. *International Journal of Epidemiology*. 2004; 33(2): 416-25.

[1283] Hu D, Hook III E and Goldie S. The impact of natural history parameters on the cost-effectiveness of Chlamydia trachomatis screening strategies. *Sexually Transmitted Diseases*. 2006; 33(7): 428-36.

[1284] Herzog S, Heijne J, Althaus C et al. Describing the progression from Chlamydia trachomatis and Neisseria gonorrhoeae to pelvic inflammatory disease: Systematic review of mathematical modelling studies. *Sexually Transmitted Diseases*. 2012; 39(8): 628-37.

[1285] The Lifetime Prevention Schedule. *Establishing Priorities among Effective Clinical Prevention Services in British Columbia. Summary and Technical Report*. September 2022 Update. Available online at https://www2.gov.bc.ca/assets/gov/health/about-bc-s-health-care-system/health-priorites/lifetime-prevention-schedule/images/lps-update-report-2022.pdf. Accessed December 2023.

[1286] Scholes D, Stergachis A, Heidrich F et al. Prevention of pelvic inflammatory disease by screening for cervical chlamydial infection. *New England Journal of Medicine*. 1996; 334(21): 1362-6

[1287] Oakeshott P, Kerry S, Aghaizu A et al. Randomised controlled trial of screening for Chlamydia trachomatis to prevent pelvic inflammatory disease: the POPI (prevention of pelvic infection) trial. *British Medical Journal*. 2010; 340(340): c1642.

2021 CTFPHC Recommendation Statement

In 2021 the CTFPHC released the following recommendation:[1288]

> *We recommend opportunistic screening of sexually active individuals under 30 years of age who are not known to belong to a high-risk group, annually, for chlamydia and gonorrhea at primary care visits, using a self- or clinician-collected sample (Conditional recommendation; very low-certainty evidence).*

Opportunistic Versus Systematic Population Screening

Several things should be noted about this recommendation. First, the recommendation is for **opportunistic screening**. "Opportunistic screening is distinct from a systematic population screening program, in which invitations for screening are sent to all eligible participants, monitored for uptake and evaluated through a centralized program, usually at the provincial level."[1289] One of the primary goals of the LPS work is to identify clinical prevention services (CPS) that are worth doing based on their overall population health impact and their cost-effectiveness. A key assumption used by the LPS is that if a CPS is worth doing in BC, then we would try to achieve screening / intervention rates that are equal to the best in the world. This is unlikely to be achieved without a systematic population screening program.

What Does the Recommendation Mean for the LPS?

Second, the CTFPHC recommendation is a **conditional recommendation based on very low-certainty evidence**. In 2013 the LPS Expert Committee (LPSEC) released a methodology report,[1290] at least in part to clarify which recommendations of effectiveness would lead to a positive response to the first question asked by the LPS when considering a CPS: Is the service effective?[1291]

Prior to 2011, the CTFPHC used a grading system similar to that of the USPSTF, which essentially provided each CPS reviewed with one of five potential summary grades: A, B, C, D, I. At the time, the LPSEC accepted an A (*the USPSTF recommends the service. There is high certainty that the net benefit is substantial*) or B grade (*the USPSTF recommends the service. There is high certainty that the net benefit is moderate or there is moderate certainty that the net benefit is moderate to substantial*) as sufficient evidence of effectiveness to trigger the detailed modelling to assess the overall population health impact and the cost-effectiveness of the CPS in BC.

In November of 2011 the CTFPHC moved to incorporate 'strong' or 'weak' recommendations for or against implementing a CPS. The weak recommendation was subsequently renamed "conditional". Furthermore, each recommendation included one of four potential grades for the evidence based on how confident the CTFPHC was that the estimates of effect are correct; high-, moderate-, low- or very low-certainty.

In 2013, the LPSEC determined that the new weak or conditional recommendation from the CTFPHC would likely overlap both the 'B' and 'C' grades of the USPSTF. A C grade from the USPSTF at the time meant that "the USPSTF recommends selectively offering or providing this service to individual patients based on

[1288] Moore A, Traversy G, Reynolds D et al. Recommendation on screening for chlamydia and gonorrhea in primary care for individuals not known to be at high risk. *CMAJ*. 2021; 193(16): E549-59.
[1289] Ibid.
[1290] Lifetime Prevention Schedule. *Evidence Review and Economic Modelling of Preventive Health Maneuvers to Update the BC Lifetime Prevention Schedule: Methodology Report*. October 21, 2013.
[1291] Lifetime Prevention Schedule. *An Overview of the Process*. Available online at https://www2.gov.bc.ca/gov/content/health/about-bc-s-health-care-system/health-priorities/lifetime-prevention. Accessed December 2023.

professional judgment and patient preferences. There is at least moderate certainty that the net benefit is small."

The decision rule applied by the LPSEC was that a weak/conditional recommendation based on at least moderate-certainty evidence would be approximately comparable to the previous 'B' recommendation from the CTFPHC and a current 'B' recommendation from the USPSTF, while a weak/conditional recommendation based on low- or very low-certainty evidence would be approximately comparable to a 'C' recommendation.[1292]

Based on these decision rules, the current **conditional recommendation; very low-certainty evidence** would be considered equivalent to a 'C' grade and would not lead to a positive response to the first question asked by the LPS when considering a CPS: Is the service effective?

When the CTFPHC and the USPSTF Disagree

The two main sources for evidence of effectiveness for the LPS are the CTFPHC and the USPSTF. On occasion, both organizations will provide a recommendation and aspects of those recommendations may differ. For example, slightly different start and stop ages for screening may be recommended by the two organizations. In the current situation, however, the difference may be significant if we agree that the CTFPHC recommendation is equivalent to a 'C' from the USPSTF while the actual recommendation from the USPSTF is a 'B' (see below).

Over time, several decision rules have been applied by the LPS when the two task forces disagree. First, if there is a gap of at least 5 years in the timing of the recommendations, the recommendation assessing the most recent evidence takes priority. Second, if the two recommendations are assessing the same or similar research evidence, the recommendation of the CTFPHC takes priority. Any reason for not following these decision rules should be clearly documented (e.g. at the outset of the modelling process).

2021 USPSTF Recommendation Statement

In 2021, based on their updated review of the literature, the USPSTF released the following recommendations:[1293]

> *The USPSTF recommends screening for chlamydia in all sexually active women 24 years or younger and in women 25 years or older who are at increased risk for infection (B recommendation).*
>
> *The USPSTF recommends screening for gonorrhea in all sexually active women 24 years or younger and in women 25 years or older who are at increased risk for infection (B recommendation).*
>
> *The USPSTF concludes that the current evidence is insufficient to assess the balance of benefits and harms of screening for chlamydia and gonorrhea in men (I recommendation).*

[1292] Lifetime Prevention Schedule. *Evidence Review and Economic Modelling of Preventive Health Maneuvers to Update the BC Lifetime Prevention Schedule: Methodology Report*. October 21, 2013.
[1293] US Preventative Services Task Force. Screening for Chlamydia and Gonorrhea: US Preventative Services Task Force Recommendation Statement. *JAMA*. 2021; 326(10): 957-66.

Evidence of Effectiveness

Differences in the Research Evidence Used to Assess Effectiveness

The CTFPHC found 14 publications that met their inclusion criteria in addressing the question: "What is the effectiveness of screening compared with no screening for chlamydia and/or gonorrhea in non-pregnant sexually active individuals?" Ten studies were randomized controlled clinical trials (RCTs), two were non-randomized controlled clinical trials (CCT) and two were retrospective cohort studies (see Table 1). The USPSTF included just four of these publications (see Table 1) in addressing the question: "In sexually active, asymptomatic adolescents and adults, including those who are pregnant, what is the effectiveness of screening for chlamydial or gonococcal infections in reducing complications of infection and transmission or acquisition of disease, including gonorrhea, chlamydia, and HIV?"[1294]

Appendix A5 of the detailed evidence review for the USPSTF[1295] includes a list of 366 publications considered for inclusion but ultimately excluded together with the reason for exclusion. None of the 10 studies included in the CTFPHC but not included in the USPSTF appear to have been considered for inclusion by the USPSTF (i.e. they do not appear in Appendix A5), suggesting a substantial difference in literature search strategies.

Table 1: Studies Included by the CTFPHC and the USPSTF in Assessing the Benefits of Screening for Chlamydia and Gonorrhea

Study Authors (Date)	Type of Study	Used by CTFPHC	Used by USPSTF	Considered (and Rejected) by the USPSTF
Scholes et al (1996)[1296]	Randomized controlled clinical trial (RCT)	Yes	Yes	NA
Ostergaard et al (2000)[1297]	RCT	Yes	Yes	NA
Oakeshott et al (2010)[1298]	RCT	Yes	Yes	NA
Hocking et al (2018)[1299]	RCT	Yes	Yes	NA
Study Authors (Date)	Type of Study	Used by CTFPHC	Used by USPSTF	Considered (and Rejected) by the USPSTF

[1294] Cantor A, Dana T, Griffin J et al. *Screening for Chlamydial and Gonococcal Infections: A Systematic Review Update for the U.S. Preventive Services Task Force. Evidence Synthesis No. 206.* AHRQ Publication No. 21-05275-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; 2021.
[1295] Ibid.
[1296] Scholes D, Stergachis A, Heidrich F et al. Prevention of pelvic inflammatory disease by screening for cervical chlamydial infection. *NEJM*. 1996; 334(21): 1362–6.
[1297] Ostergaard L, Andersen B, Moller J et al. Home sampling versus conventional swab sampling for screening of Chlamydia trachomatis in women: A cluster-randomized 1-year follow-up study. *Clinical Infectious Diseases*. 2000; 31(4): 951–7.
[1298] Oakeshott P, Kerry S, Aghaizu A et al. Randomised controlled trial of screening for Chlamydia trachomatis to prevent pelvic inflammatory disease: the POPI (prevention of pelvic infection) trial. *British Medical Journal*. 2010; 340(340): c1642.
[1299] Hocking J, Temple-Smith M, Guy R et al. Population effectiveness of opportunistic chlamydia testing in primary care in Australia: a cluster-randomised controlled trial. *Lancet*. 2018; 392(10156): 1413–22.

Table 1: Studies Included by the CTFPHC and the USPSTF in Assessing the Benefits of Screening for Chlamydia and Gonorrhea				
Van den Broek et al (2012)[1300]	RCT	Yes	No	No
Hodgins et al (2002)[1301]	RCT	Yes	No	No
Andersen et al (2011)[1302]	RCT	Yes	No	No
Garcia et al (2012)[1303]	RCT	Yes	No	No
Klovstad et al (2013)[1304]	RCT	Yes	No	No
Senok et al (2005)[1305]	RCT	Yes	No	No
Clark et al (2002)[1306]	Non-randomized controlled clinical trial (CCT)	Yes	No	No
Cohen et al (1999)[1307]	CCT	Yes	No	No
Sufrin et al (2012)[1308]	Retrospective cohort	Yes	No	No
Low et al (2006)[1309]	Retrospective cohort	Yes	No	No

[1300] van den Broek, van Bergen J, Brouwers E et al. Effectiveness of yearly, register based screening for chlamydia in the Netherlands: Controlled trial with randomised stepped wedge implementation. *BMJ*. 2012; 345: e4316

[1301] Hodgins S, Peeling R, Dery S et al. The value of mass screening for chlamydia control in high prevalence communities. *Sexually Transmitted Infections*. 2002; 78(Suppl 1): i64–8.

[1302] Andersen B, van Valkengoed I, Sokolowski I et al. Impact of intensified testing for urogenital Chlamydia trachomatis infections: A randomised study with 9-year follow-up. *Sexually Transmitted Infections*. 2011; 87(2): 156–61.

[1303] Garcia P, Holmes K, Carcamo C et al. Prevention of sexually transmitted infections in urban communities (Peru
PREVEN): A multicomponent community-randomised controlled trial. *Lancet*. 2012; 379(9821): 1120–8.

[1304] Klovstad H, Natas O, Tverdal A et al. Systematic screening with information and home sampling for genital Chlamydia trachomatis infections in young men and women in Norway: A randomized controlled trial. *BMC Infectious Diseases*. 2013; 13(1): 30.

[1305] Senok A, Wilson P, Reid M et al. Can we evaluate population screening strategies in UK general practice? A pilot randomised controlled trial comparing postal and opportunistic screening for genital chlamydial infection. *Journal of Epidemiology and Community Health*. 2005; 59(3): 198–204.

[1306] Clark K, Howell M, Li Y et al. Hospitalization rates in female US Army recruits associated with a screening program for Chlamydia trachomatis. *Sexually Transmitted Diseases*. 2002; 29(1): 1–5.

[1307] Cohen D, Nsuami M, Martin D et al. Repeated school-based screening for sexually transmitted diseases: A feasible strategy for reaching adolescents. *Pediatrics*. 1999; 104(6): 1281–5.

[1308] Sufrin C, Postlethwaite D, Armstrong M et al. Neisseria gonorrhea and Chlamydia trachomatis screening at intrauterine device insertion and pelvic inflammatory disease. *Obstetrics & Gynecology*. 2012; 120(6): 1314–21.

[1309] Low N, Egger M, Sterne J et al. Incidence of severe reproductive tract complications associated with diagnosed genital chlamydial infection: The Uppsala Women's Cohort Study. *Sexually Transmitted Infections*. 2006; 82(3): 212–8.

The Four RCTs Considered by Both Task Forces

The Study by Scholes et al.

The landmark study by Scholes et al[1310], published in 1996, set out to "experimentally verify that testing and treating women with early chlamydial infection affects their risk of subsequent pelvic inflammatory disease." A total of 36,547 women ages 18 to 34 enrolled in the Group Health Cooperative of Puget Sound in Washington State were approached to join the study, with 17,725 (48%) responding to the invitation. Of these 17,725, a total of 2,607 (14.7%) were considered to be at high risk of chlamydia infection and agreed to be in the RCT, with 1,009 allocated to the screening group and 1,598 to the usual care group. In the screening group, 645 (64%) were tested for cervical chlamydial infection and 44 (6.8%) were found to be positive. At one-year follow-up, responses were received from 76% of the 2,607, with 24% lost to follow-up. For those followed for a year, women who were assigned to the screening group had a 56% lower incidence of pelvic inflammatory disease (RR 0.44: 95% CI of 0.20 to 0.90) than in the usual care group. There were 9 confirmed cases of PID in the screening group (0.9%) and 33 in the usual care group (2.1%).

This study is given a 'fair quality' rating by the USPSTF largely due to this high loss to follow-up (24%).[1311] In addition, the study was critiqued for prematurely randomizing subjects[1312] and for keeping members of the screening group cohort who were not tested (364; 1,009 minus 645) in the statistical analysis of the screening group cohort.[1313] Abter and colleagues argue that if the 364 had been moved from the screening group cohort to the usual group cohort in the analysis, the relative risk (RR) would be 0.60 with a 95% CI of 0.22 to 1.3.[1314] Finally, others have pointed out challenges in diagnosing PID[1315,1316] and that less than half of PID cases are attributable to gonorrhea and/or chlamydia.[1317]

The Study by Ostergaard et al.

The study by Ostergaard and colleagues[1318], published in 2000, set out to "compare a screening strategy based on home sampling with a strategy of conventional testing in order to determine the prevalence of disease after 1 year and the number of treated PID cases during the 1 year of follow-up." Note that this study is assessing two different approaches to screening rather than comparing screening to no screening.

In this study, 5,487 females from 17 high schools in Denmark were cluster randomized (by school) to a study group (tested by home sampling) or a control group (tested in a physician's office). Of the 5,487, a total of 2,351 (43%) responded positively to the invitation to participate. Of the 2,351, a total of 1,761 were sexually experienced (75%) with 928 in the

[1310] Scholes D, Stergachis A, Heidrich F et al. Prevention of pelvic inflammatory disease by screening for cervical chlamydial infection. *NEJM*. 1996; 334(21): 1362–6.
[1311] Cantor A, Dana T, Griffin J et al. *Screening for Chlamydial and Gonococcal Infections: A Systematic Review Update for the U.S. Preventive Services Task Force. Evidence Synthesis No. 206.* AHRQ Publication No. 21-05275-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; 2021.
[1312] Sellors J, Paavonen J. Screening to prevent pelvic inflammatory disease. *NEJM*. 1996; 335: 1531-2.
[1313] Abter E, Mahmud M. Screening to prevent pelvic inflammatory disease. *NEJM*. 1996; 335: 1531.
[1314] Ibid.
[1315] Pitroff R. Screening to prevent pelvic inflammatory disease. *NEJM*. 1996; 335: 1532.
[1316] Hillier S, Bernstein K, Aral S. A review of the challenges and complexities in the diagnosis, etiology, epidemiology, and pathogenesis of pelvic inflammatory disease. *The Journal of Infectious Diseases*. 2021; 224 (Suppl 2): S23-8.
[1317] Mitchell C, Anyalechi G, Cohen C et al. Etiology and diagnosis of pelvic inflammatory disease: Looking beyond gonorrhea and chlamydia. *The Journal of Infectious Diseases*. 2021; 224 (Suppl 2): S29-35.
[1318] Ostergaard L, Andersen B, Moller J et al. Home sampling versus conventional swab sampling for screening of Chlamydia trachomatis in women: A cluster-randomized 1-year follow-up study. *Clinical Infectious Diseases*. 2000; 31(4): 951–7.

study group and 833 in the control group. Females in the study group were supplied with a home sampling kit and 867 (93%) were ultimately tested with 43 (5.0%) infections identified. Females in the control group were offered a free test at their local health clinic or physicians' office, with 63 of 833 (7.6%) being tested and 5 (7.9%) infections identified. Outcome measures at one year were available for 443 (48%) of the 928 in the study group (with 13 infections and 9 reporting being treated for PID) and for 487 of the 833 (58%) in the control group (with 32 infections and 20 reporting being treated for PID). The authors indicate that the difference in the proportion of infections in the control group (32 of 487 or 6.6%) is statistically significantly higher (p = 0.026) than in the study group (13 of 443 or 2.9%). Furthermore, the proportion of females self-reporting treatment for PID in the control group (20 of 487 or 4.2%) is statistically significantly higher (p = 0.045) than in the study group (9 of 443 or 2.1%).

This study is given a 'fair quality' rating by the USPSTF largely due to the high loss (47%) to follow-up.[1319] Also, as noted by Peterman et al,[1320] the low number of individuals tested for chlamydia at baseline in the control group versus the study group (7.6% vs. 93.0%) means that the control group results at 1 year include both incident and prevalent cases while the study group consists largely of incident cases. While the data is not provided, excluding prevalent cases from the control group would likely have negated the observed statistically significant differences between the two groups.

The Study by Oakeshott et al.

The study in the UK by Oakeshott and co-authors[1321], published in 2010, set out to determine "whether screening young sexually active female students for chlamydial infection and treating those found to be infected reduced the incidence of pelvic inflammatory disease in the subsequent 12 months."

In this study, 2,529 sexually active female students between the ages of 16 and 27 were randomly allocated to a screening group (1,259) or to deferred screening controls (1,270). All participants were asked to complete a questionnaire and to provide self-taken vaginal swabs. The swabs in the control group were frozen and analysed after one year. Follow-up data at 12 months was available for 95% of the screening group and 93% of the control group. Sixty-eight (5.4%) females in the study group tested positive at baseline with 59 of these being treated for chlamydia infection. In the control group, 75 (5.9%) tested positive when the samples were tested at 12 months. The incidence of pelvic inflammatory disease was 1.3% (15/1191) in screened women compared with 1.9% (23/1186) in controls (relative risk 0.65, 95% CI of 0.34 to 1.22). After adjustment for symptoms at baseline the relative risk was 0.57 (95% CI of 0.29 to 1.11).

The authors note that 43% of females in the control group were independently tested and that this high rate of testing likely reduced the effectiveness of the intervention. Furthermore, the study sample size was chosen based on an assumption of a 3.0% incidence of PID and thus was underpowered based on an observed overall incidence of PID of 1.6%.

The authors conclude that "although some evidence suggests that screening for chlamydia reduces rates of pelvic inflammatory disease, especially in women with chlamydial infection

[1319] Cantor A, Dana T, Griffin J et al. *Screening for Chlamydial and Gonococcal Infections: A Systematic Review Update for the U.S. Preventive Services Task Force. Evidence Synthesis No. 206.* AHRQ Publication No. 21-05275-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; 2021.
[1320] Peterman T, Gottlieb S, Berman S. Commentary: *Chlamydia trachomatis* screening: What are we trying to do? *International Journal of Epidemiology*. 2009; 38: 449-51.
[1321] Oakeshott P, Kerry S, Aghaizu A et al. Randomised controlled trial of screening for Chlamydia trachomatis to prevent pelvic inflammatory disease: the POPI (prevention of pelvic infection) trial. *British Medical Journal*. 2010; 340(340): c1642.

at baseline, the effectiveness of a single chlamydia test in preventing pelvic inflammatory disease over 12 months may have been overestimated."

This study is given a 'good quality' rating by the USPSTF.[1322]

The Study by Hocking et al.

The study by Hocking et al[1323], published in 2018, set out to "investigate the effect of opportunistic testing in primary care clinics on *C trachomatis* prevalence, PID and epididymitis in the population." In this study, 26 rural towns in Australia with a minimum of 500 males and females ages 16-29, and no more than six primary care clinics, were randomly allocated to receive a clinic-based chlamydia testing intervention or continue usual care. A total of 93,828 individuals were included in the intervention cohort (from 63 clinics) and 86,527 in the control cohort (from 67 clinics). Unlike previous studies with follow-up periods of 12 months, the mean follow-up in this study was 3.1 years. The intervention included computerized reminders, an education package, payments for chlamydia testing and feedback on testing rates. Annual chlamydia testing rates increased from 8.2% to 20.1% in the intervention group.

Results indicate that the estimated prevalence of chlamydia decreased from 5.0% to 3.4% during the study period. While this at first appears to be a significant success of the intervention, a similar reduction (from 4.6% to 3.4%) occurred in the control group, suggesting that the observed decrease was not specifically attributable to the intervention (the odds ratio for the difference between the intervention and control clusters was 0.9 with a 95% CI of 0.5 to 1.5). In addition, the incidence of PID diagnosed in the clinics did not significantly differ between the intervention and control groups (44.7 / 10,000 in the intervention group vs 39.2 / 10,000 in the control group, OR of 1.2 with a 95% CI of 0.8 to 1.9). When using the incidence of PID as diagnosed in hospital as the outcome, the intervention group had a marginally lower rate of PID (24.2 / 10,000 in the intervention group vs 37.9 / 10,000 in the control group, OR of 0.6 with a 95% CI of 0.4 to 1.0).

The authors conclude that their results, "in conjunction with evidence about the feasibility of sustained uptake of opportunistic testing in primary care clinics, indicate that substantial reductions in chlamydia prevalence or chlamydia-associated complications might not be achievable."

Significant strengths of this study include the large sample size, limited loss to follow-up (1.6% and 4.5% of clinics in the intervention and control groups) and a longer follow-up period including multiple rounds of testing. This study is given a 'good quality' rating by the USPSTF.[1324]

[1322] Cantor A, Dana T, Griffin J et al. *Screening for Chlamydial and Gonococcal Infections: A Systematic Review Update for the U.S. Preventive Services Task Force. Evidence Synthesis No. 206.* AHRQ Publication No. 21-05275-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; 2021.
[1323] Hocking J, Temple-Smith M, Guy R et al. Population effectiveness of opportunistic chlamydia testing in primary care in Australia: a cluster-randomised controlled trial. *Lancet*. 2018; 392(10156): 1413–22.
[1324] Cantor A, Dana T, Griffin J et al. *Screening for Chlamydial and Gonococcal Infections: A Systematic Review Update for the U.S. Preventive Services Task Force. Evidence Synthesis No. 206.* AHRQ Publication No. 21-05275-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; 2021.

The 2016 Cochrane Review

Low and colleagues included four RCTs in their review of the effectiveness of chlamydia screening versus usual care on the incidence of PID at 12 months;[1325] the studies by Scholes et al, Ostergaard et al, Oakeshott et al and Andersen et al.[1326] The RCT by Andersen et al published in 2011 was included in the evidence review by the CTFPHC but not by the USPSTF. The more recent RCT by Hocking et al. was not published until 2018.

Each of the four studies was assessed for their risk of bias. "Bias refers to factors that can systematically affect the observations and conclusions of the study and cause them to be different from the truth…Risks of bias are the likelihood that features of the study design or conduct of the study will give misleading results."[1327]

Taken together, the results of the four included RCTs suggest a 32% lower risk of PID associated with chlamydia screening (RR of 0.68; 95% CI of 0.49 to 0.94). The absolute risk of PID at 12 months is 0.75% in the intervention group and 0.92% in the control group.

The authors then subdivided the studies into those at high or unclear risk of bias (Scholes et al and Ostergaard et al) and those at low risk of bias, or better quality studies (Oakeshott et al and Andersen et al). Results for studies with an unclear/high risk of bias were considerably more positive (RR of 0.42; 95% CI of 0.22 to 0.83) than those with a low risk of bias (RR of 0.80; 95% CI of 0.55 to 1.17). In lower quality studies, the absolute risk of PID at 12 months is 0.89% in the intervention group and 2.10% in the control group. In higher quality studies, the absolute risk of PID at 12 months is 0.72% in the intervention group and 0.76% in the control group.

The authors conclude that "the risk of PID was 32% lower in women who were invited to have a single chlamydia screening test than in women who were not invited. When we removed two trials with lower quality evidence, the protective effect of chlamydia screening decreased… We are moderately sure that chlamydia screening can reduce the risk of PID, but we are not sure by how much because of our concerns about quality in some trials."[1328]

Evidence of Potential Harms

2021 USPSTF Systematic Review

The systematic review for the 2021 USPSTF recommendation considered harms such as labeling, anxiety, false-positive / false alarm results, false-negative / reassurance, or changes in risk behaviours or risk perceptions.[1329] False-positive rates for chlamydia screening in females ranged from 0-2% while false-negative rates ranged from 0-28% in five studies with a sixth study observing false-negative rates of 44-56%. False-positive rates for gonorrhea screening in females were less than 1% while false-negative rates ranged from 0-10%. They found no studies meeting inclusion criteria which "evaluated psychosocial harms related to screening or evaluated effects of screening on changes in risk behaviors or risk perceptions."

[1325] Low N, Redmond S, Uuskula A et al. Screening for genital chlamydia infection. *Cochrane Database of Systematic Reviews*. 2016; Issue 9: Art. No.: CD010866.

[1326] Andersen B, van Valkengoed I, Sokolowski I et al. Impact of intensified testing for urogenital Chlamydia trachomatis infections: A randomised study with 9-year follow-up. *Sexually Transmitted Infections*. 2011; 87(2): 156–61

[1327] Australian Government. National Health and Medical Research Council. *Building a Healthy Australia: Guidelines for Guidelines (Assessing Risk of Bias)*. Available online at https://www.nhmrc.gov.au/guidelinesforguidelines/develop/assessing-risk-bias. Accessed January 2024.

[1328] Low N, Redmond S, Uuskula A et al. Screening for genital chlamydia infection. *Cochrane Database of Systematic Reviews*. 2016; Issue 9: Art. No.: CD010866.

[1329] US Preventative Services Task Force. Screening for chlamydial and gonococcal infections: Updated evidence report and systematic review for the US Preventative Services Task Force. *JAMA*. 2021; 326(10): 957-66.

As noted previously, Appendix A5 of the detailed evidence review for the USPSTF[1330] includes a list of 366 publications considered for inclusion but ultimately excluded together with the reason for exclusion. Unfortunately, the information in this appendix does not indicate specifically which publications were considered (and rejected) when evaluating psychosocial harms or changes in risk behaviors or risk perceptions associated with screening.

2021 CTFPHC Systematic Review

In contrast, the systematic review[1331] for the 2021 CTFPHC recommendation[1332] included the following 11 publications (one RCT and 10 uncontrolled cohort studies) when considering harms:

Hocking J, Temple-Smith M, Guy R et al. Population effectiveness of opportunistic chlamydia testing in primary care in Australia: A cluster-randomised controlled trial. *Lancet*. 2018; 392 (10156): 1413–22.

Andersson N, Carre H, Janlert U et al. Gender differences in the well-being of patients diagnosed with Chlamydia trachomatis: A cross-sectional study. *Sexually Transmitted Infections*. 2018; 94(6): 401–5.

Campbell R, Mills N, Sanford E et al. Does population screening for Chlamydia trachomatis raise anxiety among those tested? Findings from a population based chlamydia screening study. *BMC Public Hea*lth. 2006; 6: 106.

Fielder R, Carey K, Carey M. Acceptability of sexually transmitted infection testing using self-collected vaginal swabs among college women. *Journal of American College Health*. 2013; 61(1): 46–53.

France C, Thomas K, Slack R et al. Psychosocial impacts of chlamydia testing are important. *BMJ*. 2001; 322: 1245.

Gottlieb S, Stoner B, Zaidi A et al. A prospective study of the psychosocial impact of a positive Chlamydia trachomatis laboratory test. *Sexually Transmitted Diseases*. 2011; 38(11): 1004–11.

Gotz H, Veldhuijzen I, van Bergen J et al. Acceptability and consequences of screening for Chlamydia trachomatis by home-based urine testing. *Sexually Transmitted Diseases*. 2005; 32(9): 557-62.

Kangas I, Andersen B, Olesen F et al. Psychosocial impact of Chlamydia trachomatis testing in general practice. *British Journal of General Practice*. 2006; 56(529): 587–93.

Low N, Connell P, McKevitt C et al. 'You can't tell by looking': pilot study of a community-based intervention to detect asymptomatic sexually transmitted infections. *International Journal of STD & AIDS*. 2003; 14(12): 830–4.

O'Farrell N, Weiss H. Effect of chlamydia diagnosis on heterosexual relationships. *International Journal of STD & AIDS*. 2013; 24(9): 722–6.

[1330] Cantor A, Dana T, Griffin J et al. *Screening for Chlamydial and Gonococcal Infections: A Systematic Review Update for the U.S. Preventive Services Task Force. Evidence Synthesis No. 206.* AHRQ Publication No. 21-05275-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; 2021.

[1331] Moore A, Traversy G, Reynolds D et al. Recommendation on screening for chlamydia and gonorrhea in primary care for individuals not known to be at high risk. *CMAJ*. 2021; 193(16): E549-59.

[1332] Pillay J, Wingart A, MacGregor T et al. Screening for chlamydia and/or gonorrhea in primary health care: Systematic reviews on effectiveness and patient preferences. *Systematic Reviews*. 2021; 10(118):

Walker J, Walker S, Fairley C et al. What do young women think about having a chlamydia test? Views of women who tested positive compared with women who tested negative. *Sexual Health*. 2013; 10(1):3 9 - 42.

While the Hocking et al RCT was included in the USPSTF assessment of effectiveness, it does not appear to have been considered with respect to data on harms. It also appears as if none of the other 10 publications were even considered by the USPSTF. That is, none of them appear in the list of 366 publications that were considered and rejected. This again suggests that very different literature search strategies were applied by the two organizations.

The authors of the CTFPHC review recognized that the literature base on harms is incomplete and inconsistent and that any conclusions drawn could only be made with low- or very-low certainty. With these caveats, they suggest the following:

- Screening for chlamydia has little effect on general anxiety or anxiety about one's sexual aspects of life but between 5-40% of individuals feel some degree of anxiety about their or their partner's potential infertility.
- Of those screened for chlamydia, 6-30% will have one or more feelings related to stigmatization (mainly related to embarrassment and disapproval by one's social environment) although the severity of these symptoms are unknown.
- A positive diagnosis may result in anxiety about fertility in 40-60% of females.
- A positive diagnosis may cause one or more symptoms related to anxiety in 40-80% of individuals though the duration of effects is unknown.
- A positive diagnosis may lead to one or more stigma-related symptoms (e.g. feeling dirty, shame, embarrassment) in 20-50% of those diagnosed.
- A positive diagnosis may cause some relationship distress in 10-50% of those diagnosed.

Overdiagnosis and Overtreatment

Overdiagnosis and overtreatment are not specifically considered by the USPSTF or the CTFPHC. Van Bergen and co-authors, on the other hand, suggest that overdiagnosis and overtreatment may also constitute a significant harm.[1333] They argue that "testing for asymptomatic infections means that test-positive individuals and their, often untested and asymptomatic, partners are treated with antibiotics although the majority will never develop either symptoms or complications." Furthermore, this overtreatment with antibiotics in asymptomatic individuals may contribute to increased antimicrobial resistance. In addition, "antibiotic treatment affects oral, vaginal and rectal microbiota. A healthy microbiome is considered a major factor in the prevention of infections and reinfection." [1334]

Are There Alternatives?

> *PID could be prevented by either preventing C. trachomatis in the first place, or by curing infections before they progress to PID. This distinction is important*.[1335]

A potential alternative with a focus on primary prevention, rather than early detection, of chlamydial infections is the 2014 USPSTF recommendation for "intensive behavioral

[1333] Van Bergen J, Hoenderboom B, David S et al. Where to go in chlamydia control? From infection control towards infectious disease control. *Sexually Transmitted Infections*. 2021; 97: 501-6.
[1334] Ibid.
[1335] Peterman T, Gottlieb S, Berman S. Commentary: *Chlamydia trachomatis* screening: What are we trying to do? *International Journal of Epidemiology*. 2009; 38: 449-51.

counselling for all sexually active adolescents and for adults who are at increased risk for STIs. (B recommendation)"[1336] They note that "interventions ranging in intensity from 30 min to ≥2 h of contact time are beneficial; evidence of benefit increases with intervention intensity. Interventions can be delivered by primary care clinicians or through referral to trained behavioral counselors. Most successful approaches provide basic information about STIs and STI transmission; assess risk for transmission; and provide training in pertinent skills, such as condom use, communication about safe sex, problem solving, and goal setting."[1337]

The current modelling for the LPS notes that high intensity (> 2 hours) behavioural counselling interventions are associated with a 62% reduction in STI incidence in adolescents (OR = 0.38, 95% CI of 0.24–0.60) and a 30% reduction in STI incidence in adults (OR = 0.70, 95% CI of 0.56–0.87).[1338] If this intervention was applied in 29% of situations in which it was appropriate, then the clinically preventable burden (CPB) associated with behavioural counselling interventions for the prevention of sexually transmitted diseases in British Columbia would be estimated at 2,381 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) would be estimated to be $12,454 per QALY.

Conclusions

While both the CTFPHC and the USPSTF have recently updated their recommendations for screening for chlamydial and gonococcal infections, the CTFPHC appears to have taken a more inclusive approach with respect to the literature on effectiveness and harms and a more nuanced approach to interpreting this literature. The USPSTF recognizes that the early RCTs, which tended to return positive results on the effectiveness of screening and subsequent reduction in PID, were of poorer quality and at higher risk of bias than later studies. The more recent higher quality studies found that the evidence of effectiveness of screening and subsequent reduction in PID was weak or non-existent. Yet it appears that the four RCTs assessed by the USPSTF were given equal weight in order to achieve a B grade recommendation (*the USPSTF recommends the service. There is high certainty that the net benefit is moderate or there is moderate certainty that the net benefit is moderate to substantial*).

Based on a more detailed review of the available evidence, we suggest that the conditional recommendation for opportunistic screening based on very low-certainty evidence by the CTFPHC more closely aligns with the current research evidence on benefits and harms of screening. In our opinion, the available literature does not support a finding that there is moderate certainty that the net benefit is moderate to substantial.

We conclude that the available evidence leads to a negative response to the first question asked by the LPS when considering a CPS: Is the service effective? Thus, detailed modelling of the clinically preventable burden and cost-effectiveness of the CPS is not recommended.

[1336] LeFevre M. Behavioral counselling interventions to prevent sexually transmitted infections: US Preventive Services Task Force recommendation statement. *Annals of Internal Medicine*. 2014; 161(12): 894-901.
[1337] Ibid.
[1338] O'Connor E, Lin J, Burda B et al. Behavioral sexual risk-reduction counselling in primary care to prevent sexually transmitted infections: An updated systematic evidence review for the US Preventive Services Task Force. *Annals of Internal Medicine*. 2014; 161(12): 874.

United States Preventive Services Task Force Recommendations (2013)

Hepatitis C virus is the most common chronic bloodborne pathogen in the United States and a leading cause of complications from chronic liver disease. The prevalence of the anti-HCV antibody in the United States is approximately 1.6% in noninstitutionalized persons. According to data from 1999 to 2008, about three fourths of patients in the United States living with HCV infection were born between 1945 and 1965, with a peak prevalence of 4.3% in persons aged 40 to 49 years from 1999 to 2002. The most important risk factor for HCV infection is past or current injection drug use, with most studies reporting a prevalence of 50% or more. The incidence of HCV infection was more than 200 000 cases per year in the 1980s but decreased to 25 000 cases per year by 2001. According to the Centers for Disease Control and Prevention (CDC), there were an estimated 16 000 new cases of HCV infection in 2009 and an estimated 15 000 deaths in 2007. Hepatitis C–related end-stage liver disease is the most common indication for liver transplants among U.S. adults, accounting for more than 30% of cases. Studies suggest that about one half of the recently observed 3-fold increase in incidence of hepatocellular carcinoma is related to acquisition of HCV infection 2 to 4 decades earlier.

The USPSTF recommends screening for HCV infection in persons at high risk for infection. The USPSTF also recommends offering 1-time screening for HCV infection to adults born between 1945 and 1965. (B recommendation)[1339]

United States Preventive Services Task Force Recommendations – (2019 DRAFT)

HCV is the most common chronic bloodborne pathogen in the United States and a leading cause of complications from chronic liver disease. HCV infection is associated with more deaths than the top 60 other reportable infectious diseases combined, including HIV. The most important risk factor for HCV infection is past or current injection drug use. In the United States, an estimated 4.1 million persons have past or current HCV infection (i.e., tests positive for the anti-HCV antibody). Of these persons with antibodies, approximately 2.4 million have current infections based on testing with molecular assays for HCV RNA. The estimated prevalence of chronic HCV infection is approximately 1.0% (2013 to 2016). An estimated 41,200 new HCV infections occurred in the United States in 2016. Cases of acute HCV infection have increased approximately 3.5-fold (2010 to 2016) over the last decade. The increase in acute HCV incidence has mostly affected young, white persons who inject drugs (PWID), especially those living in rural areas. There has also been an increase in the number of women ages 15 to 44 years with HCV infection.

The USPSTF recommends screening for hepatitis C virus (HCV) infection in adults ages 18 to 79 years. (B recommendation.)[1340]

[1339] Moyer VA. Screening for hepatitis C virus infection in adults: U.S. Preventive Services Task Force recommendation statement. *Annals of Internal Medicine*. 2013; 159(5): 349-57.

[1340] U.S. Preventive Services Task Force. *Draft Recommendation Statement Hepatitis C Virus Infection in Adolescents and Adults: Screening.* 2019. Available at https://www.uspreventiveservicestaskforce.org/Page/Document/draft-recommendation-statement/hepatitis-c-screening1. Accessed October 2019.

Canadian Task Force on Preventive Health Care Recommendations (2017)

> *The task force recommends against screening for HCV in asymptomatic Canadian adults (including baby boomers) who are not at elevated risk of HCV infection. Strong recommendation based on very low-quality evidence.*
>
> *A strong recommendation against screening is warranted given its uncertain benefits but the certainty that it would lead to high levels of resource consumption. Referring individuals with screen-detected HCV for assessment would reduce access to assessment and treatment for people with clinically evident HCV.*[1341]

Background

In 2014, the BC Lifetime Prevention Schedule Expert Committee (LPSEC) requested that the CPB and CE of "offering 1-time screening for HCV infection to adults born between 1945 and 1965" in BC be modelled, based on the 2013 USPSTF recommendation.

In 2018, the LPSEC requested that all 26 CPS modelled to date be updated using 2017 data (or the most recently available data) and that all modelling assumptions be consistently applied in each of the individual models. At the time of this update, the CTFPHC recommendation "against screening for HCV in asymptomatic Canadian adults (including baby boomers)" had been published. In considering the divergent recommendations of the USPSTF and the CTFPHC, the LPSEC recommended that the analysis of CPB and CE be updated following the USPSTF recommendation to offer one-time screening for HCV infection to adults born between 1945 and 1965 due to the higher HCV infection rate in BC compared with the rest of Canada.

In 2019, the LPSEC became aware of a significant error in the calculation of CPB in the existing model. In addition, a substantial amount of new and updated data is currently available to allow for a more thorough model of CPB and CE.

Modelling the Clinically Preventable Burden

In this section, we will update and recalculate the CPB associated with one-time screening for HCV infection in BC adults born between 1945 and 1964.

In modelling CPB, we made the following assumptions:

- Hepatitis C infections tend to occur as "twin epidemics". ***New infections*** occur in younger birth cohorts who are commonly co-infected with HIV and/or the hepatitis B virus (HBV), socioeconomically marginalized, and living with mental health and addictions. ***Prevalent infections*** tend to be acquired in the distant past (prevalent infections are currently highest in the 1945 - 1964 birth cohort) and do not usually involve ongoing risk activities.[1342]
- The hepatitis C virus has multiple genotypes. A genotype is a way of categorizing HCV based on similar genes. Until recently, HCV was categorized into six genotypes[1343], which could be split into sub-types, but as genome sequencing

[1341] Canadian Task Force on Preventive Health Care. Recommendations on hepatitis C screening for adults. *Canadian Medical Association Journal*. 2017; 189(16): E594-E604.
[1342] Janjua N, Yu A, Kuo M, et al. Twin epidemics of new and prevalent hepatitis C infections in Canada: BC Hepatitis Testers Cohort. *BMC Infectious Diseases*. 2016; 16(334):
[1343] Hajarizadeh B, Grebely J and Dore GJ. Epidemiology and natural history of HCV infection. *Nature Reviews Gastroenterology & Hepatology*. 2013; 10(9): 553.

technology has improved, as many as eight distinct genotypes have been discovered.[1344]

- HCV genotypes are important because different genotypes respond differently to some medication used to treat and cure HCV.[1345] The BC Centre for Disease Control routinely performs HCV genotyping after confirming an HCV infection "as it will inform the type and length of treatment."[1346]
- Recent treatment advances for HCV include direct-acting antivirals (DAA). Some of the most recent DAA are "pangenotypic" meaning that cure rates are similar regardless of genotype.[1347,1348]
- HCV Genotype 1 is the most common genotype in North America.[1349] Genotypes 1, 2 and 3 are the most common in BC.[1350]
- The presence of an HCV infection is verified by the presence of HCV antibodies in the blood. A person thus infected is termed anti-HCV positive, meaning that HCV antibodies have been detected. The majority of HCV infections are asymptomatic.[1351]
- An HCV infection is considered active if the HCV virus is replicating itself. This is determined by testing for the presence of HCV RNA (ribonucleic acid), the virus' genetic material.[1352]
- Approximately 25% of persons infected with HCV spontaneously clear the infection (i.e. without medication).[1353,1354,1355] In these individuals, the hepatitis C virus stops replicating and they are considered cured.

[1344] Borgia SM, Hedskog C, Parhy B et al. Identification of a novel hepatitis C virus genotype from Punjab, India: expanding classification of hepatitis C virus into 8 genotypes. *The Journal of Infectious Diseases.* 2018; 218(11): 1722-9.
[1345] Treatment Action Group. *HCV Genotypes.*2016. Available at http://www.treatmentactiongroup.org/sites/default/files/Genotypes.pdf. Accessed October 2019.
[1346] BC Centre for Disease Control. *Communicable Disease Control. Hepatitis C.* 2016. Available at http://www.bccdc.ca/health-professionals/clinical-resources/communicable-disease-control-manual/communicable-disease-control. Accessed October 2019.
[1347] Treatment Action Group. *HCV Genotypes.*2016. Available at http://www.treatmentactiongroup.org/sites/default/files/Genotypes.pdf. Accessed October 2019.
[1348] Ponziani FR, Miele L, Tortora A et al. Treatment of early stage chronic hepatitis C virus infection. *Expert Review of Clinical Pharmacology.* 2018; 11(5): 519-24.
[1349] Hajarizadeh B, Grebely J and Dore GJ. Epidemiology and natural history of HCV infection. *Nature Reviews Gastroenterology & Hepatology.* 2013; 10(9): 553.
[1350] BC Centre for Disease Control. *Communicable Disease Control. Hepatitis C.* 2016. Available at http://www.bccdc.ca/health-professionals/clinical-resources/communicable-disease-control-manual/communicable-disease-control. Accessed October 2019.
[1351] Hajarizadeh B, Grebely J and Dore GJ. Epidemiology and natural history of HCV infection. *Nature Reviews Gastroenterology & Hepatology.* 2013; 10(9): 553.
[1352] BC Centre for Disease Control. *Communicable Disease Control. Hepatitis C.* 2016. Available at http://www.bccdc.ca/health-professionals/clinical-resources/communicable-disease-control-manual/communicable-disease-control. Accessed October 2019.
[1353] Government of Canada. *For Health Professionals: Hepatitis C*. 2019. Available at https://www.canada.ca/en/public-health/services/diseases/hepatitis-c/health-professionals-hepatitis-c.html. Accessed October 2019.
[1354] Hajarizadeh B, Grebely J and Dore GJ. Epidemiology and natural history of HCV infection. *Nature Reviews Gastroenterology & Hepatology.* 2013; 10(9): 553.
[1355] Hajarizadeh B, Grebely J and Dore GJ. Epidemiology and natural history of HCV infection. *Nature Reviews Gastroenterology & Hepatology.* 2013; 10(9): 553.

- Individuals who do not spontaneously clear the infection continue to have HCV RNA present and are considered HCV RNA positive.
- Successful treatment of HCV interferes with the replication of the hepatitis C virus.[1356] Removal of the virus and an absence of HCV RNA after 12 weeks indicates having achieved a sustained virologic response (SVR), or a cure.[1357]
- Individuals who have not either spontaneously cleared HCV or achieved SVR are considered to be actively infected. We use the term *chronic* HCV infection to identify these individuals.
- An active HCV infection kills liver cells (mostly through the body's response to the inflammation caused by HCV). Part of the body's natural defence against infection involves placing fibrous collagen[1358] in the area around damaged cells. The collagen is normally then dissolved as part of the completed healing process. When infected with hepatitis C however, the body is producing collagen at a faster rate than it can be dissolved leading to an accumulation of scar tissue in the liver that is termed fibrosis. Eventually, this accumulation of scar tissue (i.e. fibrosis progression), reduces the liver's ability to function since healthy cells are being cut off from nutrients and oxygen provided by the blood.[1359]
- Fibrosis generally progresses slowly and is classified in stages. One commonly used classification system is the METAVIR system (see Table 1).[1360,1361]

Table 1: Liver Fibrosis Stages (METAVIR Scoring)

Stage	Technical Definition	Common Definition	Liver Damage and Liver Function
F0	No Fibrosis	Mild fibrosis	No liver damage.
F1	Portal fibrosis without septa*	Mild fibrosis	Very mild liver damage.
F2	Portal fibrosis with few septa*	Significant fibrosis	Scarring has built up around the blood supply to the liver.
F3	Numerous septa* without cirrhosis	Severe fibrosis	The scars around different blood vessels in the liver are joined but liver function is unaffected.
F4	Cirrhosis	Compensated cirrhosis	The scarring is beginning to build up in the tissues of the liver and it's function is impaired.
		Decompensated cirrhosis	The liver can no longer maintain its function due to the extent of the scarring.

** A septum is a partition separating two chambers. Septa is the plural of septum.*

[1356] Treatment Action Group. *HCV Genotypes.*2016. Available at http://www.treatmentactiongroup.org/sites/default/files/Genotypes.pdf. Accessed October 2019.
[1357] BC Centre for Disease Control. *Communicable Disease Control. Hepatitis C.* 2016. Available at http://www.bccdc.ca/health-professionals/clinical-resources/communicable-disease-control-manual/communicable-disease-control. Accessed October 2019.
[1358] Scar tissue
[1359] The Hepatitis C Trust. *How Hepatitis C Damages the Liver*. 2019. Available at http://www.hepctrust.org.uk/information/impact-hepatitis-c-liver/hepatitis-c-and-liver-damage. Accessed October 2019.
[1360] Poynard T, Bedossa P and Opolon P. Natural history of liver fibrosis progression in patients with chronic hepatitis C. *The Lancet*. 1997; 349(9055): 825-32.
[1361] The Hepatitis C Trust. *Hepatitis C Liver Damage Progression*. 2019. Available at http://www.hepctrust.org.uk/information/impact-hepatitis-c-liver/progression-hepatitis-c. Accessed October 2019.

- After progressing through the stages of fibrosis, individuals with *chronic* HCV can further progress to hepatic decompensation (decompensated cirrhosis) and / or hepatocellular carcinoma.[1362]
- There is not any conclusive evidence linking genotype and the rate of fibrosis progression.[1363]

- We model HCV infection overall, rather than on a genotype level, since current treatment success rates and disease progression are largely genotype-independent.

- In their analysis of the burden of disease of HCV in Canada, Myers and colleagues back-calculated HCV progression rates by sex and 10-year age band.[1364] We use these data and apply a weighting to the Myers et al. numbers based on the proportion of each sex who have HCV in BC.[1365] The results are shown in Table 2.

Table 2: Disease Progression through to Cirrhosis and Hepatocellular Carcinoma (HCC)
Annual Rate of Progression to Next Stage, by Age

	Current Stage (From) / Future Stage (To)	f0 to f1	f1 to f2	f2 to f3	f3 to Cirrhosis	f3 to HCC	Cirrhosis to HCC
Male	20 - 29	5.2%	3.8%	5.3%	2.5%	0.0%	0.3%
	30 - 39	3.8%	2.7%	3.9%	5.7%	0.0%	0.5%
	40 - 49	13.9%	10.1%	14.3%	8.8%	0.1%	0.9%
	50 - 59	17.1%	12.4%	17.5%	4.8%	0.1%	1.4%
	60 - 69	19.4%	14.1%	19.9%	9.9%	0.2%	2.4%
	70 - 79	21.8%	15.8%	22.4%	19.1%	0.3%	3.9%
	80+	17.9%	13.0%	18.3%	19.1%	0.3%	3.9%
Female	20 - 29	4.3%	3.1%	4.4%	2.1%	0.0%	0.3%
	30 - 39	3.1%	2.3%	3.2%	4.7%	0.0%	0.4%
	40 - 49	11.6%	8.4%	11.9%	7.4%	0.0%	0.7%
	50 - 59	14.3%	10.4%	14.6%	4.0%	0.1%	1.2%
	60 - 69	16.2%	11.7%	16.6%	8.3%	0.1%	2.0%
	70 - 79	18.2%	13.2%	18.6%	15.9%	0.2%	3.3%
	80+	14.9%	10.8%	15.3%	1.6%	0.2%	3.3%
Weighted Total	20 - 29	4.9%	3.5%	5.0%	2.4%	0.0%	0.3%
	30 - 39	3.5%	2.6%	3.6%	5.3%	0.0%	0.5%
	40 - 49	13.1%	9.5%	13.4%	8.3%	0.1%	0.8%
	50 - 59	16.1%	11.7%	16.4%	4.5%	0.1%	1.3%
	60 - 69	18.2%	13.2%	18.7%	9.3%	0.2%	2.3%
	70 - 79	20.5%	14.8%	21.0%	17.9%	0.3%	3.7%
	80+	16.8%	12.2%	17.2%	12.6%	0.3%	3.7%

BC HCV Diagnosed who are Male	**63.1%**
BC HCV Diagnosed who are Female	**36.9%**

[1362] Xu F, Moorman AC, Tong X et al. All-cause mortality and progression risks to hepatic decompensation and hepatocellular carcinoma in patients infected with hepatitis C virus. *Clinical Infectious Diseases*. 2015; 62(3): 289-97.
[1363] Hajarizadeh B, Grebely J and Dore GJ. Epidemiology and natural history of HCV infection. *Nature Reviews Gastroenterology & Hepatology*. 2013; 10(9): 553.
[1364] Myers RP, Krajden M, Bilodeau M et al. Burden of disease and cost of chronic hepatitis C virus infection in Canada. *Canadian Journal of Gastroenterology and Hepatology*. 2014; 28(5): 243-50.
[1365] Bartlett S, Yu A, Chapinal N, et al. The population level care cascade for hepatitis C in British Columbia, Canada as of 2018: Impact of direct acting antivirals. *Liver International*. 2019; DOI: 10.1111/liv.14227.

- In addition to the annual progression probabilities outlined in Table 2, we have assumed that, once cirrhosis has developed, there is an annual risk of 3 – 6% of **hepatic decompensation**.[1366,1367] We model an annual risk of hepatic decompensation after cirrhosis of 4.5% (the mid-point of 3% and 6%) and vary this between 3% and 6% in our sensitivity analysis.
- The annual probability of death due to hepatic decompensation ranges from 13.5% to 21.6%.[1368,1369,1370] We model an annual risk of death following hepatic decompensation of 17.6% (the mid-point of 13.5% and 21.6%) and vary this between 13.5% and 21.6% in our sensitivity analysis.

- Once cirrhosis has developed, there is an annual risk of 1 – 5% of developing hepatocellular carcinoma (HCC).[1371,1372,1373,1374] Our model values fall within this range (see Table 2).

- We model the annual probability of death due to **HCC** at 70.7% (43.0% to 77.0%) in the first year and 16.2% (11.0% – 23.0%) each subsequent year.[1375]
- We model the annual probability of a **liver transplant** following decompensated cirrhosis or liver cancer is 3.2%.[1376,1377]

- Myers and colleagues report an annual probability of death after liver transplant of between 10.7% and 33.1% in the first year and between 3.9% and 4.8% each subsequent year.[1378]
- Wong et al. use a 14.2% annual probability of death within the first year of a liver transplant and 3.4% each subsequent year.[1379]

[1366] Rein DB, Smith BD, Wittenborn JS et al. The cost-effectiveness of birth-cohort screening for hepatitis C antibody in U.S. primary care settings. *Annals of Internal Medicine.* 2012; 156(4): 263-70.
[1367] Westbrook RH and Dusheiko G. Natural history of hepatitis C. *Journal of Hepatology.* 2014; 61(1): S58-S68.
[1368] Rein DB, Smith BD, Wittenborn JS et al. The cost-effectiveness of birth-cohort screening for hepatitis C antibody in U.S. primary care settings. *Annals of Internal Medicine.* 2012; 156(4): 263-70.
[1369] Westbrook RH and Dusheiko G. Natural history of hepatitis C. *Journal of Hepatology.* 2014; 61(1): S58-S68.
[1370] Wong WW, Erman A, Feld JJ et al. Model-based projection of health and economic effects of screening for hepatitis C in Canada. *CMAJ Open.* 2017; 5(3): E662.
[1371] Rein DB, Smith BD, Wittenborn JS et al. The cost-effectiveness of birth-cohort screening for hepatitis C antibody in U.S. primary care settings. *Annals of Internal Medicine.* 2012; 156(4): 263-70.
[1372] Hajarizadeh B, Grebely J and Dore GJ. Epidemiology and natural history of HCV infection. *Nature Reviews Gastroenterology & Hepatology.* 2013; 10(9): 553.
[1373] Westbrook RH and Dusheiko G. Natural history of hepatitis C. *Journal of Hepatology.* 2014; 61(1): S58-S68.
[1374] Wong WW, Erman A, Feld JJ et al. Model-based projection of health and economic effects of screening for hepatitis C in Canada. *CMAJ Open.* 2017; 5(3): E662.
[1375] Myers RP, Krajden M, Bilodeau M et al. Burden of disease and cost of chronic hepatitis C virus infection in Canada. *Canadian Journal of Gastroenterology and Hepatology*. 2014; 28(5): 243-50.
[1376] Rein DB, Smith BD, Wittenborn JS et al. The cost-effectiveness of birth-cohort screening for hepatitis C antibody in U.S. primary care settings. *Annals of Internal Medicine.* 2012; 156(4): 263-70.
[1377] Wong WW, Erman A, Feld JJ et al. Model-based projection of health and economic effects of screening for hepatitis C in Canada. *CMAJ Open.* 2017; 5(3): E662.
[1378] Myers RP, Krajden M, Bilodeau M et al. Burden of disease and cost of chronic hepatitis C virus infection in Canada. *Canadian Journal of Gastroenterology and Hepatology*. 2014; 28(5): 243-50.
[1379] Wong WW, Erman A, Feld JJ et al. Model-based projection of health and economic effects of screening for hepatitis C in Canada. *CMAJ Open.* 2017; 5(3): E662.

- We model annual probability of death after **liver transplant** after Myers et al.[1380] and use the midpoint of the ranges for liver transplant deaths (21.9% in the first year and 4.4% in each subsequent year.)

- In 2019, an individual born in 1964 would be approximately 55 years of age while an individual born in 1945 would be approximately 74 years of age. The average age of the cohort is 65 (average of 55 and 74 rounded up). The average life expectancy of a 65 year old in BC is 20.8 years.

- For the 65-year-old cohort representative of the 1945 – 1964 birth cohort we assume that any HCV infected individual whose disease had progressed beyond cirrhosis (i.e. fibrosis stage f4) by age 65 had been detected and identified as HCV infected.
- In their modelling, Wong et al. estimate treatment naïve patients with a mean age of 50 years old to be distributed into the following stages of fibrosis: f0 – 8%, f1 – 20%, f2 – 35%, f3 – 21% and f4 (cirrhosis) – 16%.[1381]
- In a different model, Wong et al. assumed the following distribution in 55 – 79 year olds based on intake data from a tertiary treatment facility: f0 – 5%, f1 – 10%, f2 – 15%, f3 – 45% and f4 (cirrhosis) – 25%.[1382]

- We model the distribution of cases detected by screening after the treatment naïve patients and use the tertiary intake data in our sensitivity analysis.

- The BC Hepatitis Testers Cohort (BC-HTC) consists of over 1.7 million individuals in British Columbia tested for HCV or human immunodeficiency virus (HIV) or those reported as a case of hepatitis B virus (HBV), HCV, HIV or active tuberculosis (TB) since 1990.[1383]
- Based on data from the BC-HTC, in the BC 1945-64 birth cohort, there are an estimated 37,056 individuals in BC who are HCV antibody positive; 30,574 have been diagnosed[1384] and an estimated 6,482 are undiagnosed.[1385] In 2018, there are an estimated 1,278,177 individuals in the BC 1945-64 birth cohort, suggesting that 2.392% (Table 11, row *f*) of the cohort are diagnosed HCV antibody positive and 0.507% (6,482 / 1,278,177) are undiagnosed (Table 11, row *g*).
- Using the estimated 0.507% of undiagnosed cases in the BC 1945-64 birth cohort, we calculated the number of cases of HCV that would be detected by screening within our birth cohort of 40,000 at 113.3 (Table 11, row *m*). We proceed to model these 113.3 previously undiagnosed cases detected through screening within our birth cohort based on the assumption of no universal screening (they would ***not*** be

[1380] Myers RP, Krajden M, Bilodeau M et al. Burden of disease and cost of chronic hepatitis C virus infection in Canada. *Canadian Journal of Gastroenterology and Hepatology*. 2014; 28(5): 243-50.
[1381] Wong WW, Lee KM, Singh S et al. Drug therapies for chronic hepatitis C infection: a cost-effectiveness analysis. *CMAJ Open.* 2017; 5(1): E97.
[1382] Wong WW, Erman A, Feld JJ et al. Model-based projection of health and economic effects of screening for hepatitis C in Canada. *CMAJ Open*. 2017; 5(3): E662.
[1383] Bartlett S, Yu A, Chapinal N, et al. The population level care cascade for hepatitis C in British Columbia, Canada as of 2018: Impact of direct acting antivirals. *Liver International*. 2019; DOI: 10.1111/liv.14227.
[1384] Bartlett S, Yu A, Chapinal N, et al. The population level care cascade for hepatitis C in British Columbia, Canada as of 2018: Impact of direct acting antivirals. *Liver International*. 2019; DOI: 10.1111/liv.14227.
[1385] Dr. Mel Krajden. Medical Head, Hepatitis, BC Centre for Disease Control. Personal Communication. November 2019.

detected). That is, we modelled changes in their disease states assuming no intervention with DAA for the 20.8 years of life remaining for the average 65 year old British Columbian (see Table 3).

Table 3: Undetected Individuals with RNA+ HCV in BC 1945 - 64 Birth Cohort within BC Birth Cohort of 40,000

Number of Indivduals in Each Disease State at the Start of the Year - In the ***Absence*** of Screening and Treatment

Age	f0	f1	f2	f3	Cirrhosis	Decomp. Cirr	1st Year HCC	HCC	1st Year Liver Transplant	Liver Transplant	HCV-Related Death	Total
65	***9.1***	***22.7***	***39.7***	***23.8***	***18.1***	0.0	0.0	0.0	0.0	0.0	0.0	113.3
66	7.4	21.3	35.2	29.0	19.1	0.8	0.4	0.0	0.0	0.0	0.0	113.3
67	6.1	19.9	31.5	32.8	20.5	1.5	0.5	0.1	0.0	0.0	0.5	113.3
68	5.0	18.3	28.2	35.6	22.2	2.1	0.5	0.2	0.1	0.0	1.1	113.3
69	4.1	16.8	25.4	37.5	24.0	2.7	0.6	0.3	0.1	0.1	1.9	113.3
70	3.3	15.3	22.9	38.7	25.9	3.2	0.6	0.4	0.1	0.2	2.8	113.3
71	2.6	13.7	20.3	36.4	30.7	3.7	1.1	0.5	0.1	0.2	3.9	113.3
72	2.1	12.2	18.1	34.1	34.7	4.3	1.2	0.7	0.2	0.3	5.4	113.3
73	1.7	10.8	16.1	31.7	38.0	5.0	1.4	0.9	0.2	0.4	7.2	113.3
74	1.3	9.6	14.3	29.3	40.5	5.7	1.5	1.0	0.2	0.6	9.2	113.3
75	1.1	8.4	12.8	27.0	42.5	6.3	1.6	1.2	0.3	0.7	11.5	113.3
76	0.8	7.4	11.3	24.8	43.8	6.9	1.6	1.4	0.3	0.9	14.0	113.3
77	0.7	6.5	10.0	22.6	44.7	7.5	1.7	1.6	0.3	1.1	16.7	113.3
78	0.5	5.6	8.9	20.6	45.1	7.9	1.7	1.7	0.3	1.3	19.6	113.3
79	0.4	4.9	7.9	18.7	45.1	8.3	1.7	1.8	0.4	1.5	22.6	113.3
80	0.3	4.3	6.9	17.0	44.8	8.6	1.7	1.9	0.4	1.7	25.7	113.3
81	0.3	3.8	6.3	16.0	43.3	8.9	1.7	2.0	0.4	1.9	28.9	113.3
82	0.2	3.4	5.7	15.0	41.7	9.0	1.6	2.0	0.4	2.2	32.1	113.3
83	0.2	3.0	5.1	14.0	40.2	9.0	1.6	2.1	0.4	2.4	35.3	113.3
84	0.2	2.7	4.6	13.1	38.7	8.9	1.5	2.1	0.4	2.6	38.5	113.3
85	0.1	2.4	4.1	12.2	37.2	8.8	1.5	2.1	0.4	2.8	41.7	113.3
86	0.1	2.1	3.7	11.3	35.7	8.7	1.4	2.0	0.4	3.0	44.8	113.3

- Transition data from Table 2 was then used to estimate how many of the 113.3 individuals in the cohort would enter a given disease state (e.g. cirrhosis, decompensated cirrhosis, HCC, liver transplant recipient and death) by year / age in the absence of any screening / treatment program (see Table 4). That is, of the 113.3 individuals, 96.2 either already had or would eventually get cirrhosis and 34.9 of these would move to decompensated cirrhosis. Of the 113.3 individuals, 28.4 (1.27 + 27.08) would move to HCC and 5.8 (4.09 + 1.69) would get a liver transplant. Finally, a total of 47.9 HCV-related deaths would occur in the cohort, 23.3 due to HCC, 22.4 due to decompensated cirrhosis and 2.2 following a liver transplant (see Table 4).

Table 4: Undetected Individuals with RNA+ HCV in BC 1945 - 64 Birth Cohort within BC Birth Cohort of 40,000

Number of Incident Cases in each Disease State by Year - In the ***Absence*** of Screening and Treatment

						HCC Originating From		Liver Tx Originating From		Deaths Resulting From					
Age	f1	f2	f3	Cirrhosis	Decomp Cirrhosis	f3	Cirrhosis	Decomp Cirrhosis	HCC	Decomp Cirrhosis	Liver Tx (Within the 1st Yr)	Liver Tx (*After* the 1st Yr)	HCC (Within the 1st Yr)	HCC (*After* the 1st Yr)	Total HCV-Related Deaths
65	1.65	2.99	7.41	2.22	0.82	0.04	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
66	1.35	2.82	6.58	2.70	0.86	0.05	0.43	0.03	0.01	0.14	0.00	0.00	0.32	0.00	0.46
67	1.10	2.62	5.88	3.05	0.92	0.05	0.46	0.05	0.02	0.26	0.01	0.00	0.34	0.02	0.63
68	0.90	2.42	5.27	3.31	1.00	0.06	0.50	0.07	0.02	0.37	0.01	0.00	0.36	0.04	0.79
69	0.74	2.22	4.74	3.49	1.08	0.06	0.54	0.09	0.03	0.47	0.02	0.00	0.39	0.05	0.94
70	0.68	2.28	4.80	6.93	1.16	0.10	0.95	0.10	0.03	0.56	0.02	0.01	0.43	0.06	1.08
71	0.54	2.04	4.27	6.53	1.38	0.10	1.13	0.12	0.05	0.65	0.03	0.01	0.74	0.08	1.51
72	0.43	1.82	3.80	6.11	1.56	0.09	1.28	0.14	0.06	0.76	0.04	0.01	0.87	0.11	1.78
73	0.34	1.61	3.38	5.68	1.71	0.08	1.40	0.16	0.07	0.87	0.04	0.02	0.97	0.14	2.04
74	0.27	1.42	3.01	5.25	1.82	0.08	1.49	0.18	0.08	0.99	0.05	0.03	1.05	0.17	2.28
75	0.22	1.25	2.68	4.84	1.91	0.07	1.56	0.20	0.09	1.11	0.06	0.03	1.11	0.20	2.50
76	0.17	1.10	2.38	4.44	1.97	0.07	1.61	0.22	0.10	1.21	0.06	0.04	1.15	0.23	2.70
77	0.14	0.96	2.11	4.06	2.01	0.06	1.64	0.24	0.10	1.31	0.07	0.05	1.19	0.25	2.86
78	0.11	0.84	1.87	3.70	2.03	0.05	1.66	0.25	0.11	1.39	0.07	0.06	1.20	0.27	3.00
79	0.09	0.73	1.65	3.36	2.03	0.05	1.66	0.27	0.11	1.46	0.08	0.07	1.21	0.29	3.10
80	0.06	0.52	1.19	2.15	2.01	0.04	1.65	0.28	0.12	1.51	0.08	0.08	1.21	0.31	3.18
81	0.05	0.46	1.08	2.02	1.95	0.04	1.59	0.28	0.12	1.55	0.09	0.09	1.20	0.32	3.24
82	0.04	0.41	0.97	1.90	1.88	0.04	1.54	0.29	0.12	1.57	0.09	0.10	1.15	0.33	3.24
83	0.03	0.37	0.88	1.78	1.81	0.04	1.48	0.29	0.12	1.57	0.09	0.10	1.11	0.34	3.21
84	0.03	0.33	0.79	1.66	1.74	0.03	1.42	0.29	0.12	1.56	0.09	0.11	1.07	0.34	3.18
85	0.02	0.29	0.71	1.54	1.67	0.03	1.37	0.28	0.11	1.55	0.09	0.12	1.03	0.34	3.12
86	0.02	0.26	0.64	1.43	1.61	0.03	1.31	0.28	0.11	1.52	0.09	0.13	0.99	0.33	3.06
Total	**8.97**	**29.76**	**66.09**	**78.11**	**34.94**	**1.27**	**27.08**	**4.09**	**1.69**	**22.37**	**1.18**	**1.05**	**19.09**	**4.20**	**47.90**

- HCV testing data from the BC-HTC is summarized on Table 5.[1386] A total of 1,235,457 British Columbians had been tested for HCV by December 31, 2015. Of these, 55,568 (4.5%) tested positive and were still alive. A total of 3,459,242 British Columbians had not yet been tested, or 74% of the population.

- For the 1,325,760 individuals born between 1945 and 1965, 416,669 (31.4%, see Table 11, row *c*) had been tested for HCV by December 31, 2015 (see Table 5). Of 416,669 that had been tested, 34,511 (8.3%) tested positive and were still alive. A total of 909,091 (or 68.6%) of this cohort had not yet been tested.

Table 5: Testing for HCV Positive Individuals in BC

As of December 31, 2015, Adjusted for Deaths

Birth Year Cohort	2015 Population BC	Ever Tested for HCV	% of Cohort Tested	HCV Positive	% of Tested HCV Positive
<1945	504,792	104,771	20.8%	2,677	2.6%
1945-65	1,325,760	416,669	31.4%	34,511	8.3%
1966-75	635,543	252,364	39.7%	11,187	4.4%
>1975	2,228,604	461,653	20.7%	7,193	1.6%
Total	**4,694,699**	**1,235,457**	**26.3%**	**55,568**	**4.5%**

- Based on the data in Table 5, we assumed that 31.4% (Table 11, row *c*) of the BC 1945-64 birth cohort in our model has been screened.

- Using data from the BC-HTC, Bartlett and colleagues provide details on the population level care cascade for Hep C in BC based on all individuals ever tested

[1386] Dr. Mel Krajden. Medical Head, Hepatitis, BC Centre for Disease Control. Personal Communication. September, 2019.

between 1990 and 2015, with linkage to the data on medical visits, hospitalizations, cancers, prescription drugs and deaths through to December 31, 2018. We use this data in Table 6.[1387]

- A total of 44,507 individuals who are HCV antibody positive have had HCV RNA testing. 32,031 of these 44,507 (72.0%) tested RNA positive. For the 1945-64 birth cohort, 19,060 of the 25,577 (74.5%) tested RNA positive (Table 6 and Table 11, row *j*).
- Of the 17,441 individuals who have had HCV treatment initiated, an estimated 15,672 (89.9%) achieved a sustained virologic response (SVR). For the 1945-64 birth cohort, an estimated 10,895 of 12,030 (90.6%) achieved SVR.

Table 6: The Care Cascade for Hepatitis C in BC

As of December 31, 2018, Adjusted for Deaths

Birth Year Cohort	Tested HCV Antibody #	Tested HCV Antibody %	2018 Population BC	HCV Antibody % +ve	HCV RNA Tested	HCV RNA Positive	HCV RNA % +ve	HCV Treatment Initiated	SVR Achieved / Unknown	% Achieving SVR[1]
<1945	2,249	4.2%	426,050	0.53%	1,770	1,315	74.3%	697	616	88.4%
1945-64	30,574	57.2%	1,278,177	2.39%	25,577	19,060	74.5%	12,030	10,895	90.6%
1965-74	11,679	21.9%	680,687	1.72%	9,472	6,680	70.5%	2,981	2,641	88.6%
>1974	8,939	16.7%	2,605,235	0.34%	7,688	4,976	64.7%	1,733	1,520	87.7%
Total	**53,441**	**100.0%**	**4,990,150**	**1.07%**	**44,507**	**32,031**	**72.0%**	**17,441**	**15,672**	**89.9%**

[1] *Patients who were treated, but who did not have an HCV RNA negative test on record (unknown) were assumed to achieve SVR at the same rate as those had an HCV RNA negative test recorded.*

- In their modelling work, Wong and colleagues assumed an uptake of screening ranging from 76.6% to 90.0% based on the cohort's risk of infection and age range, using clinical expert's opinions.[1388] We have assumed that 83.3% (the mid-point of the Wong et al estimates) of the unscreened population within the 1945-64 birth cohort would accept screening (see Table 11, row *l*) and varied this from 76.6% to 90.0% in the sensitivity analysis.

- In their modelling work, Wong and colleagues assumed an uptake of treatment ranging from 80.0% to 95.0% based on the cohort's risk of infection and age range, using clinical expert's opinions.[1389] We have assumed that, in the absence of personal financial barriers, the proportion of the population that is HCV RNA+ that is eligible for and will accept treatment is estimated at 87.5% % (the mid-point of the Wong et al estimates) (see Table 11, row *n*), and varied this from 80.0% to 95.0% in the sensitivity analysis.

[1387] Bartlett S, Yu A, Chapinal N, et al. The population level care cascade for hepatitis C in British Columbia, Canada as of 2018: Impact of direct acting antivirals. *Liver International*. 2019; DOI: 10.1111/liv.14227.
[1388] Wong WW, Erman A, Feld JJ et al. Model-based projection of health and economic effects of screening for hepatitis C in Canada. *CMAJ Open*. 2017; 5(3): E662.
[1389] Wong WW, Erman A, Feld JJ et al. Model-based projection of health and economic effects of screening for hepatitis C in Canada. *CMAJ Open*. 2017; 5(3): E662.

- The efficacy of Direct Acting Antiviral (DAA) treatment in producing a sustained viral response (i.e. a cure) in *clinical trials* is 95%.[1390,1391,1392,1393]
- As noted above, the effectiveness of DAA treatment in BC in the 1945-64 birth cohort appears to be 90.6% (see Table 6).[1394]
- Newer types of DAA treatment continue to come on to the market. Some of these treatments are more efficacious for specific genotypes, but pangenomic treatments are now available where the efficacy is similar for all genotypes. Since 2017 in BC, 66.9% of DAA treatment for HCV has been by Epclusa, a pangenomic treatment. In 2018 and 2019, 91.1% of HCV treatment in BC was with Epclusa, Maviret and Zepatier.[1395] Epclusa and Maviret are both pangenomic, while Zepatier is indicated for genotypes 1 and 4.
- **Epclusa** (sofosbuvir 400 mg – velpatasvir 100 mg) results in an SVR in 98.2% of HCV infected individuals of all genotypes, with or without cirrhosis (except genotype 3 with cirrhosis). For individuals with genotype 3 HCV and cirrhosis, 96.3% achieved SVR.[1396] Overall, Epclusa achieved SVR rates of 95 – 99% in clinical trials.[1397,1398]
- In clinical trials of **Zepatie**r, overall SVR rates of 95% were reported for treatment-naïve participants with HCV genotypes 1, 4 and 6.[1399]
- In clinical trials of **Maviret** (glecaprevir 300 mg – pibrentasvir 120 mg), SVR rates in excess of 99% for all genotypes without cirrhosis were achieved, except genotype 3 for which SVR rates were 95%.[1400,1401]

[1390] Kowdley KV, Gordon SC, Reddy KR et al. Ledipasvir and sofosbuvir for 8 or 12 weeks for chronic HCV without cirrhosis. *New England Journal of Medicine*. 2014; 370(20): 1879-88.
[1391] Afdhal N, Zeuzem S, Kwo P et al. Ledipasvir and sofosbuvir for untreated HCV genotype 1 infection. *New England Journal of Medicine*. 2014; 370(20): 1889-98.
[1392] Afdhal N, Reddy KR, Nelson DR et al. Ledipasvir and sofosbuvir for previously treated HCV genotype 1 infection. *New England Journal of Medicine*. 2014; 370(16): 1483-93.
[1393] Zeuzem S, Dusheiko GM, Salupere R et al. Sofosbuvir and ribavirin in HCV genotypes 2 and 3. *New England Journal of Medicine*. 2014; 370(21): 1993-2001.
[1394] Bartlett SR, Yu A, Chapinal N et al. The population level care cascade for hepatitis C in British Columbia, Canada as of 2018: Impact of Direct Acting Antivirals. *Liver International*. 2019; 00: 1-12.
[1395] Tijana Fazlagic. A/Executive Director, Pharmacare Benefits, Pharmaceutical Therapies & Pharmacare Division, BC Ministry of Health. Personal Communication. October 30, 2019.
[1396] Jacobson IM, Lawitz E, Gane EJ et al. Efficacy of 8 weeks of sofosbuvir, velpatasvir, and voxilaprevir in patients with chronic HCV infection: 2 phase 3 randomized trials. *Gastroenterology*. 2017; 153(1): 113-22.
[1397] Feld JJ, Jacobson IM, Hézode C et al. Sofosbuvir and velpatasvir for HCV genotype 1, 2, 4, 5, and 6 infection. *New England Journal of Medicine*. 2015; 373(27): 2599-607.
[1398] Foster GR, Afdhal N, Roberts SK et al. Sofosbuvir and velpatasvir for HCV genotype 2 and 3 infection. *New England Journal of Medicine*. 2015; 373(27): 2608-17.
[1399] Zeuzem S, Ghalib R, Reddy KR et al. Grazoprevir–elbasvir combination therapy for treatment-naive cirrhotic and noncirrhotic patients with chronic hepatitis C virus genotype 1, 4, or 6 infection: a randomized trial. *Annals of Internal Medicine.* 2015; 163(1): 1-13.
[1400] Asselah T, Kowdley KV, Zadeikis N et al. Efficacy of glecaprevir/pibrentasvir for 8 or 12 weeks in patients with hepatitis C virus genotype 2, 4, 5, or 6 infection without cirrhosis. *Clinical Gastroenterology and Hepatology*. 2018; 16(3): 417-26.
[1401] Zeuzem S, Foster GR, Wang S et al. Glecaprevir–pibrentasvir for 8 or 12 weeks in HCV genotype 1 or 3 infection. *New England Journal of Medicine*. 2018; 378(4): 354-69.

- We model the effectiveness of DAA treatment in the 1945-64 birth cohort at 97% (midpoint of 95% and 99% for Epclusa, the most common type of DAA currently prescribed) and vary this between 95% - 99% in the sensitivity analysis (Table 11, row *p*).

- We assume that a salvage treatment using a combination of sofosbuvir / velpatasvir / voxilaprevir is attempted for individuals who do not respond to the first treatment. We model the effectiveness of the salvage DAA treatment at a rate of 97%, varied between 95% - 99% in the sensitivity analysis (Table 11, row *p*).[1402]

- We then updated our model assuming that 87.5% (Table 11, row *n*) of the 113.3 individuals with undiagnosed RNA+ HCV infection detected through screening would accept treatment and that the overall effectiveness of DAA treatment, including salvage treatment, in achieving SVR would be 99.9% (Table 11, row *q*). We assume that disease progression stops once SVR is achieved. Using this approach means that 14.3 of the 113.3 individuals with undiagnosed RNA+ HCV infection detected through screening would either not accept treatment or would not achieve SVR if treated. Using only these 14.3 individuals beginning at age 65, we allowed the disease to progress without any intervention for the 20.8 years of life remaining for the average 65 year old British Columbian (see Table 7).

Table 7: Undetected Individuals with RNA+ HCV in BC 1945 - 64 Birth Cohort within BC Birth Cohort of 40,000

Number of Indivduals in Each Disease State at the Start of the Year - Untreated or Failed Treatment

Age	f0	f1	f2	f3	Cirrhosis	Decomp. Cirr	1st Year HCC	HCC	1st Year Liver Transplant	Liver Transplant	HCV-Related Death	Total
65	1.14	2.85	4.99	2.99	2.28	0.00	0.00	0.00	0.00	0.00	0.00	14.3
66	0.93	2.68	4.43	3.64	2.41	0.10	0.06	0.00	0.00	0.00	0.00	14.3
67	0.76	2.50	3.96	4.13	2.58	0.19	0.06	0.01	0.01	0.00	0.06	14.3
68	0.62	2.31	3.55	4.47	2.79	0.27	0.06	0.03	0.01	0.00	0.14	14.3
69	0.51	2.12	3.19	4.71	3.02	0.34	0.07	0.04	0.01	0.01	0.24	14.3
70	0.42	1.93	2.87	4.86	3.25	0.40	0.08	0.05	0.01	0.02	0.35	14.3
71	0.33	1.73	2.56	4.58	3.86	0.47	0.13	0.06	0.02	0.03	0.49	14.3
72	0.26	1.54	2.28	4.29	4.37	0.54	0.15	0.08	0.02	0.04	0.68	14.3
73	0.21	1.36	2.03	3.98	4.78	0.63	0.17	0.11	0.02	0.06	0.90	14.3
74	0.17	1.21	1.80	3.69	5.10	0.71	0.19	0.13	0.03	0.07	1.16	14.3
75	0.13	1.06	1.60	3.39	5.34	0.79	0.20	0.15	0.03	0.09	1.45	14.3
76	0.11	0.93	1.42	3.11	5.51	0.87	0.21	0.18	0.04	0.11	1.76	14.3
77	0.08	0.81	1.26	2.85	5.62	0.94	0.21	0.20	0.04	0.14	2.10	14.3
78	0.07	0.71	1.12	2.59	5.67	1.00	0.21	0.21	0.04	0.16	2.46	14.3
79	0.05	0.62	0.99	2.36	5.67	1.05	0.22	0.23	0.05	0.19	2.84	14.3
80	0.04	0.54	0.87	2.14	5.63	1.08	0.21	0.24	0.05	0.22	3.23	14.3
81	0.04	0.48	0.79	2.01	5.44	1.11	0.21	0.25	0.05	0.24	3.63	14.3
82	0.03	0.43	0.71	1.89	5.25	1.13	0.21	0.26	0.05	0.27	4.04	14.3
83	0.02	0.38	0.64	1.77	5.06	1.13	0.20	0.26	0.05	0.30	4.44	14.3
84	0.02	0.34	0.58	1.65	4.87	1.12	0.19	0.26	0.05	0.33	4.85	14.3
85	0.02	0.30	0.52	1.53	4.68	1.11	0.18	0.26	0.05	0.35	5.25	14.3
86	0.01	0.27	0.47	1.43	4.49	1.09	0.18	0.26	0.05	0.38	5.64	14.3

[1402] Dr. Naveed Janjua, Epidemiologist and Senior Scientists, Hepatitis, BC Centre for Disease Control. Personal Communication. November 2019.

- Transition data from Table 2 was then used to estimate how many of the 14.3 individuals in the cohort would enter a given disease state (e.g. cirrhosis, decompensated cirrhosis, HCC, liver transplant recipient and death) by year / age in the absence of any screening / treatment program (see Table 8). That is, of the 14.3 individuals, 12.1 either already had or would eventually get cirrhosis and 4.40 of these would move to decompensated cirrhosis. Of the 14.3 individuals, 3.6 (0.16 + 3.41) would move to HCC and 0.73 (0.51 + 0.21) would get a liver transplant. Finally, a total of 6.02 HCV-related deaths would occur in the cohort, 2.93 due to HCC, 2.81 due to decompensated cirrhosis and 0.28 following a liver transplant (see Table 8).

Table 8: Undetected Individuals with RNA+ HCV in BC 1945 - 64 Birth Cohort within BC Birth Cohort of 40,000

Number of Incident Cases in each Disease State by Year - In the *Presence* of Screening and Treatment

						HCC Originating From		Liver Tx Originating From		Deaths Resulting From					
Age	f1	f2	f3	Cirrhosis	Decomp Cirrhosis	f3	Cirrhosis	Decomp Cirrhosis	HCC	Decomp Cirrhosis	Liver Tx (Within the 1st Yr)	Liver Tx (*After* the 1st Yr)	HCC (Within the 1st Yr)	HCC (*After* the 1st Yr)	Total HCV-Related Deaths
65	0.21	0.38	0.93	0.28	0.10	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
66	0.17	0.35	0.83	0.34	0.11	0.01	0.05	0.00	0.00	0.02	0.00	0.00	0.04	0.00	0.06
67	0.14	0.33	0.74	0.38	0.12	0.01	0.06	0.01	0.00	0.03	0.00	0.00	0.04	0.00	0.08
68	0.11	0.30	0.66	0.42	0.13	0.01	0.06	0.01	0.00	0.05	0.00	0.00	0.05	0.00	0.10
69	0.09	0.28	0.60	0.44	0.14	0.01	0.07	0.01	0.00	0.06	0.00	0.00	0.05	0.01	0.12
70	0.09	0.29	0.60	0.87	0.15	0.01	0.12	0.01	0.00	0.07	0.00	0.00	0.05	0.01	0.14
71	0.07	0.26	0.54	0.82	0.17	0.01	0.14	0.01	0.01	0.08	0.00	0.00	0.09	0.01	0.19
72	0.05	0.23	0.48	0.77	0.20	0.01	0.16	0.02	0.01	0.10	0.00	0.00	0.11	0.01	0.22
73	0.04	0.20	0.43	0.71	0.21	0.01	0.18	0.02	0.01	0.11	0.01	0.00	0.12	0.02	0.26
74	0.03	0.18	0.38	0.66	0.23	0.01	0.19	0.02	0.01	0.12	0.01	0.00	0.13	0.02	0.29
75	0.03	0.16	0.34	0.61	0.24	0.01	0.20	0.03	0.01	0.14	0.01	0.00	0.14	0.02	0.31
76	0.02	0.14	0.30	0.56	0.25	0.01	0.20	0.03	0.01	0.15	0.01	0.01	0.15	0.03	0.34
77	0.02	0.12	0.27	0.51	0.25	0.01	0.21	0.03	0.01	0.16	0.01	0.01	0.15	0.03	0.36
78	0.01	0.11	0.23	0.46	0.26	0.01	0.21	0.03	0.01	0.17	0.01	0.01	0.15	0.03	0.38
79	0.01	0.09	0.21	0.42	0.26	0.01	0.21	0.03	0.01	0.18	0.01	0.01	0.15	0.04	0.39
80	0.01	0.07	0.15	0.27	0.25	0.01	0.21	0.03	0.01	0.19	0.01	0.01	0.15	0.04	0.40
81	0.01	0.06	0.14	0.25	0.24	0.01	0.20	0.04	0.01	0.19	0.01	0.01	0.15	0.04	0.41
82	0.00	0.05	0.12	0.24	0.24	0.00	0.19	0.04	0.01	0.20	0.01	0.01	0.15	0.04	0.41
83	0.00	0.05	0.11	0.22	0.23	0.00	0.19	0.04	0.01	0.20	0.01	0.01	0.14	0.04	0.40
84	0.00	0.04	0.10	0.21	0.22	0.00	0.18	0.04	0.01	0.20	0.01	0.01	0.13	0.04	0.40
85	0.00	0.04	0.09	0.19	0.21	0.00	0.17	0.04	0.01	0.19	0.01	0.02	0.13	0.04	0.39
86	0.00	0.03	0.08	0.18	0.20	0.00	0.17	0.03	0.01	0.19	0.01	0.02	0.12	0.04	0.38
Total	**1.13**	**3.74**	**8.31**	**9.83**	**4.40**	**0.16**	**3.41**	**0.51**	**0.21**	**2.81**	**0.15**	**0.13**	**2.40**	**0.53**	**6.02**

- A comparison of the results between Table 4 and Table 8 suggest that screening and treatment in the birth cohort would result in the following:
    - The number of new cases of cirrhosis would be reduced by 68.3 (see Table 11, row *u*), from 78.1 in the *absence* of screening and treatment (see Table 4) to 9.8 in the *presence* of screening and treatment (see Table 8).
    - The number of cases of decompensated cirrhosis would be reduced by 30.6 (see Table 11, row *v*), from 34.9 in the *absence* of screening and treatment (see Table 4) to 4.4 in the *presence* of screening and treatment (see Table 8).
    - The number of cases of HCC would be reduced by 24.8 (see Table 11, row *w*), from 28.4 in the *absence* of screening and treatment (see Table 4) to 3.6 in the *presence* of screening and treatment (see Table 8).
    - The number of liver transplants would be reduced by 5.1 (see Table 11, row *x*), from 5.8 in the *absence* of screening and treatment (see Table 4) to 0.7 in the *presence* of screening and treatment (see Table 8).

- The number of HCV-related deaths would be reduced by 41.9 (see Table 11, row *y*), from 47.9 in the *absence* of screening and treatment (see Table 4) to 6.0 in the *presence* of screening and treatment (see Table 8).

- Impairment in health-related quality of life (QoL) associated with various HCV-related disease states is based on a study of 751 HCV patients recruited from several tertiary care settings in Vancouver, Canada[1403] and utilized in Canadian modelling studies.[1404,1405,1406] Impairment in QoL following a liver transplant are from Ratcliffe and colleagues[1407] as calculated by Williams et al.[1408]
- We have assumed an average QoL for a 65 year old in BC to be 0.80 (see Reference Document) and calculated the impairment in QoL accordingly, as follows:
  - Non-cirrhosis (fibrosis stage 0-3): -8.8% (ranging from -3.8% to -13.8%)
  - Compensated cirrhosis (fibrosis stage 4): -13.8% (ranging from -8.8% to -18.8%)
  - Decompensated cirrhosis: -18.8% (ranging from -8.8% to -18.8%)
  - HCC: -10.0% (ranging from -6.3% to -15.0%)
  - Liver transplant (1st year): -43.8%
  - Liver transplant (subsequent years): -16.3%
  - On-treatment: -11.3% (ranging from -6.3% to -16.3%) (Table 11, row *af*)
  - Viral clearance: No change in QoL
- We then calculated the number of QALYs lost by individuals in the cohort who would be in a given disease state by year / age in the ***absence*** of any screening / treatment program (see Table 9) as well as the number of QALYs lost by individuals in the cohort who would be in a given disease state by year / age in the ***presence*** of a screening / treatment program (see Table 10).
- Based on this approach, the QALYs gained because of disease states avoided due to screening and treatment are as follows:
  - Non-cirrhosis – 69.9 QALYs gained (Table 11, row *z*)
  - Compensated cirrhosis – 74.7 QALYs gained (Table 11, row *aa*)
  - Decompensated cirrhosis – 16.8 QALYs gained (Table 11, row *ab*)
  - HCC – 3.7 QALYs gained (Table 11, row *ac*)

[1403] Hsu PC, Federico CA, Krajden M et al. Health utilities and psychometric quality of life in patients with early- and late-stage hepatitis C virus infection. *Journal of Gastroenterology and Hepatology.* 2012; 27(1): 149-57.
[1404] Wong WW, Tu H-A, Feld JJ et al. Cost-effectiveness of screening for hepatitis C in Canada. *Canadian Medical Association Journal.* 2015; 187(3): E110-E21.
[1405] Wong WW, Erman A, Feld JJ et al. Model-based projection of health and economic effects of screening for hepatitis C in Canada. *CMAJ Open.* 2017; 5(3): E662.
[1406] Wong WW, Lee KM, Singh S et al. Drug therapies for chronic hepatitis C infection: a cost-effectiveness analysis. *CMAJ Open.* 2017; 5(1): E97.
[1407] Ratcliffe J, Longworth L, Young T et al. Assessing health-related quality of life pre- and post-liver transplantation: a prospective multicenter study. *Liver Transplantation*. 2002; 8(3): 263-270.
[1408] Williams J, Miners A, Harris R et al. The Cost-Effectiveness of One-Time Birth Cohort Screening for Hepatitis C as Part of the National Health Service Health Check Programme in England. *Value in Health*. 2019:

- Liver transplant – 4.4 QALYs gained (Table 11, row *ad*)
- HCV – related death – 387.1 QALYs gained (Table 11, row *ag*)

Table 9: QALYs Lost by Disease State and Age
In the ***Absence*** of Screening and Treatment

Age	Non-Cirrhosis	Cirrhosis	Decomp. Cirrhosis	HCC	Liver Transplant	HCV-Related Death	Total
65	6.7	1.99	0.00	0.00	0.00	0.0	**8.7**
66	6.5	2.10	0.12	0.04	0.00	0.0	**8.8**
67	6.3	2.26	0.23	0.05	0.01	8.2	**17.1**
68	6.1	2.44	0.32	0.06	0.03	10.8	**19.7**
69	5.9	2.64	0.40	0.07	0.04	12.9	**21.9**
70	5.6	2.85	0.48	0.08	0.06	14.6	**23.7**
71	5.1	3.38	0.56	0.12	0.08	16.1	**25.4**
72	4.7	3.82	0.65	0.15	0.10	21.4	**30.8**
73	4.2	4.18	0.75	0.18	0.13	24.0	**33.5**
74	3.8	4.46	0.85	0.20	0.16	26.1	**35.6**
75	3.4	4.67	0.95	0.22	0.19	27.6	**37.1**
76	3.1	4.82	1.04	0.24	0.22	28.8	**38.2**
77	2.8	4.92	1.12	0.26	0.25	29.1	**38.5**
78	2.5	4.96	1.19	0.27	0.29	29.2	**38.4**
79	2.2	4.96	1.25	0.28	0.32	28.8	**37.8**
80	2.0	4.92	1.29	0.29	0.36	27.9	**36.8**
81	1.8	4.76	1.33	0.29	0.39	26.7	**35.4**
82	1.7	4.59	1.35	0.29	0.42	25.6	**33.9**
83	1.6	4.42	1.35	0.29	0.45	24.0	**32.0**
84	1.4	4.26	1.34	0.29	0.48	22.2	**30.0**
85	1.3	4.09	1.32	0.28	0.50	20.3	**27.8**
86	1.2	3.93	1.30	0.28	0.53	18.4	**25.7**
Total	**80.0**	**85.42**	**19.17**	**4.24**	**5.00**	**442.8**	**636.7**

Table 10: QALYs Lost by Disease State and Age
In the ***Presence*** of Screening and Treatment

Age	Non-Cirrhosis	Cirrhosis	Decomp. Cirrhosis	HCC	Liver Transplant	HCV-Related Death	Total
65	0.8	0.25	0.00	0.00	0.00	0.0	**1.1**
66	0.8	0.26	0.02	0.00	0.00	0.0	**1.1**
67	0.8	0.28	0.03	0.01	0.00	1.0	**2.1**
68	0.8	0.31	0.04	0.01	0.00	1.4	**2.5**
69	0.7	0.33	0.05	0.01	0.01	1.6	**2.8**
70	0.7	0.36	0.06	0.01	0.01	1.8	**3.0**
71	0.6	0.42	0.07	0.02	0.01	2.0	**3.2**
72	0.6	0.48	0.08	0.02	0.01	2.7	**3.9**
73	0.5	0.53	0.09	0.02	0.02	3.0	**4.2**
74	0.5	0.56	0.11	0.03	0.02	3.3	**4.5**
75	0.4	0.59	0.12	0.03	0.02	3.5	**4.7**
76	0.4	0.61	0.13	0.03	0.03	3.6	**4.8**
77	0.4	0.62	0.14	0.03	0.03	3.7	**4.8**
78	0.3	0.62	0.15	0.03	0.04	3.7	**4.8**
79	0.3	0.62	0.16	0.04	0.04	3.6	**4.8**
80	0.3	0.62	0.16	0.04	0.04	3.5	**4.6**
81	0.2	0.60	0.17	0.04	0.05	3.4	**4.4**
82	0.2	0.58	0.17	0.04	0.05	3.2	**4.3**
83	0.2	0.56	0.17	0.04	0.06	3.0	**4.0**
84	0.2	0.54	0.17	0.04	0.06	2.8	**3.8**
85	0.2	0.51	0.17	0.04	0.06	2.6	**3.5**
86	0.2	0.49	0.16	0.03	0.07	2.3	**3.2**
Total	**10.1**	**10.74**	**2.41**	**0.53**	**0.63**	**55.7**	**80.1**

- Treatment based cures of HCV infection have a positive effect on extrahepatic disease states such as type 2 diabetes, chronic kidney disease and mood and anxiety disorders.[1409] We have assumed that the impairment in QoL associated with being in a state of non-cirrhosis in HCV positive individuals noted above takes into account the potential change in QoL associated with extrahepatic manifestations.
- Although highly effective and well tolerated, each DAA has its own metabolism and presents an important potential for drug–drug interactions.[1410,1411] The model does not take into account any additional resources that might be required in managing drug–drug interactions or the potential harms associated with drug–drug interactions.
- Other assumptions used in assessing the CPB are detailed in the Reference Document.

Based on these assumptions, the calculation of CPB is 555 QALYs (Table 11, row *aj*). This represents the potential CPB of one-time screening for 83% of the previously unscreened BC birth cohort born between 1945 and 1964 and treating 88% of individuals detected with RNA+ HCV with direct acting antiviral (DAA) treatment.

[1409] Rossi C, Jeong D, Wong S, et al. Sustained virological response from interferon-based hepatitis C regimens is associated with reduced risk of extrahepatic manifestations. *Journal of Hepatology*. 2019; 71: 1116-1125.
[1410] Pons S, Boyer A, Lamblin G et al. Managing drug–drug interactions with new direct-acting antiviral agents in chronic hepatitis C. *British Journal of Clinical Pharmacology*. 2017; 83(2): 269-93.
[1411] Néant N & Solas C. Drug-drug interactions potential of direct-acting antivirals for the treatment of chronic hepatitis C virus infection. *International Journal of Antimicrobial Agents*. 2018; https://doi.org/10.1016/j.ijantimicag.2018.10.014.

Table 11: CPB of Screening to Detect and Treat Hepatitis C Infection in a Birth Cohort of 40,000 (B.C.) For Individuals Born Between 1945 - 64			
Row Label	**Variable**	**Base Case**	**Data Source**
a	Median age of Birth Cohort (2019)	65	√
b	Birth Cohort population of 65 year olds	35,996	BC Life Table
c	% of Birth Cohort screened	31.4%	Table 5
d	Estimated # of individuals in Birth Cohort **screened**	11,313	b * c
e	Estimated # of individuals in Birth Cohort **unscreened**	24,683	b - d
f	Estimated % of individuals in Birth Cohort living with **diagnosed** HVC	2.392%	√
g	Estimated % of individuals in Birth Cohort living with **undiagnosed** HVC	0.507%	√
h	Estimated # of individuals in Birth Cohort living with **diagnosed** HVC	861	b * f
i	Estimated # of individuals in Birth Cohort living with **undiagnosed** HVC	183	b * g
j	% of individuals with undiagnosed HCV expected to be RNA+	74.5%	Table 6
k	# of individuals with undiagnosed HCV expected to be RNA+	136.0	i * j
l	Adherence with screening	83.3%	√
m	Cases of undiagnosed RNA+ HCV infection detected through screening	113.3	k * l
n	% eligible for and accepting treatment	87.5%	√
o	Cases of undiagnosed RNA+ HCV infection detected through screening receiving treatment	99.2	m * n
p	Effectiveness of antiviral therapy in producing a sustained viral response (i.e. a cure) in BC Birth Cohort	97.0%	√
q	Total SVR rate, including salvage treatment	99.9%	= 1 - (1 - p)^2
r	Cases of undiagnosed RNA+ HCV infection detected through screening receiving treatment and achieving a SVR (i.e. are 'cured')	99.1	o * q
s	Cases of undiagnosed RNA+ HCV infection that are detected through screening but are untreated or fail to achieve SVR	14.3	m - r
	Disease states avoided due to screening and treatment		
t	- Non-cirrhosis	91.6	Table 4 - Table 8
u	- Cirrhosis	68.3	Table 4 - Table 8
v	- Decompensated cirrhosis	30.5	Table 4 - Table 8
w	- HCC	24.8	Table 4 - Table 8
x	- Liver transplant	5.1	Table 4 - Table 8
y	- HCV-related death	41.9	Table 4 - Table 8
	QALYs gained because of disease states avoided due to screening and treatment		
z	- Non-cirrhosis	69.9	Table 9 - Table 10
aa	- Cirrhosis	74.7	Table 9 - Table 10
ab	- Decompensated cirrhosis	16.8	Table 9 - Table 10
ac	- HCC	3.7	Table 9 - Table 10
ad	- Liver transplant	4.4	Table 9 - Table 10
ae	- HCV-related death	387.1	Table 9 - Table 10
af	QALYs gained	556.6	z + aa + ab + ac + ad + ae
ag	QALY decrement associated with treatment	11.3%	√
ah	Length of time on treatment (12 weeks) - in years	0.23	12 / 52
ai	QALYs lost due to treatment	2.1	o * (ag * 0.8) * ah
aj	Total (net) QALYs gained	554.5	af - ai

√ = Estimates from the literature

We also modified several major assumptions and recalculated the CPB as follows:

- Assume the annual progression probabilities are **reduced** as follows:
    - From cirrhosis to hepatic decomposition is reduced from 4.5% to 3.0%
    - From hepatic decomposition to death is reduced from 17.6% to 13.5%
    - From hepatocellular carcinoma to death is reduced from 70.7% to 43.0% in Year 1 and from 16.2% to 11.0% in subsequent years.
    - CPB = 463
- Assume the annual progression probabilities are **increased** as follows:
    - From cirrhosis to hepatic decomposition is reduced from 4.5% to 6.0%
    - From hepatic decomposition to death is reduced from 17.6% to 21.6%
    - From hepatocellular carcinoma to death is reduced from 70.7% to 77.0% in Year 1 and from 16.2% to 23.0% in subsequent years.
    - CPB = 614
- Assume that the proportion of the unscreened population within the 1945-64 birth cohort that would accept screening is **reduced** from 83.3% to 76.6% (Table 11, row l). CPB = 510
- Assume that the proportion of the unscreened population within the 1945-64 birth cohort that would accept screening is **increased** from 83.3% to 90.0% (Table 11, row l). CPB = 599
- Assume that the uptake of treatment is **reduced** from 87.5% to 80.0% (Table 11, row n). CPB = 507
- Assume that the uptake of treatment is **increased** from 87.5% to 95.0% (Table 11, row n). CPB = 602
- Assume there is **more** of an annual QoL decrement associated with various disease states follows:
    - Non-cirrhosis from -8.8% to -13.8%
    - Compensated cirrhosis from -13.8% to -18.8%
    - HCC from -10.0% to -15.0%
    - Treatment from -11.3% to -6.3%
    - CPB = 623
- Assume there is **less** of an annual QoL decrement associated with various disease states follows:
    - Non-cirrhosis from -8.8% to -3.8%
    - Compensated cirrhosis from -13.8% to -8.8%
    - Decompensated cirrhosis from -18.8% to -8.8%
    - HCC from -10.0% to -6.3%
    - Treatment from -11.3% to -16.3%

- CPB = 478

- Assume the rate of sustained virologic response (SVR) **increases** from 97% to 99% (Table 11, row *p*). CPB = 555
- Assume the rate of sustained virologic response (SVR) **decreases** from 97% to 95% (Table 11, row *p*). CPB = 554

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with one-time screening for HCV infection in BC adults born between 1945 and 1965.

In modelling CE, we made the following assumptions:

- **Screening for HCV** – We assumed that there would be two office visits associated with screening, one to initiate screening and one to discuss lab results and follow-up treatment, if necessary (Table 12, row *l*). Furthermore, we have assumed that 50% of the office visit would be required (as per the Reference Document) but that the entire office visit to discuss lab results would be required if the lab test is positive.
- An HCV antibody test is used to determine if HCV antibodies are present in the serum. HCV antibodies are produced when an individual is exposed to HCV and usually remain present for life. Anti-HCV becomes detectable 5-10 weeks after infection, and confirms that the individual has been infected at some time. Nucleic Acid Testing (NAT) is required to confirm if active infection is present by detecting hepatitis C RNA. If HCV RNA is detected, a repeat HCV RNA test would be performed after 6 months to establish chronic infection.[1412]
- In BC, the majority (95%) of HCV antibody tests and all HCV RNA tests are performed at the BC Center for Disease Control (BCCDC) Public Health Laboratory.[1413]
- We estimated the cost of a hepatitis C antibody EIA test to be $24.28 in 2016 CAD$ or $27.40 in 2022 CAD$ (Table 12, row *p*).[1414] A positive screening test would be followed by a hepatitis C RNA amp probe and a hepatitis C RNA quant test to confirm RNA detection and quantify RNA for a total cost per positive screening test of $234.62 in 2016 CAD$ or $264.73 in 2022 CAD$.[1415] Total lab costs associated with a positive screening test of $529.46 (Tale 12, row *q*) include a repeat HCV RNA test after 6 months to establish chronic infection.
- **Cost of Direct-Acting Antivirals** (DAA) – As noted previously, the majority of current HCV treatment in BC is with Epclusa, Maviret and Zepatier.

[1412] BC Centre for Disease Control. *Communicable Disease Control: Hepatitis C*. August 2016. Available online at http://www.bccdc.ca/resource-gallery/Documents/Guidelines%20and%20Forms/Guidelines%20and%20Manuals/Epid/CD%20Manual/Chapter%201%20-%20CDC/HepC_Guidelines.pdf. Accessed November 2019.
[1413] BC Centre for Disease Control. *Communicable Disease Control: Hepatitis C*. August 2016. Available online at http://www.bccdc.ca/resource-gallery/Documents/Guidelines%20and%20Forms/Guidelines%20and%20Manuals/Epid/CD%20Manual/Chapter%201%20-%20CDC/HepC_Guidelines.pdf. Accessed November 2019.
[1414] Leggett L, Coward S, Soril L, et al. *Hepatitis C Screening in Alberta: A Health Technology Assessment*. Government of Alberta. 2016. Available at https://open.alberta.ca/publications/hepatitis-c-screening-in-alberta. Accessed November 2019.
[1415] Ibid.

- **Epclusa** is made by Gilead Sciences and contains the following medicines: sofosbuvir – 400 mg and velpatasvir – 100 mg. The wholesale price of Epclusa in Canada is reported as $60,000 per treatment (1 pill per day x 12 weeks).[1416] Using the Pacific Blue Cross Pharmacy Compass[1417] and searching for "Epclusa, 400 mg-100 mg. DIN: 02456370" results in prices per pill ranging from $728.72 - $837.85 excluding a $10 - $13 dispensing fee. We calculate a treatment cost of $61,222 - $70,392 CAD per treatment (12 weeks of daily pills).
- **Zepatier,** made by Merck, is a fixed-dose formulation (one pill) containing the following two medicines: elbasvir – 50 mg and grazoprevir – 100 mg. The wholesale price of Zepatier in Canada is reported as $60,300 per 12 week treatment.[1418]
- **Maviret**, made by Abbvie, consists of a combination of two DAAs (glecaprevir and pibrentasvir). The wholesale price of Maviret in Canada is reported as $40,000 per 8-week treatment.[1419] The Government of BC lists three treatment lengths with Maviret; 8, 12 and 16 weeks.[1420] Using the midpoint (12 weeks) results in an estimated cost of $60,000 for a 12-week course of treatment. Using the Pacific Blue Cross Pharmacy Compass[1421] and searching for "Maviret, 100 mg-40 mg. DIN: 02467550" results in prices per pill ranging from $242.85 - $260.28 excluding a $10.25 - $12.95 dispensing fee. We calculate a treatment cost of $61,210 - $65,600 CAD per treatment (12 weeks of pills three times a day).
- While the listed prices for current DAAs are approximately $60,000 per course of treatment, a number of countries have been able to negotiate substantial price discounts. While details of these contractual arrangements are confidential they do suggest a steep price discount, particularly if governments "present plans (to the pharmaceutical companies) that ensure a greater number of patients undertake treatment."[1422]
- Available evidence suggests that Australia, Italy, Spain and Portugal have all negotiated DAA course prices of between $10,000 and $16,000.[1423] DAA prices in the UK have also recently been "slashed"[1424] leading Williams et al to use a cost of approximately $17,000 in their recent UK-based cost-effectiveness modelling.[1425]

[1416] CATIE. *Hepatitis C treatment Epclusa approved in Canada—key information*. 2016 Available at https://www.catie.ca/en/catienews/2016-07-20/hepatitis-c-treatment-epclusa-approved-canada-key-information. Accessed November 2019.
[1417] Pacific Blue Cross. *Pharmacy Compass.* 2019. Available at https://www.pac.bluecross.ca/pharmacycompass. Accessed November 2019.
[1418] CATIE. *Zepatier for hepatitis C approved in Canada*. 2016 Available at https://www.catie.ca/en/catienews/2016-01-29/zepatier-hepatitis-c-approved-canada. Accessed November 2019.
[1419] ClaimSecure. *MAVIRET™ - Short Course Antiviral Therapy for All Genotypes of Hepatitis C Virus.* 2018. Available at https://www.claimsecure.com/drug-reviews-blog/2018/february/maviret-short-course-antiviral-therapy-for-all-genotypes-of-hepatitis-c-virus/. Accessed November 2019.
[1420] Government of BC. *Limited Coverage Drugs – glecaprevir-pibrentasvir.* Available at https://www2.gov.bc.ca/gov/content/health/practitioner-professional-resources/pharmacare/prescribers/limited-coverage-drug-program/limited-coverage-drugs-glecaprevir-pibrentasvir. Accessed November 2019.
[1421] Pacific Blue Cross. *Pharmacy Compass.* 2019. Available at https://www.pac.bluecross.ca/pharmacycompass. Accessed November 2019.
[1422] Douglass CH, Pedrana A, Lazarus JV et al. Pathways to ensure universal and affordable access to hepatitis C treatment. *BMC Medicine.* 2018; 16(1): 175.
[1423] Douglass CH, Pedrana A, Lazarus JV et al. Pathways to ensure universal and affordable access to hepatitis C treatment. *BMC Medicine.* 2018; 16(1): 175.
[1424] Hurley R. Slashed cost of hepatitis C drugs spurs drive to eliminate the disease. BMJ. 2018; 361: k1679.
[1425] Williams J, Miners A, Harris R et al. The Cost-Effectiveness of One-Time Birth Cohort Screening for Hepatitis C as Part of the National Health Service Health Check Programme in England. *Value in Health*. 2019:

- BC has also negotiated a confidential price reduction for DAA. For modelling purposes, we have assumed a cost per treatment for DAA in BC of $13,500 (the midpoint between $10,000 and $17,000) and modified this in the sensitivity analysis from $10,000 to $17,000 (Table 12, row *v*).
- In their analysis of the cost-effectiveness of one-time birth cohort screening for HCV in England, Williams and collaegues asumed a 50% increase in the cost of DAA for a second course of treatment if SVR is not achieved after the first course of treatment. We have done likewise (Table 12, row *ac*).
- **Follow-up** - Patients on DAA treatment would require an average of 9 follow-up visits to their physician, at weeks 2, 4, 8, 12, 16, 24, 32, 40 and 48 (Table 12, row *x*).[1426] Each visit would include the following three lab tests: complete blood count (CBC), thyroid stimulating hormone (TSH) and a renal panel. The costs of the lab tests are estimated at $10.96,[1427] $9.90[1428] and $31.52,[1429] respectively, for a total cost of $52.38[1430] (Table 12, row *y*). We have assumed that the entire visit would be utilized to discuss progress and lab results and that a lab visit would be associated with each physician follow-up visit.
- **Costs Avoided** – As noted above, successful treatment with DAA means that a variety of diseases states (and their direct health care costs) are avoided.
- The incremental annual health care cost associated with an HCV infection (non-cirrhosis stages f0 to f3) is $383 (in 2013 CAD$ or $440 in 2022 CAD$). This average cost is adjusted for the proportion of patients who are not under care, estimated to range from 39% for stage f0 down to 24% for stage f3.[1431] These costs are based on El Saadany et al.'s research and include inpatient care, outpatient visits, diagnostic procedures, surgical procedures, and medication. Costs for each resource used were obtained from the Province of Alberta.[1432]
- The incremental annual health care cost associated with compensated cirrhosis (stage f4) is $803 (in 2013 CAD$ or $922 in 2022 CAD$). These costs are also based on El Saadany et al.'s research and include inpatient care, outpatient visits, diagnostic procedures, surgical procedures, and medication.[1433,1434]
- The incremental annual health care cost associated with decompensated cirrhosis is $11,179 (in 2001 CAD$ or $16,819 in 2022 CAD$). These costs are also based on El

[1426] McGarry LJ, Pawar VS, Panchmatia HR et al. Economic model of a birth cohort screening program for hepatitis C virus. *Hepatology*. 2012; 55(5): 1344-55.
[1427] Fee item 90205 – hematology profile
[1428] Fee item 92325 - thyroid stimulating hormone (TSH) – any method
[1429] Includes fee items 91000 (primary base fee, $15.62), 91040 (albumin – serum/plasma, $1.55), 91235 (bicarbonate - serum/plasma, $2.37), 91326 (calcium – total, serum/plasma, $1.55), 91366 (chloride - serum/plasma, $1.49), 91421 (creatinine - serum/plasma, $1.52), 91707 (glucose quantitative – serum/plasma, $1.46), 92071 (phosphates – serum/plasma, $1.62), 92100 (potassium – serum/plasma, $1.39), 92231 (sodium – serum/plasma, $1.38) and 92368 (urea – serum/plasma, $1.57).
[1430] See https://www.dr-bill.ca/msp_billing_codes?code_search=92368. Accessed November 2023.
[1431] Myers RP, Krajden M, Bilodeau M et al. Burden of disease and cost of chronic hepatitis C virus infection in Canada. *Canadian Journal of Gastroenterology and Hepatology*. 2014; 28(5): 243-50.
[1432] El Saadany S, Coyle D, Giulivi A et al. Economic burden of hepatitis C in Canada and the potential for prevention. *European Journal of Health Economics*. 2005; 6: 159-165.
[1433] El Saadany S, Coyle D, Giulivi A et al. Economic burden of hepatitis C in Canada and the potential for prevention. *European Journal of Health Economics*. 2005; 6: 159-165.
[1434] Myers RP, Krajden M, Bilodeau M et al. Burden of disease and cost of chronic hepatitis C virus infection in Canada. *Canadian Journal of Gastroenterology and Hepatology*. 2014; 28(5): 243-50.

Saadany et al.'s research and include inpatient care, outpatient visits, diagnostic procedures, surgical procedures, and medication.[1435]

- Based on data from Ontario, the cost estimates for the *acute phase of a fatal liver cancer* are $27,560 (95% CI of $25,747 to $29,373) (in 2009 CAD).[1436] We converted this to $34,614 in 2022 CAD.
- Based on data from Ontario, the estimated *first year costs* associated with a liver cancer survivor are $32,717 (95% CI of $30,591 to $34,844) (in 2009 CAD).[1437] We converted this to $41,090 in 2022 CAD.
- Based on data from the US, the *ongoing annual costs* associated with a liver cancer survivor after the first year are estimated at $6,611 (in 2010 USD) or $7,044 in 2017 CAD.[1438] Survival following liver cancer averages 4.7 years (see Reference Document).
- The cost for a liver transplant, including pre-transplant work-up, the transplant and the first year post-transplant care cost $121,732 (in 1998 CAD$ or $197,959 in 2022 CAD$). Annual costs following the first year post-transplant average $4,882 (in 1998 CAD$ or $7,939 in 2022 CAD$).[1439]
- Treatment based cures of HCV infection have a positive effect on extrahepatic disease states such as type 2 diabetes, chronic kidney disease and mood and anxiety disorders.[1440] We have assumed that the costs associated with being in a state of non-cirrhosis in HCV positive individuals noted above takes into account the potential costs associated with extrahepatic manifestations
- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.

Based on these assumptions, the estimated cost per QALY would be $3,846 (Table 12, row *aw*). This represents the potential CE of one-time screening for 83% of the previously unscreened BC birth cohort born between 1945 and 1964 and treating 88% of individuals detected with RNA+ HCV with direct acting antiviral (DAA) treatment.

[1435] El Saadany S, Coyle D, Giulivi A et al. Economic burden of hepatitis C in Canada and the potential for prevention. *European Journal of Health Economics*. 2005; 6: 159-165.
[1436] de Oliveira C, Bremner K, Pataky R et al. Understanding the costs of cancer care before and after diagnosis for the 21 most common cancers in Ontario: a population-based descriptive study. *Canadian Medical Association Journal Open*. 2013; 1(1): E1-E8.
[1437] de Oliveira C, Bremner K, Pataky R et al. Understanding the costs of cancer care before and after diagnosis for the 21 most common cancers in Ontario: a population-based descriptive study. *Canadian Medical Association Journal Open*. 2013; 1(1): E1-E8.
[1438] Mariotto A, Robin Y, Shao Y et al. Projections of the cost of cancer care in the United States: 2010–2020. *Journal of the National Cancer Institute*. 2011; 103(2): 117-28. This study included the costs of care for 14 major cancers which did not include liver cancer. We used the 'other' cancer category to estimate ongoing annual costs for liver cancer.
[1439] Taylor M, Grieg P, Detsky A, et al. Factors associated with the high cost of liver transplantation in adults. *Canadian Journal of Surgery*. 2002; 45(6): 425-434.
[1440] Rossi C, Jeong D, Wong S, et al. Sustained virological response from interferon-based hepatitis C regimens is associated with reduced risk of extrahepatic manifestations. *Journal of Hepatology*. 2019; 71: 1116-1125.

Table 12: CE of Screening to Detect and Treat Hepatitis C Infection in a Birth Cohort of 40,000 (B.C.)			
Row Label	**Variable**	**Base Case**	**Data Source**
a	Median age of Birth Cohort (2019)	65	Table 11, row a
b	Birth Cohort population of 65 year olds	35,996	Table 11, row b
c	Estimated # of individuals in Birth Cohort **unscreened**	24,683	Table 11, row e
d	Adherence with screening	83.3%	Table 11, row l
e	Population screened	20,561	= c * d
f	Estimated # of individuals in Birth Cohort living with **undiagnosed** HVC	183	Table 11, row i
g	Anti-HCV positive tests	152	= d * f
h	Anti-HCV negative tests	20,409	= e - g
i	Cases of undiagnosed RNA+ HCV infection detected through screening	113.3	Table 11, row m
j	Eligible and accepting treatment	87.5%	Table 11, row n
k	Treated cases	99.2	= i + j
	Costs of screening		
l	# of office visits required - 1 to initiate screening, 1 to discuss lab results	2	Assumed
m	Cost of 10-minute office visit	$35.97	Ref Doc
n	Portion of office visit needed	50%	Ref Doc
o	Cost of office visits	$745,036	(e * l * m * n) + (g * l)
p	Lab costs initial screening test	$27.40	√
q	Lab costs per positive screening tests (including 2nd confirmatory test at 6 months)	$529.46	√
r	Costs of lab tests	$643,871	(e * p) + (g * q)
s	Cost of patient time and travel for office visit and per lab test	$74.32	Ref Doc
t	Patient time costs - screening	$3,067,436	(e * l * n * s) + (e * s) + (g * s)
u	Total costs of screening	$4,456,343	= o + r + t
	Cost of treatment - First Round		
v	Drug costs per treatment - antiviral therapy	$13,500	√
w	Costs of antiviral therapy	$1,338,528	= k * v
x	Follow-up visits during treatment	9	√
y	Cost of lab tests / follow-up	$52.38	√
z	Follow-up costs (office visits & lab costs)	$78,839	= k * (x * (m + y))
aa	Patient time (office & lab visits)	$132,639	= k * (x * 2) * s
ab	Total cost of treatment - first round	$1,550,006	
	Cost of treatment - Second Round		
ac	Drug costs per treatment - antiviral therapy	$20,250	= v * 1.5
ad	Effectiveness of antiviral therapy in producing SVR (i.e. a cure)	97.0%	Table 11, row p
ae	Number of patients requiring a second round of treatment	3.0	= k - (k * ad)
af	Costs of antiviral therapy	$60,234	= ac * ae
ag	Follow-up visits during treatment	9	√
ah	Follow-up costs (office visits & lab costs)	$2,365	= (ae * ag) * (m + y)
ai	Patient time (office & lab visits)	$3,979	= (ae * ag) * 2 * s
aj	Total cost of treatment - second round	$66,578	= af + ah + ai
ak	Total cost of screening and treatment	$6,072,928	= u + ab + aj
	Costs Avoided		
al	Costs avoided, living with HCV stages f0 - f3	$439,634	Calculated
am	Costs avoided, living with cirrhosis	$625,919	Calculated
an	Costs avoided, living with decompensated cirrhosis	$1,879,339	Calculated
ao	Costs avoided, living with HCC	$418,063	Calculated
ap	Costs avoided, dying of HCC	$704,896	Calculated
aq	Costs avoided, living with liver transplant	$1,100,076	Calculated
ar	Total cost avoided (undiscounted)	$5,167,927	= SUM (al…aq)
	CE calculation		
as	Net Costs (undiscounted)	$905,001	= ak - ar
at	QALYs saved (undiscounted)	555	Table 11, row aj
au	Costs (1.5% discount rate)	$1,795,006	Calculated
av	QALYs saved (1.5% discount rate)	467	Calculated
aw	**CE ($/QALY saved)**	**$3,846**	= au / av

√ = Estimates from the literature

We also modified several major assumptions and recalculated the cost per QALY as follows:

- Assume the annual progression probabilities are **reduced** as follows:
    - From cirrhosis to hepatic decomposition is reduced from 4.5% to 3.0%
    - From hepatic decomposition to death is reduced from 17.6% to 13.5%
    - From hepatocellular carcinoma to death is reduced from 70.7% to 43.0% in Year 1 and from 16.2% to 11.0% in subsequent years.
    - CE = $3,989
- Assume the annual progression probabilities are **increased** as follows:
    - From cirrhosis to hepatic decomposition is reduced from 4.5% to 6.0%
    - From hepatic decomposition to death is reduced from 17.6% to 21.6%
    - From hepatocellular carcinoma to death is reduced from 70.7% to 77.0% in Year 1 and from 16.2% to 23.0% in subsequent years.
    - CE = $3,525
- Assume that the proportion of the unscreened population within the 1945-64 birth cohort that would accept screening is **reduce**d from 83.3% to 76.6% (Table 11, row l). CE = $3,846 (no change)
- Assume that the proportion of the unscreened population within the 1945-64 birth cohort that would accept screening is **increased** from 83.3% to 90.0% (Table 11, row l). CE = $3,846 (no change)
- Assume that the uptake of treatment is **reduced** from 87.5% to 80.0% (Table 11, row n). CE = $4,741
- Assume that the uptake of treatment is **increase**d from 87.5% to 95.0% (Table 11, row n). CE = $3,092
- Assume there is **mor**e of an annual QoL decrement associated with various disease states follows:
    - Non-cirrhosis from -8.8% to -13.8%
    - Compensated cirrhosis from -13.8% to -18.8%
    - HCC from -10.0% to -15.0%
    - Treatment from -11.3% to -6.3%
    - CE = $3,411
- Assume there is **less** of an annual QoL decrement associated with various disease states follows:
    - Non-cirrhosis from -8.8% to -3.8%
    - Compensated cirrhosis from -13.8% to -8.8%
    - Decompensated cirrhosis from -18.8% to -8.8%
    - HCC from -10.0% to -6.3%
    - Treatment from -11.3% to -16.3%
    - CE = $4,484

- Assume the proportion of an office visit required is **reduced** from 50% to 33% (Table 12, row n). CE = $2,194
- Assume the proportion of an office visit required is **increased** from 50% to 67% (Table 12, row n). CE = $5,498
- Assume the costs of DAA per treatment are **reduced** from $13,500 to $10,000 (Table 12, row v). CE = $3,069
- Assume the costs of DAA per treatment are **increased** from $13,500 to $17,000 (Table 12, row v). CE = $4,623
- Assume the annual treatment costs per disease state are **reduced** by 25%. **CE = $6,137**
- Assume the annual treatment costs per disease state are **increased** by 25%. **CE = $1,554**
- Assume the rate of sustained virologic response (SVR) **increases** from 97% to 99% (Table 11, row *p*). CE = $3,740
- Assume the rate of sustained virologic response (SVR) **decreases** from 97% to 95% (Table 11, row *p*). CE = $3,962

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with one-time screening for Hepatitis C infection for 83% of the previously unscreened BC birth cohort born between 1945 and 1964 and treating 88% of individuals detected with RNA+ HCV with direct acting antiviral (DAA) treatment is estimated to be 467 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $3,846 per QALY (see Table 13).

Table 13: Screening to Detect and Treat Hepatitis C Infection in a Birth Cohort of 40,000 (B.C.)

Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
1.5% Discount Rate	467	388	526
3% Discount Rate	396	329	449
0% Discount Rate	555	463	623
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$3,846**	$1,554	$6,137
3% Discount Rate	$6,300	$4,046	$8,555
0% Discount Rate	$1,632	Cost-saving	$3,962
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	Cost-saving	Cost-saving	Cost-saving
3% Discount Rate	Cost-saving	Cost-saving	$473
0% Discount Rate	Cost-saving	Cost-saving	Cost-saving

Our calculated cost per QALY of $3,846 (ranging from $1,554 to $6,137) is substantially lower than the Canadian estimate modelled by Wong et al in 2015 ranging from $34,359 to $44,034.[1441] There are a number of important differences between our model and the Wong model.

First, the Wong model is based on screening and treating individual's ages 25-64 years or 45-64 years while our model is based on screening the 1945-64 birth cohort with an average age of 65 years.

Second, the Wong model assumed a price per treatment of approximately $55,000 compared with our current estimate of $13,500. Changing our base case cost per treatment to $55,000 would increase our cost per QALY from $3,846 to $13,058.

Third, the Wong model does not appear to include healthcare costs avoided associated with treatment success. If our model excluded these costs, our cost per QALY would increase from $3,846 to $13,011.

If these last two variables were modified simultaneously in our base case, then our cost per QALY would increase from $3,846 to $22,224.

[1441] Wong WW, Tu H-A, Feld JJ et al. Cost-effectiveness of screening for hepatitis C in Canada. *Canadian Medical Association Journal.* 2015; 187(3): E110-E21.

Behavioural Counselling Interventions

Definition

In 2002, the USPSTF published an article outlining its vision for a broader appreciation of the importance of behavioural counselling interventions in clinical care.[1442] The paper includes important definitional and context information for this area and we have thus quoted liberally from the paper below.

> *Behavioral counselling interventions address complex behaviors that are integral to daily living; they vary in intensity and scope from patient to patient; they require repeated action by both patient and clinician, modified over time, to achieve health improvement; and they are strongly influenced by multiple contexts (family, peers, worksite, school, and community). Further, "counselling" is a broadly used but imprecise term that covers a wide array of preventive and therapeutic activities, from mental health or marital therapy to the provision of health education and behavior change support. Thus, we have chosen to use the term "behavioral counselling interventions" to describe the range of personal counselling and related behavior-change interventions that are effectively employed in primary care to help patients change health-related behaviors. (p.270)*

> *Behavioral counselling interventions in clinical care are those activities delivered by primary care clinicians and related healthcare staff to assist patients in adopting, changing, or maintaining behaviors proven to affect health outcomes and health status. Common health promoting behaviors include smoking cessation, healthy diet, regular physical activity, appropriate alcohol use, and responsible use of contraceptives. (p. 269-70)*

> *The strongest evidence for the efficacy of primary care behavior-change interventions comes from tobacco-cessation research and, to a lesser extent, problem drinking. Accumulating evidence also shows the effectiveness of similar interventions for other behaviors. These interventions often provide more than brief clinician advice. Effective interventions typically involve behavioral counselling techniques and use of other resources to assist patients in undertaking advised behavior changes. For example, intervention adjuncts to brief clinician advice may involve a broader set of healthcare team members (e.g., nurses, other office staff, health educators, and pharmacists), a number of complementary communication channels (e.g., telephone counselling, video or computer assisted interventions, self-help guides, and tailored mailings), and multiple contacts with the patient. (p. 268)*

In 2014, the USPSTF published an article discussing challenges it encounters in aggregating the behavioural counselling intervention literature, including clear descriptions of the study population, intervention protocols, assessment of outcomes, and linking behaviour changes to health outcomes.[1443] Researchers are encouraged to pay closer attention to these issues in designing and writing up their behavioural intervention research.

[1442] Whitlock EP, Orleans CT, Pender N et al. Evaluating primary care behavioral counselling interventions: an evidence-based approach. *American Journal of Preventive Medicine*. 2002; 22(4): 267-84.
[1443] Curry S, Grossman D, Whitlock E et al. Behavioral counselling research and evidence-based practice recommendations: U.S. Preventive Services Task Force Perspectives. *Annals of Internal Medicine*. 2014; 160: 407-13.

Canadian Task Force on Preventive Health Care (2001)

A 2001 report from the CTFPHC titled "Counselling for Risky Health Habits: A Conceptual Framework for Primary Care Practitioners" noted that,

> *Risky lifestyle choices contribute to many contemporary health conditions. Primary care practitioners have frequent opportunities to help patients clarify issues and alter adverse behaviour patterns….The six risky behaviours addressed in this paper are appropriate targets for counselling. Some situations respond to brief on-the-spot advice, others require a few repeated counselling sessions utilizing concepts from behavioural theory, and certain ones need referral to a structured counselling program that employs a longer time-frame and allows for the opportunity to use a range of methods.*[1444]

The "six risky behaviours" include dietary patterns, unintentional injury, problem drinking, physical inactivity patterns, **risky sexual patterns** and cigarette smoking.

United States Preventive Services Task Force Recommendations (2014)

> *The USPSTF recommends intensive behavioral counselling for all sexually active adolescents and for adults who are at increased risk for STIs. (B recommendation)*
>
> *All sexually active adolescents are at increased risk for STIs. Other risk groups include adults with current STIs or other infections within the past year, adults who have multiple sex partners, and adults who do not consistently use condoms.*
>
> *Clinicians should be aware of populations with a particularly high prevalence of STIs. African Americans have the highest STI prevalence of any racial/ethnic group, and prevalence is higher in American Indians, Alaska Natives, and Latinos than in white persons. Increased STI prevalence rates are also found in men who have sex with men (MSM), persons with low incomes living in urban settings, current or former inmates, military recruits, persons who exchange sex for money or drugs, persons with mental illness or a disability, current or former intravenous drug users, persons with a history of sexual abuse, and patients at public STI clinics.*
>
> *Behavioral counselling interventions can reduce a person's likelihood of acquiring an STI. Interventions ranging in intensity from 30 min to ≥2 h of contact time are beneficial; evidence of benefit increases with intervention intensity. Interventions can be delivered by primary care clinicians or through referral to trained behavioral counselors. Most successful approaches provide basic information about STIs and STI transmission; assess risk for transmission; and provide training in pertinent skills, such as condom use, communication about safe sex, problem solving, and goal setting.*[1445]

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with behavioural counselling interventions for the prevention of sexually transmitted diseases in a British Columbia birth cohort of 40,000.

[1444] Canadian Task Force on Preventive Health Care. *Counselling for Risky Health Habits: A Conceptual Framework for Primary Care Practitioners* 2001. Available at http://canadiantaskforce.ca/files/guidelines/2001-risky-health-habits-en.pdf. Accessed February 2015.

[1445] LeFevre ML. Behavioral counselling interventions to prevent sexually transmitted infections: US Preventive Services Task Force recommendation statement. *Annals of Internal Medicine*. 2014; 161(12): 894-901.

In estimating CPB, we made the following assumptions:

- The age and sex specific incidence rates per 100,000 for acute hepatitis B are taken from the BCCDC Annual Summary of Reportable Diseases 2016.[1446] The age and sex specific incidence rates per 100,000 for human immunodeficiency virus (HIV) are taken from the BCCDC HIV Annual Annual Report 2015.[1447] The age and sex specific incidence rates per 100,000 for chlamydia, gonorrhea and syphilis infections are taken from the BCCDC Annual Report 2015.[1448] The incidence of human papillomavirus (HPV) infection in females is taken from an Ontario study.[1449] We have assumed that the age specific incidence rate for males is the same as for females.[1450] We calculated the incidence of herpes simplex virus type 2 (HSV-2) infection based on the number of patients within each age group who had their first herpes-related physician billings in 2006, as reported by the BC Centre for Disease Control.[1451] We reduced the rates of first herpes-related visits proportional to the percentage of age-specific laboratory-diagnosed HSV infections in BC that were from genital specimens and were confirmed HSV-2. In 2005, approximately 31% of HSV-2 cases were identified in males and 69% percent in females; therefore, new cases were distributed between sexes according to these proportions (see Table 1).

Table 1: Sexually Transmitted Infections in British Columbia
Rate per 100,000 by Sex and Age Group

	HIV		Chlamydia		Gonorrhea		Hepatitis B - Acute		Syphilis		HPV		HSV-2	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
10-14	-	-	40	2	4	-	-	-	-	-	NA	NA	2.8	1.3
15-19	2	1	1,433	322	121	64	-	-	1	6	25,000	25,000	140.1	63.3
20-24	1	11	1,993	961	195	219	-	-	5	35	8,800	8,800	209.6	94.7
25-29	1	23	1,111	895	162	281	-	-	3	64	8,300	8,300	222.9	100.7
30-39	4	14	427	395	76	202	-	0.3	2	61	13,000	13,000	248.0	112.2
40-59	2	13	86	103	17	69	0.2	0.3	1	49	7,600	7,600	164.9	74.5
60+	1	3	6	17	2	15	-	0.2	0	10	NA	NA	113.0	51.6

NA = not available

- The age- and sex- specific incidence rates were combined with years of life in a given age group by sex in the BC birth cohort to calculate the expected number of STIs by age and sex (see Tables 2 and 3).

[1446] BC Centre for Disease Control. *British Columbia Annual Summary of Reportable Diseases 2016*. 2017. Available at http://www.bccdc.ca/resource-gallery/Documents/Statistics%20and%20Research/Statistics%20and%20Reports/Epid/Annual%20Reports/2016CDAnnualReportFinal.pdf. Accessed February 2018.

[1447] BC Centre for Disease Control. HIV Annual Report 2015. Available at http://www.bccdc.ca/resource-gallery/Documents/Statistics%20and%20Research/Statistics%20and%20Reports/STI/HIV_Annual_Report_2015-FINAL.pdf. Accessed February 2018.

[1448] BC Centre for Disease Control. STI Annual Report 2015. Available at http://www.bccdc.ca/resource-gallery/Documents/Statistics%20and%20Research/Statistics%20and%20Reports/STI/STI_Annual_Report_2015-FINAL.pdf. Accessed February 2018.

[1449] Sellors JW, Karwalajtys TL, Kaczorowski J et al. Incidence, clearance and predictors of human papillomavirus infection in women. *Canadian Medical Association Journal*. 2003; 168(4): 421-5.

[1450] Giuliano AR, Lu B, Nielson CM et al. Age-specific prevalence, incidence, and duration of human papillomavirus infections in a cohort of 290 US men. *Journal of Infectious Diseases*. 2008; 198(6): 827-35.

[1451] Li X, Kim PH-J and Gilbert M. *Trends in Herpes Simplex Virus Cases in British Columbia, 1992-2006*. 2008. Available at http://www.bccdc.ca/NR/rdonlyres/11F4B322-54F7-48AC-A116-6D1081449B98/0/STI_Report_TrendsInHSV19922006_20090520.pdf. Accessed March 2015.

Table 2: Estimated Number of Sexually Transmitted Infections in a *Male* Birth Cohort of 20,000									
Age Group	Individuals in Birth Cohort	Years of Life in Birth Cohort	Chlamydia	HIV	Gonorrhea	Hepatitis B - Acute	Syphilis	HPV	HSV-2
15-19	19,882	99,412	320	1	63	0	6	24,853	63
20-24	19,815	99,073	952	11	217	0	34	8,718	94
25-29	19,701	98,505	882	22	277	0	63	8,176	99
30-34	19,564	97,819	386	13	197	0	59	12,716	110
35-39	19,408	97,038	383	13	196	0	59	12,615	109
40-44	19,223	96,115	99	12	66	0	47	7,305	72
45-49	18,993	94,967	98	12	65	0	46	7,217	71
50-54	18,690	93,451	96	12	64	0	46	7,102	70
55-59	18,270	91,351	94	12	63	0	44	6,943	68
Total Ages 15 - 59		**867,731**	**3,312**	**110**	**1,208**	**2**	**405**	**95,646**	**754**

Table 3: Estimated Number of Sexually Transmitted Infections in a *Female* Birth Cohort of 20,000									
Age Group	Individuals in Birth Cohort	Years of Life in Birth Cohort	Chlamydia	HIV	Gonorrhea	Hepatitis B - Acute	Syphilis	HPV	HSV-2
15-19	19,899	99,493	1,425	2	120	0	1	24,873	139
20-24	19,867	99,333	1,980	1	194	0	4	8,741	208
25-29	19,825	99,124	1,101	1	161	0	3	8,227	221
30-34	19,773	98,864	422	4	76	0	2	12,852	245
35-39	19,707	98,536	421	4	75	0	2	12,810	244
40-44	19,624	98,118	84	2	16	0	1	7,457	162
45-49	19,509	97,547	84	2	16	0	1	7,414	161
50-54	19,349	96,744	83	2	16	0	1	7,353	160
55-59	19,116	95,582	82	2	16	0	1	7,264	158
Total Ages 15 - 59		**883,342**	**5,683**	**21**	**690**	**1**	**17**	**96,991**	**1,698**

- The data in Tables 2 and 3 was used to populate rows *a* - *n* in Table 4.
- High intensity (> 2 hours) behavioural counselling interventions are associated with a 62% (OR = 0.38, 95% CI of 0.24–0.60) reduction in STI incidence in adolescents and a 30% (OR = 0.70, 95% CI of 0.56–0.87) reduction in STI incidence in adults (Table 4, rows *o* & *p*).[1452]
- Reductions in quality of life attributable to an infection with chlamydia, gonorrhea, HPV and HSV-2 are based on data provided in the relevant appendixes of the document *Vaccines for the 21st Century: A Tool for Decision Making* (Table 4, rows *y*, *aa*, *dd* & *ee*).[1453] These appendixes include an estimated rate for all sequelae

[1452] O'Connor EA, Lin JS, Burda BU et al. Behavioral sexual risk-reduction counselling in primary care to prevent sexually transmitted infections: an updated systematic evidence review for the US Preventive Services Task Force. *Annals of Internal Medicine*. 2014; 161(12): 874.

[1453] Institute of Medicine. *Vaccines for the 21st Century: A Tool for Decision Making.* Washington, DC: National Academy Press; 2000.

following the infection, together with the time in a given state and the relevant change in quality of life over that time period.

- *Vaccines for the 21st Century: A Tool for Decision Making* suggest that chronic pelvic pain is associated with a 0.40 reduction in quality of life for a period of 22.73 years. The GBD study, however, found that moderate pelvic pain is associated a disability weight of 0.114 (95% CI of 0.078 to 0.159).[1454] Given the average QoL of women ages less than 30 of 0.914 (see Reference Document), the 0.114 disability weight results in a reduced QoL of 12.5% (95% CI of 8.5% to 17.4%). We therefore modified the assumption in *Vaccines for the 21st Century: A Tool for Decision Making* from 0.40 reduction in quality of life associated with chronic pelvic pain to 0.125.
- *Vaccines for the 21st Century: A Tool for Decision Making* suggest that infertility is associated with a 0.18 reduction in quality of life for 22.73 years. The GBD study, however, found that primary infertility ("wants to have a child and has a fertile partner but the couple cannot conceive") is associated with a disability weight of just 0.008 (95% CI of 0.003 to 0.015).[1455] Given the average QoL of women ages less than 50 of approximately 0.886 (see Reference Document), the 0.008 disability weight results in a reduced QoL of 0.9% (95% CI of 0.3% to 1.7%). We therefore modified the assumption in *Vaccines for the 21st Century: A Tool for Decision Making* from 0.18 reduction in quality of life associated with infertility to 0.009.
- We assumed that the average HIV infection would occur at age 40[1456] with 44 years of life remaining at a 17% reduced quality of life (Table 4, row *z*).[1457] We assumed a reduction of 0.05 QALYs per infection with syphilis (Table 4, row *cc*), roughly equivalent to the calculated reductions for chlamydia (0.049, Table 4, row *y*) and gonorrhea (0.055, Table 4, row *aa*). We assumed an 18.5% reduction in quality of life attributable to a hepatitis B – acute infection (Table 4, row *bb*).[1458]
- Other assumptions used in assessing the clinically preventable burden are detailed in the Reference Document.

Based on these assumptions, the CPB associated with behavioural counselling interventions for the prevention of sexually transmitted diseases is 3,267 QALYs (Table 4, row *ff*).

[1454] Institute for Health Metrics and Evaluation. *GBD 2016 sequelae, health states, health state lay descriptions, and disability weights*. Available online at http://ghdx.healthdata.org/record/global-burden-disease-study-2016-gbd-2016-disability-weights. Accessed January 2018.
[1455] Ibid.
[1456] Siegfried N, Uthman OA and Rutherford GW. Optimal time for initiation of antiretroviral therapy in asymptomatic, HIV-infected, treatment-naive adults. *The Cochrane Library*. 2010: 2.
[1457] Long EF, Mandalia R, Mandalia S et al. Expanded HIV testing in low-prevalence, high-income countries: a cost-effectiveness analysis for the United Kingdom. *PLoS One*. 2014; 9(4): e95735.
[1458] Colombo GL, Gaeta GB, Viganò M et al. A cost-effectiveness analysis of different therapies in patients with chronic hepatitis B in Italy. *ClinicoEconomics and Outcomes Research*. 2011; 3: 37.

Table 4: CPB of Behavioural Counselling Interventions for the Prevention of Sexually Transmitted Infections in a Birth Cohort of 40,000			
Row Label	**Variable**	**Base Case**	**Data Source**
a	Estimated number of STIs in birth cohort as adolescents - Chlamydia	1,746	Tables 2 and 3
b	Estimated number of STIs in birth cohort as adults - Chlamydia	7,250	Tables 2 and 3
c	Estimated number of STIs in birth cohort as adolescents - HIV	4	Tables 2 and 3
d	Estimated number of STIs in birth cohort as adults - HIV	127	Tables 2 and 3
e	Estimated number of STIs in birth cohort as adolescents - Gonorrhea	183	Tables 2 and 3
f	Estimated number of STIs in birth cohort as adults - Gonorrhea	1,715	Tables 2 and 3
g	Estimated number of STIs in birth cohort as adolescents - Hep B-Acute	0	Tables 2 and 3
h	Estimated number of STIs in birth cohort as adults - Hep B-Acute	2	Tables 2 and 3
i	Estimated number of STIs in birth cohort as adolescents - Syphilis	7	Tables 2 and 3
j	Estimated number of STIs in birth cohort as adults - Syphilis	415	Tables 2 and 3
k	Estimated number of STIs in birth cohort as adolescents - HPV	49,726	Tables 2 and 3
l	Estimated number of STIs in birth cohort as adults - HPV	142,911	Tables 2 and 3
m	Estimated number of STIs in birth cohort as adolescents - HSV-2	202	Tables 2 and 3
n	Estimated number of STIs in birth cohort as adults - HSV-2	2,250	Tables 2 and 3
	Benefits Associated with Behavioural Counselling		
o	Effectiveness of high intensity behavioural counselling in reducing STI incidence in adolescents	62%	√
p	Effectiveness of high intensity behavioural counselling in reducing STI incidence in adults	30%	√
q	Adherence with behavioural counselling	29%	Ref Doc
r	Estimated # of chlamydia infections avoided	945	= ((a * o) + (b * p)) * q
s	Estimated # of HIV infections avoided	12	= ((c * o) + (d * p)) * q
t	Estimated # of gonorrhea infections avoided	182	= ((e * o) + (f * p)) * q
u	Estimated # of Hep B-Acute infections avoided	0.2	= ((g * o) + (h * p)) * q
v	Estimated # of syphilis infections avoided	37	= ((i * o) + (j * p)) * q
w	Estimated # of HPV infections avoided	21,374	= ((k * o) + (l * p)) * q
x	Estimated # of HSV-2 infections avoided	232	= ((m * o) + (n * p)) * q
y	Reduction in QALYs per infection - Chlamydia	0.049	√
z	Reduction in QALYs per infection - HIV	7.48	√
aa	Reduction in QALYs per infection - Gonorrhea	0.055	√
bb	Reduction in QALYs per infection - Hep B - Acute	0.185	
cc	Reduction in QALYs per infection - Syphilis	0.050	Assumed
dd	Reduction in QALYs per infection - HPV	0.146	√
ee	Reduction in QALYs per infection - HSV-2	0.0028	√
ff	**Potential QALYs gained, Behavioural Counseling increasing from 0% to 29%**	**3,267**	= r * y + s * z + t * aa + u * bb + v * cc + w * dd * x * ee

√ = Estimates from the literature

We also modified a number of major assumptions and recalculated the CPB as follows:

- Assume the effectiveness of high intensity behavioural counselling interventions in reducing the incidence of STIs is reduced from 62% to 40% in adolescents and from 30% to 13% in adults (Table 4, rows *o & p*): **CPB = 1,697 QALYs**.
- Assume the effectiveness of high intensity behavioural counselling interventions in reducing the incidence of STIs is increased from 62% to 74% in adolescents and from 30% to 44% in adults (Table 4, rows *o & p*): **CPB = 4,472 QALYs**.

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with behavioural counselling interventions for the prevention of sexually transmitted diseases in a British Columbia birth cohort of 40,000.

In estimating CE, we made the following assumptions:

- We have assumed that all individuals between the ages of 15 and 59 who had sexual intercourse within the past 12 months would be eligible for this intervention. Rates of sexually transmitted diseases are relatively rare before age 15 and after age 60 (see Table 1 above). The rates by sex and age group for those who have 'ever had sexual intercourse' and 'had sexual intercourse in the past 12 months' are taken from the 2010 Canadian Community Health Survey Public Use Microdata File.[1459] Based on this data, approximately 81% of individuals between the ages of 15 and 59 have been sexually active within the past 12 months (see Table 5).

Table 5: Sexual Behaviours in British Columbia
By Age and Sex, 2010

Age Group	Ever had sexual intercourse		Had sexual intercourse in past 12 months		BC Population in 2010		BC Population at Risk	
	Males	Females	Males	Females	Males	Females	Males	Females
15-17	31.9%	19.3%	28.4%	17.7%	87,147	78,702	24,774	13,932
18-19	70.0%	63.3%	61.8%	59.9%	59,622	54,725	36,876	32,794
20-24	84.4%	87.5%	74.6%	77.7%	154,199	150,826	114,961	117,200
25-29	91.9%	91.2%	87.0%	84.1%	158,599	158,757	138,019	133,532
30-34	99.3%	96.6%	93.6%	93.2%	146,617	146,738	137,211	136,730
35-39	95.7%	96.7%	89.1%	91.1%	148,222	151,380	132,139	137,833
40-44	99.5%	97.9%	91.4%	85.6%	158,902	162,455	145,166	139,097
45-49	99.5%	95.9%	86.1%	82.7%	178,859	182,002	154,079	150,497
50-59	99.5%	95.9%	86.1%	82.7%	328,360	331,907	282,868	274,454
Total			**82.1%**	**80.1%**	**1,420,527**	**1,417,492**	**1,166,093**	**1,136,069**

- **Frequency of screening** - We assumed that a general practitioner would enquire about a patient's sexual behaviours once every four years (Table 7, row *c*).
- **Patient time costs for behavioural counselling intervention** - We assumed three hours of patient time would be required (including travel to and from the session) (Table 7, row *o*).
- **Costs of a behavioural counselling intervention** - We assumed that a clinical nurse specialist with a wage rate of $65 per hour ($122,000 per year) would lead the session. Their direct time involvement would be 3.5 hours (2.5 for the session and 1 hour for preparation). To these costs we added 24% for benefits (e.g., dental, long-term disability, etc.), 40% for non-productive paid hours (e.g., statutory holidays, vacations, sick time, educational leave, etc.) and 50% for overhead costs (e.g., use of the facility and support staff). Based on these assumptions, the estimated costs per behavioural counselling intervention would be $592 (Table 7, row *n*). We have

[1459] Statistics Canada. *Canadian Community Health Survey Public Use Microdata File 2009-2010 and 2010*. All computations, use and interpretation of these data are entirely that of H. Krueger & Associates Inc.

assumed that each session would be attended by an average of 5 individuals (Table 7, row *l*).

- **Costs per infection avoided** - The direct medical costs per infection avoided are taken from a US study (Table 7, rows *x – dd*).[1460] These costs, provided in 2008 US dollars, were adjusted to 2022 CAD. When costs were provided separately for males and females, we estimated the combined average costs based on the proportion of infections by sex expected in BC (Table 2 and 3) (see Table 6).

Table 6: Estimated Direct Medical Cost of Selected Sexually Transmitted Infections

		2008 US$			2022 Can$					
STI	**Sex**	Est	Range		Est	Range		% M/F	Est	Range
Chlamydia										
	Male	$30	$15	$45	$33	$16	$49	37%	$261	$131 $392
	Female	$364	$182	$546	$395	$198	$593	63%		
Gonorrhea										
	Male	$79	$40	$119	$86	$43	$129	64%	$193	$97 $290
	Female	$354	$177	$531	$384	$192	$577	36%		
HBV		$2,667	$2,172	$2,924	$2,897	$2,359	$3,176			
HIV		$304,500	$229,300	$379,700	$330,735	$249,056	$412,414			
HPV										
	Male	$45	$23	$78	$49	$25	$85	50%	$128	$65 $221
	Female	$191	$96	$329	$207	$104	$357	50%		
HSV-2										
	Male	$761	$381	$1,142	$827	$414	$1,240	31%	$722	$361 $1,083
	Female	$621	$311	$932	$675	$338	$1,012	69%		
Syphilis		$709	$355	$1,064	$770	$386	$1,156			

- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the CE associated with behavioural counselling interventions for the prevention of sexually transmitted diseases is $12,454 per QALY (Table 7, row *kk*).

[1460] Owusu-Edusei Jr K, Chesson HW, Gift TL et al. The estimated direct medical cost of selected sexually transmitted infections in the United States, 2008. *Sexually Transmitted Diseases*. 2013; 40(3): 197-201.

Table 7: CE of Behavioural Counselling Interventions for the Prevention of Sexually Transmitted Infections in a Birth Cohort of 40,000			
Row Label	**Variable**	**Base Case**	**Data Source**
a	Years of life between the ages of 15 and 59 in birth cohort	1,751,073	Tables 2 and 3
b	Proportion of years sexually active	81%	Table 5
	Costs of intervention		
c	Frequency of screening to determine sexual activity (every x years)	4	Assumed
d	Total number of screens	437,768	= a / c
e	Cost of 10-minute office visit	$35.97	Ref Doc
f	Value of patient time and travel for office visit	$74.32	Ref Doc
g	Portion of 10-minute office visit for screen	50%	Ref Doc
h	Cost of screening	$24,140,727	= d * (e + f) * g
i	Screen positive for sexual activity	354,592	= d * b
j	Adherence with behavioural counselling	29%	Table 4, row q
k	Attendance at a behavioural counselling intervention	102,832	= i * j
l	Individuals per behavioural counselling intervention	5	Assumed
m	Total number of behavioural counselling interventions	20,566	= k / m
n	Cost per behavioural counselling intervention	$592	√
o	Value of patient time and travel for behavioural counselling intervention	$111.48	√
p	Cost of behavioural counselling interventions	$23,647,395	= (m * n) + (k * o)
	Cost avoided		
q	Estimated # of chlamydia infections avoided	945	Table 4, row r
r	Estimated # of HIV infections avoided	12	Table 4, row s
s	Estimated # of gonorrhea infections avoided	182	Table 4, row t
t	Estimated # of Hep B-Acute infections avoided	0.2	Table 4, row u
u	Estimated # of syphilis infections avoided	37	Table 4, row v
v	Estimated # of HPV infections avoided	21,374	Table 4, row w
w	Estimated # of HSV-2 infections avoided	232	Table 4, row x
x	Cost of chlamydia infection avoided	$261	√
y	Cost of HIV infection avoided	$330,735	√
z	Cost of gonorrhea infection avoided	$193	√
aa	Cost of Hep B-Acute infection avoided	$2,897	√
bb	Cost of syphilis infection avoided	$770	√
cc	Cost of HPV infection avoided	$128	√
dd	Cost of HSV-2 infection avoided	$722	√
	CE calculation		
ee	Cost of intervention over lifetime of birth cohort	$47,788,122	= h + p
ff	Costs avoided	$7,098,383	= q * x + r * y + s * z + t * aa + u * bb + v * cc + w * dd
gg	QALYs saved	3,267	Table 4, row ff
hh	Cost of intervention over lifetime of birth cohort (1.5% discount)	$34,828,196	Calculated
ii	Costs avoided (1.5% discount)	$5,173,333	Calculated
jj	QALYs saved (1.5% discount)	2,381	Calculated
kk	**CE ($/QALY saved)**	**$12,454**	= (hh - ii) / jj

√ = Estimates from the literature

We also modified several major assumptions and recalculated the cost per QALY as follows:

- Assume the effectiveness of high intensity behavioural counselling interventions in reducing the incidence of STIs is reduced from 62% to 40% in adolescents and from 30% to 13% in adults (Table 4, rows *o & p*): CE = $26,163/QALY.

- Assume the effectiveness of high intensity behavioural counselling interventions in reducing the incidence of STIs is increased from 62% to 74% in adolescents and from 30% to 44% in adults (Table 4, rows *o & p*): **CE = $8,437/QALY**.
- Assume screening to determine sexual activity is less frequent, carried out once every 5 years rather than once every 4 years (Table 7, rows *c*): CE = $9,529/QALY.
- Assume screening to determine sexual activity is more frequent, carried out once every 3 years rather than once every 4 years (Table 7, rows *c*): CE = $17,329/QALY.
- Assume the average number of individuals attending each behavioural counselling intervention is increased from 5 to 10 (Table 7, rows *l*): CE = $10,589/QALY.
- Assume the average number of individuals attending each behavioural counselling intervention is reduced from 5 to 1 (Table 7, rows *l*): **CE = $27,370/QALY.**
- Assume the average direct cost per HIV infection is reduced from $330,735 to $249,056 (Table 7, rows *y*): CE = $12,747/QALY.
- Assume the average direct cost per HIV infection is increased from $330,735 to $412,414 (Table 7, rows *y*): CE = $12,161/QALY.
- Assume the average direct cost per HPV infection is reduced from $128 to $65 (Table 7, rows *cc*): CE = $12,870/QALY.
- Assume the average direct cost per HPV infection is increased from $128 to $221 (Table 7, rows *cc*): CE = $11,846/QALY.

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with behavioural counselling interventions for the prevention of sexually transmitted diseases is estimated to be 2,381 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $12,454 per QALY (see Table 8).

Table 8: Behavioural Counselling Interventions for the Prevention of Sexually Transmitted Infections in a Birth Cohort of 40,000
Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Gap between 0% and Best in the World (29%)			
1.5% Discount Rate	**2,381**	1,697	3,259
3% Discount Rate	1,780	925	2,437
0% Discount Rate	3,267	1,697	4,472
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$12,454**	$8,437	$27,370
3% Discount Rate	$12,454	$8,437	$27,370
0% Discount Rate	$12,454	$8,437	$27,370
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$3,966	$2,237	$18,883
3% Discount Rate	$3,966	$2,237	$18,883
0% Discount Rate	$3,966	$2,237	$18,883

United States Preventive Services Task Force Recommendations (2009)

> *Tobacco use, cigarette smoking in particular, is the leading preventable cause of death in the United States. Tobacco use results in more than 400 000 deaths annually from cardiovascular disease, respiratory disease, and cancer. Smoking during pregnancy results in the deaths of about 1000 infants annually and is associated with an increased risk for premature birth and intrauterine growth retardation. Environmental tobacco smoke contributes to death in an estimated 38 000 people annually.*
>
> *The USPSTF strongly recommends that clinicians screen all adults for tobacco use and provide tobacco cessation interventions for those who use tobacco products. (A Recommendation).*
>
> *The USPSTF strongly recommends that clinicians screen all pregnant women for tobacco use and provide augmented pregnancy-tailored counselling to those who smoke. (A Recommendation)*[1461]

Canadian Task Force on Preventive Health Care Recommendations (1994)

> *A large body of evidence has accumulated regarding the health effects of smoking. Tobacco use has been consistently linked with a variety of serious pulmonary, cardiovascular and neoplastic diseases. Evaluation of this evidence is beyond the scope of this chapter but detailed reviews and estimates of relative risk for the many tobacco associated diseases have been published elsewhere. Likewise, reviews of the evidence regarding the health consequences of ETS are published elsewhere. In 1992 the U.S. Environmental Protection Agency (EPA) named ETS a Group A carcinogen (shown to cause cancer in humans) at typical environmental levels.*
>
> *There is good evidence to support counselling for smoking cessation in the periodic health examination of individuals who smoke (A Recommendation). Nicotine replacement therapy can be effective as an adjunct (A Recommendation).*
>
> *There is fair evidence to support physicians also referring patients to other programs after offering cessation advice (B Recommendation).*
>
> *There is insufficient evidence to evaluate counselling to reduce ETS exposure (C Recommendation) but it may be useful to combine such counselling with cessation advice, again based on the burden of suffering, the potential benefits of the intervention and the effectiveness of cessation advice.*[1462]

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with behavioural counselling and interventions for the prevention of tobacco use in a British Columbia birth cohort of 40,000.

In estimating CPB, we made the following assumptions:

- The proportion of the BC population that are light smokers (less than 10 cigarettes per day), moderate smokers (10-19 cigarettes per day) and heavy smokers (20 or

[1461] U.S. Preventive Services Task Force. Counselling and interventions to prevent tobacco use and tobacco-caused disease in adults and pregnant women: U.S. Preventive Services Task Force reaffirmation recommendation statement. *Annals of Internal Medicine*. 2009; 150(8): 551-5.

[1462] Taylor MC and Dingle JL. *Canadian Guide to Clinical Preventive Health Care: Chapter 43: Prevention of Tobacco-Caused Disease*. 1994. Health Canada. Available at http://www.phac-aspc.gc.ca/publicat/clinic-clinique/pdf/s6c43e.pdf. Accessed July 2008.

more cigarettes per day) by age group is based on 2014 CCHS data.[1463] No data is available for ages 80+ so we assumed a 50% decline in smoking rate between the ages of 79 and 84 and further 50% decline between the ages of 85 and 89. Between the ages of 18 and 89, the proportion of life years lived with light smoking is 7.9% (200,053 of 2,520,119 life years), moderate smoking is 3.9% (98,295 of 2,520,119 life years) and heavy smoking is 2.3% (59,090 of 2,520,119 life years) (see Table 1).

Table 1: Years of Life Lived and Current Smoking Between the Ages of 18 and 89
in a British Columbia Birth Cohort of 40,000

Age Group	*Individuals in Birth Cohort*	*% of BC Population Current Smokers*			*BC Population Current Smokers*				*Life Years Lived*	*Years Lived as Current Smokers*		
		Light	Mod	Heavy	Light	Mod	Heavy	Total		Light	Mod	Heavy
18-19	39,759	10.3%	0.4%	0.4%	4,093	143	143	4,380	79,517	8,186	286	287
20-24	39,677	20.5%	1.9%	0.4%	8,130	767	176	9,073	198,385	40,650	3,835	878
25-29	39,518	14.9%	5.2%	2.3%	5,897	2,071	905	8,873	197,592	29,485	10,355	4,527
30-34	39,327	16.6%	5.2%	1.3%	6,530	2,042	516	9,088	196,633	32,650	10,208	2,580
35-39	39,103	8.9%	6.7%	1.2%	3,495	2,631	486	6,612	195,517	17,474	13,154	2,431
40-44	38,835	6.8%	5.0%	3.5%	2,654	1,925	1,376	5,955	194,174	13,268	9,625	6,879
45-49	38,492	4.4%	2.9%	3.2%	1,712	1,109	1,237	4,058	192,462	8,560	5,547	6,183
50-54	38,031	7.6%	4.1%	4.6%	2,891	1,545	1,750	6,186	190,154	14,454	7,726	8,750
55-59	37,379	3.9%	7.9%	4.3%	1,453	2,957	1,618	6,028	186,897	7,267	14,783	8,092
60-64	36,435	3.9%	4.7%	3.5%	1,413	1,728	1,276	4,418	182,174	7,067	8,642	6,382
65-69	35,035	4.7%	3.5%	3.0%	1,640	1,225	1,052	3,917	175,175	8,200	6,124	5,260
70-74	32,929	3.7%	3.6%	2.1%	1,202	1,201	698	3,102	164,644	6,011	6,007	3,492
75-79	29,753	2.9%	0.9%	1.4%	860	254	425	1,539	148,766	4,301	1,270	2,123
80-84	25,060	1.4%	0.4%	0.7%	362	107	179	648	125,300	1,811	535	894
85-89	18,546	0.7%	0.2%	0.4%	134	40	66	240	92,728	670	198	331
Total		**7.9%**	**3.9%**	**2.3%**					**2,520,119**	**200,053**	**98,295**	**59,090**

- A significant proportion of smokers quit on their own.[1464] According to the *Treating Tobacco Use and Dependence: 2008 Update* document, individuals who quit on their own have a success (abstinence rate) of 10.9%. This increases to 28.0% (95% CI of 23.0% - 33.6%) with 2-3 brief counselling interventions with a primary care provider and the use of medications.[1465] We used the rate of 10.9% to populate row *w* in Table 2 and the 28.0% to populate row *x*.
- Other assumptions used in assessing the clinically preventable burden are detailed in the Reference Document.

[1463] This analysis is based on the Statistics Canada's Canadian Community Health 2014 Public Use Microdata File. All computations, use and interpretation of these data are entirely that of H. Krueger & Associates Inc.
[1464] Smith A and Chapman S. Quitting smoking unassisted: the 50-year research neglect of a major public health phenomenon. *Journal of the American Medical Association*. 2014; 311(2): 137-8.
[1465] Fiore M, Jaen C, Baker T et al. *Clinical Practice Guideline. Treating Tobacco Use and Dependence: 2008 Update*. 2008. U.S. Department of Health and Human Services. Available at http://www.ahrq.gov/professionals/clinicians-providers/guidelines-recommendations/tobacco/clinicians/treating_tobacco_use08.pdf. Accessed January 2014.

Based on these assumptions, the CPB associated with behavioural counselling and interventions for the prevention of tobacco use is 5,904 QALYs (Table 2, row *ac*). The CPB of 5,904 represents the gap between no coverage and the 'best in the world' coverage estimated at 51%.

Table 2: CPB of Behavioural Counselling and Interventions to Prevent Tobacco Use in a BC Birth Cohort of 40,000

Label	Variable	Base Case	Data Source
	Estimated current status		
a	# of life years lived between the ages of 18-89 in birth cohort	2,520,119	Table 1
b	% of life years at light smoking (<10 cigarettes / day)	7.9%	Table 1
c	# of life years at light smoking	200,053	= (a * b)
d	% of life years at moderate smoking (10-19 cigarettes / day)	3.9%	Table 1
e	# of life years at moderate smoking	98,295	= (a * d)
f	% of life years at heavy smoking (≥20 cigarettes / day)	2.3%	Table 1
g	# of life years at heavy smoking	59,090	= (a * f)
	Life years lost due to Smoking		
h	% of life years lost due to light smoking	10.2%	Ref Doc
i	# of life years lost due to light smoking	20,360	= (c * h)
j	% of life years lost due to moderate smoking	18.4%	Ref Doc
k	# of life years lost due to moderate smoking	18,037	= (e * j)
l	% of life years lost due to heavy smoking	27.9%	Ref Doc
m	# of life years lost due to heavy smoking	16,492	= (g * l)
n	Life years lost due to smoking	**54,890**	= i + k + m
	QALYs lost due to Smoking		
o	% of QoL lost due to light smoking	3.7%	Ref Doc
p	# of QALYs lost due to light smoking	6,569	= (c - i) * o
q	% of QoL lost due to moderate smoking	3.9%	Ref Doc
r	# of QALYs lost due to moderate smoking	3,123	= (e - k) * q
s	% of QoL lost due to heavy smoking	7.3%	Ref Doc
t	# of QALYs lost due to heavy smoking	3,114	= (g - m) * s
u	QALYs lost due to smoking	**12,807**	= p + r + t
v	**Total QALYs lost due to smoking**	**67,696**	= n + u
	***Benefits* if 51% of smokers received counselling and an intervention**		
w	Quit rate without intervention	10.9%	√
x	Quit rate with intervention	28.0%	√
y	QALYs gained without intervention	7,379	= v * w
z	QALYs gained with intervention with 100% adherence	18,955	= v * x
aa	Net QALYs gained with 100% adherence	11,576	= z - y
ab	Estimated adherence with screening and intervention	51%	Ref Doc
ac	**Potential QALYs gained, Screening & Intervention from 0% to 51%**	**5,904**	= aa * ab

√ = Estimates from the literature

We also modified a number of major assumptions and recalculated the CPB as follows:

- Assume the disutility of light smoking is reduced from 3.7% to 2.1% (Table 2, row *o*), the disutility of moderate smoking is reduced from 3.9% to 2.2% (Table 2, row *q*) and the disutility of heavy smoking is reduced from 7.3% to 5.0% (Table 2, row *s*): CPB = 5,460 QALYs.
- Assume the disutility of light smoking is increased from 3.7% to 5.3% (Table 2, row *o*), the disutility of moderate smoking is increased from 3.9% to 5.5% (Table 2, row *q*) and the disutility of heavy smoking is increased from 7.3% to 9.7% (Table 2, row *s*): CPB = 6,366 QALYs.

- Assume that the quit rate with intervention (2-3 sessions + medication) is reduced from 28.0% to 23.0% (Table 2, row *x*): **CPB = 4,178 QALYs**.
- Assume that the quit rate with intervention (2-3 sessions + medication) is increased from 28.0% to 33.6% (Table 2, row *x*): **CPB = 7,837 QALYs**.

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with behavioural counselling and interventions for the prevention of tobacco use in a British Columbia birth cohort of 40,000.

In estimating CE, we made the following assumptions:

- For modelling purposes, we assumed that of the smokers who would successfully quit as a result of the intervention, 50% would quit at age 30, 25% at age 40 and 25% at age 50.
- **Average cost of smoking cessation aids per quit attempt** – in 2011, BC PharmaCare estimated the costs for pharmacological aids to smoking cessation based on a 12 week supply including mark-up and dispensing fees.[1466] Varenicline (Champix®) was estimated to cost $336, buproprion (Zyban®) $209, nicotine patch $273 and nicotine gum $122-$289. In deriving the average cost we assumed that 56% of all smokers would use the patch, 22% would use varenicline and 22% of all smokers would use nicotine gum.[1467] The mid-point for the cost estimate of nicotine gum was used. Based on these assumptions, the average cost of smoking cessation aids per quit attempt in BC was $272.01 (in 2011 CAD) or $321.75 (in 2022 CAD).
- **Portion of counselled who use a smoking cessation aid** – Because the effectiveness of the intervention is based on 2-3 brief counselling sessions and the use of medication, we have assumed the 100% of those counselled would use a smoking cessation aid.
- In estimating the costs avoided due to the intervention, we assumed annual costs avoided of $893 per light smoker, $1,576 per moderate smoker and $2,332 per heavy smoker (see Reference Document). These costs avoided, however, are not fully realized until 20 years following smoking cessation.[1468,1469] This gradual increase in costs avoided was incorporated into the model.
- The later in life smoking cessation occurs, the fewer the benefits. Based on data provided by Jha and colleagues,[1470] we have assumed that 91.3% of potential benefits would occur if smoking cessation occurred at age 30, 82.6% at age 40 and 56.5% at age 50.
- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.

[1466] BC Ministry of Health. *Effective Pharmacological Aids to Smoking Cessation*. 2011. Available at http://www.health.gov.bc.ca/pharmacare/pdf/sc-prod-info.pdf. Accessed January 2014.
[1467] BC Stats. *Report on the B.C. Smoking Cessation Program Evaluation Survey*. November 2020. Available online at https://www2.gov.bc.ca/assets/gov/health/health-drug-coverage/pharmacare/bc_smoking_cessation_survey_evaluation_20201116.pdf. Accessed November 2023.
[1468] Kenfield S, Stampfer M, Rosner B, Colditz GA. Smoking and smoking cessation in relation to mortality in women. *Journal of the American Medical Association*. 2008; 299(17): 2037-47.
[1469] Krueger H, Turner D, Krueger J, Ready E. The economic benefits of risk factor reduction in Canada: Tobacco smoking, excess weight and physical inactivity. *Canadian Journal of Public Health*. 2014; 105(1): e69-e78.
[1470] Jha P, Ramasundarahettige C, Landsman V et al. 21st-century hazards of smoking and benefits of cessation in the United States. *New England Journal of Medicine*. 2013; 368(4): 341-50.

- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, behavioural counselling and interventions for the prevention of tobacco use is associated cost-savings of $11.5 million (Table 3, row *y*).

Table 3: CE of Behavioural Counselling and Interventions to Prevent Tobacco Use in a BC Birth Cohort of 40,000

Row Label	Variable	Base Case	Data Source
a	# of life years lived between the ages of 18-89 in birth cohort	2,520,119	Table 1
b	# of life years lived as smokers between the ages of 18-89 in birth cohort	357,438	Table 2, row c + Table 2, row e + Table 2, row g
	Estimated cost of screening		
c	Number of annual screens to assess willingness to quit	357,438	= b
d	Proportion of office visit required	50%	See Ref Doc
e	Cost of 10-minute office visit	$35.97	See Ref Doc
f	Patient time costs / office visit	$74.32	See Ref Doc
g	Estimated cost of screening	$19,710,910	= (e + f) * d * c
	Estimated cost of intervention		
h	Average # of smokers in birth cohort ages 20-29	8,973	Table 1
i	Estimated adherence with screening and intervention	51%	Table 2, row ab
j	# of brief counselling interventions	3	√
k	Cost of smoking cessation aids	$321.75	√
l	Estimated cost of intervention	$2,986,524	= ((h*i)*j)*(e+f))+(h*i*k)
m	Average # of smokers in birth cohort ages 30-39	7,850	Table 1
n	Estimated cost of intervention	$2,612,676	= ((m*i)*j)*(e+f)+(m*i*k)
o	Average # of smokers in birth cohort ages 40-49	5,006	Table 1
p	Estimated cost of intervention	$1,666,247	= ((o*i)*j)*(e+f)+(o*i*k)
q	**Total cost of interventions**	**$7,265,447**	= l + n + p
r	**Estimated costs avoided due to intervention**	**$55,978,709**	Calculated
	CE Calculation		
s	Cost of intervention over lifetime of birth cohort	$26,976,357	= g + q
t	Costs avoided due to intervention over lifetime of birth cohort	$55,978,709	= r
u	QALYs saved	5,904	Table 2, row ac
v	Cost of intervention over lifetime of birth cohort (1.5% discount)	$19,414,115	Calculated
w	Costs avoided due to intervention over lifetime of birth cohort (1.5% discount)	$30,955,338	Calculated
x	QALYs saved (1.5% discount)	3,265	Calculated
y	Costs saved due to intervention (1.5% discount)	-$11,541,223	= v - w
z	**CE ($/QALY saved)**	**Cost-saving**	

√ = Estimates from the literature

We also modified a number of major assumptions and recalculated the cost per QALY as follows:

- Assume the disutility of light smoking is reduced from 3.7% to 2.1% (Table 2, row *o*), the disutility of moderate smoking is reduced from 3.9% to 2.2% (Table 2, row *q*) and the disutility of heavy smoking is reduced from 7.3% to 5.0% (Table 2, row *s*): CE = Cost-saving.
- Assume the disutility of light smoking is increased from 3.7% to 5.3% (Table 2, row *o*), the disutility of moderate smoking is increased from 3.9% to 5.5% (Table 2, row *q*) and the disutility of heavy smoking is increased from 7.3% to 9.7% (Table 2, row *s*): CE = Cost-saving.
- Assume that the quit rate with intervention (2-3 sessions + medication) is reduced from 28.0% to 23.0% (Table 2, row *x*): CE = Cost-saving.

- Assume that the quit rate with intervention (2-3 sessions + medication) is increase from 28.0% to 33.6% (Table 2, row *x*): CE = Cost-saving.
- Assume the proportion of an office visit required for screening is reduced from 50% to 33% (Table 3, row *d*): CE = Cost-saving.
- Assume the proportion of an office visit required for screening is increased from 50% to 67% (Table 3, row *d*): CE = Cost-saving.

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with behavioural counselling and interventions for the prevention of tobacco use is estimated to be 3,265 quality-adjusted life years (QALYs) while resulting in cost-savings (see Table 4).

Table 4: Behavioural Counselling and Interventions to Prevent Tobacco Use in a BC Birth Cohort of 40,000

Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Gap between No Service and 'Best in the World' (51%)			
1.5% Discount Rate	**3,265**	2,310	4,334
3% Discount Rate	1,821	1,288	2,417
0% Discount Rate	5,904	4,178	7,837
Gap between BC Current (19%) and 'Best in the World' (51%)			
1.5% Discount Rate	1,216	861	1,615
3% Discount Rate	678	480	900
0% Discount Rate	2,200	1,557	2,920
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**Cost-saving**	Cost-saving	Cost-saving
3% Discount Rate	Cost-saving	Cost-saving	$367
0% Discount Rate	Cost-saving	Cost-saving	Cost-saving
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	Cost-saving	Cost-saving	Cost-saving
3% Discount Rate	Cost-saving	Cost-saving	Cost-saving
0% Discount Rate	Cost-saving	Cost-saving	Cost-saving

United States Preventive Services Task Force Recommendations (2018)[1471]

Excessive alcohol use is one of the most common causes of premature mortality in the United States. From 2006 to 2010, an estimated 88 000 alcohol-attributable deaths occurred annually in the United States, caused by both acute conditions (e.g., injuries from motor vehicle collisions) and chronic conditions (e.g., alcoholic liver disease). Alcohol use during pregnancy is also one of the major preventable causes of birth defects and developmental disabilities.

The USPSTF recommends screening for unhealthy alcohol use in primary care settings in adults 18 years or older, including pregnant women, and providing persons engaged in risky or hazardous drinking with brief behavioral counseling interventions to reduce unhealthy alcohol use. (B recommendation)

The USPSTF concludes that the current evidence is insufficient to assess the balance of benefits and harms of screening and brief behavioral counseling interventions for alcohol use in primary care settings in adolescents aged 12 to 17 years. (I statement)

Canadian Task Force on Preventive Health Care Recommendations (1989) [1472]

In 1989 the Canadian Task Force on the Periodic Health Examination concluded that there was fair evidence that routine case-finding for problem drinking, and that brief counselling intervention in patients identified thereby was effective in reducing alcohol consumption and related consequences.

Best in the World

- In a 2016 US survey of 1,506 primary care providers, 96% reported screening patients for alcohol misuse but only 38% used a USPSTF-preferred screening tool.[1473]
- In a 2013 US consumer survey, 24.7% of respondents who visited a primary care provider in the past year reported receiving alcohol screening (24.9% of women and 24.5% of men).[1474]
- Based on data from the 2011 US Behavioural Risk Factor Surveillance System, 15.7% of U.S. adults reported ever discussing alcohol use with a health professional (ranging from a low of 8.7% in Kansas to a high of 25.5% in the District of Columbia). This increased to 17.4% for current drinkers, 25.4% for binge drinkers and 34.9% for binge drinkers reporting ≥10 episodes in the past 30 days.[1475]
- In Oregon, 4.6% of individuals are screened in primary care for unhealthy alcohol use[1476] but 41% of Medicaid enrollees in the state with an alcohol use disorder

[1471] US Preventive Services Task Force. Screening and Behavioral Counseling Interventions to Reduce Unhealthy Alcohol Use in Adolescents and Adults: US Preventive Services Task Force Recommendation Statement. *JAMA*. 2018: 320(18); 1899-1909.

[1472] Haggerty JL. *Canadian Guide to Clinical Preventive Health Care: Chapter 42: Early Detection and Counselling of Problem Drinking*. 1994. Health Canada. Available at http://www.phac-aspc.gc.ca/publicat/clinic-clinique/pdf/s6c42e.pdf. Accessed July 2008.

[1473] Tan C, Hungerford D, Denny C et al. Screening for alcohol misuse: Practices among U.S. primary care providers, DocStyles 2016. *American Journal of Preventive Medicine*. 2018: 54(2); 173-80.

[1474] Denny C, Hungerford D, McKnight-Eily L et al. Self-reported prevalence of alcohol screening among U.S. adults. *American Journal of Preventive Medicine.* 2016: 50(3); 380-83.

[1475] McKnight-Eily L, Liu Y, Brewer R et al. Vital signs: Communication between health professional and their patients about alcohol use – 44 state and the District of Columbia, 2011. *Morbidity and Mortality Weekly Report*. 2014: 63(1): 16-22.

[1476] Rieckmann T, Renfro S, McCarty D et al. Quality metrics and systems transformation: Are we advancing alcohol and drug screening in primary care? *Health Services Research*. 2018: 53(3); 1702-26.

receive treatment,[1477] suggesting that primary care providers may target at-risk patients for formal screening.

- Screening for alcohol misuse (a score of ≥ 5 on the Alcohol Use Disorders Identification Test (AUDIT-C) in the primary care settings of Poland (2.0%), England (4.6%) and the Netherlands (5.3%) is also low but results return a high positive rate (41.2% in Poland, 48.9% in England and 44.4% in The Netherlands). Modelling work by Angus and colleagues estimated that a high proportion of individuals with positive results would receive a brief intervention **over a 10-year time horizon** (cumulatively 95.8% in Poland, 85.9% in England and 70.4% in The Netherlands).[1478]
- In integrated health-care systems where screening is mandated and built into the electronic medical record system, screening can be nearly universal. In one study of the US Veterans Health Administration system, 93% of individuals were screened for alcohol misuse in 2004.[1479]
- In a survey of 8,476 primary care patients from six European countries, 8.7% (4.8% in females and 14.6% in males) were found to have alcohol dependence, of whom 22.3% (95% CI from 19.4% to 25.2%) sought and received professional help, 18.6% (95% CI from 13.7% to 23.5%) in females and 24.1% (95% CI from 20.4% to 227.8%) in males. The proportion receiving professional help ranged from a low of 16.6% in Latvia to a high of 38.5% in Italy (95% CI from 26.7% to 50.2%).[1480]
- A survey of US midwives, nurse practitioners and nurses providing prenatal care (n = 578) found that 35.2% of respondents reported screening for client alcohol use, with 23.3% using a specific screening tool.[1481] 11.6% reported screening "all of the time", 8.6% screened "most of the time", and 15.1% screened "some of the time".
- A survey of Norwegian midwives (n=103) found that 97% of respondents "mostly" or "always" asked pregnant women about their alcohol use at the first consultation, with 42% using a screening instrument.[1482]

[1477] McCarty D, Gu Y, Renfro S et al. Access to treatment for alcohol use disorders following Oregon's health care reforms and Medicaid expansion. *Journal of Substance Abuse Treatment*. 2018: 94; 24-8.
[1478] Angus C, Li J, Romero-Rodriguez et al. Cost-effectiveness of strategies to improve delivery of brief interventions for heavy drinking in primary care: Results from the ODHIN trial. *The European Journal of Public Health*. 2018: 29(2); 219-25.
[1479] Bradley K, Williams E, Achtmeyer C et al. Implementation of evidence-based alcohol screening in the Veterans Health Administration. *The American Journal of Managed Care*. 2006: 12; 597-606.
[1480] Rehm J, Allamani A, Elekes Z et al. Alcohol dependence and treatment utilization in Europe – a representative cross-sectional study in primary care. *BMC Family Practice*. 2015: 16(90).
[1481] Chiodo LM, Cosmian C, Pereira K et al. Prenatal Alcohol Screening During Pregnancy by Midwives and Nurses. *Alcoholism: Clinical and Experimental Research*. 2019; 43(8): 1747-58.
[1482] Wangberg SC. Norwegian midwives' use of screening for and brief interventions on alcohol use in pregnancy. *Sexual & Reproductive Healthcare*. 2015; 6(3): 186-90.

- For modelling purposes, we assume that the ***best in the world*** screening rate for the general population is 93% (Table 14, row *ar*) based on results from the US Veterans Health Administration system[1483] and 97% (Table 14, row *ba*) for pregnant women based on the results from Norwegian midwives.[1484] Furthermore, we assume that the ***best in the world*** proportion with a positive screen result that receive a brief intervention is 41% (based on the Oregon Medicaid enrollees study[1485] – Table 14, row *at*). We reduce this number to 30% to compare and contrast with our previous analysis.

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with screening and behavioural counseling interventions to reduce unhealthy alcohol use in adults 18 years or older, including pregnant women, in a British Columbia birth cohort of 40,000.

In estimating CPB, we made the following assumptions:

- There are 2,419,325 life years lived between the ages of 18 and 84 in a BC birth cohort of 40,000 (see Table 1). Of the total life years, 1,242,083 are in females (Table 14, row *a*) and 1,177243 are in males (Table 14, row *b*).

Table 1: Years of Life Lived
Between the Ages of 18 and 84
in a British Columbia Birth Cohort of 40,000

Age Group	*Individuals in Birth Cohort Entering Age Group* Females	Males	**Total**	*Life Years Lived* Females	Males	**Total**
18-19	19,894	19,876	**39,770**	39,776	39,728	**79,503**
20-24	19,881	19,851	**39,732**	99,314	99,024	**198,338**
25-29	19,843	19,751	**39,594**	99,101	98,440	**197,541**
30-34	19,796	19,621	**39,417**	98,834	97,745	**196,580**
35-39	19,736	19,474	**39,210**	98,499	96,953	**195,452**
40-44	19,661	19,303	**38,964**	98,068	96,011	**194,079**
45-49	19,561	19,094	**38,656**	97,478	94,833	**192,311**
50-54	19,422	18,827	**38,249**	96,645	93,269	**189,913**
55-59	19,224	18,461	**37,685**	95,436	91,094	**186,530**
60-64	18,932	17,947	**36,879**	93,628	87,997	**181,625**
65-69	18,489	17,208	**35,697**	90,843	83,512	**174,356**
70-74	17,799	16,132	**33,930**	86,461	76,965	**163,426**
75-79	16,704	14,560	**31,265**	79,488	67,475	**146,963**
80-84	14,963	12,306	**27,269**	68,513	54,198	**122,710**
Total				**1,242,083**	**1,177,243**	**2,419,325**

[1483] Bradley K, Williams E, Achtmeyer C et al. Implementation of evidence-based alcohol screening in the Veterans Health Administration. *The American Journal of Managed Care*. 2006: 12; 597-606.
[1484] Wangberg SC. Norwegian midwives' use of screening for and brief interventions on alcohol use in pregnancy. *Sexual & Reproductive Healthcare*. 2015; 6(3): 186-90.
[1485] McCarty D, Gu Y, Renfro S et al. Access to treatment for alcohol use disorders following Oregon's health care reforms and Medicaid expansion. *Journal of Substance Abuse Treatment*. 2018: 94; 24-8.

- There is no firm consensus worldwide regarding the definition of risky drinking. Any alcohol use is considered unhealthy in pregnant women.[1486]
- The categorization of alcohol exposure commonly used in Canadian research[1487,1488] is abstainer, low alcohol use (less than 1.5 drinks [containing 13.6g of ethanol] a day for females and 3 drinks a day for males), hazardous alcohol use (1.5 to 3 drinks a day for females and 3 to 4.5 drinks per day for males) and harmful alcohol use (more than 3 drinks a day for females and 4.5 drinks a day for males).
- The proportion of the BC population with low alcohol use, hazardous alcohol use and harmful alcohol use by sex and age group is based on 2014 Canadian Community Health Survey (CCHS) data.[1489] Alcohol consumption rates are adjusted for underreporting.[1490,1491,1492] Individuals who consume alcohol are grouped into these three categories based on their weekly consumption patterns.
- A significant proportion of individuals with low alcohol consumption levels consume their alcohol via binge drinking. A female binge drinker is defined as a female who consumes at least *four* drinks on one occasion at least once per month during the past 12 months. A male binge drinker is defined as a male who consumes at least *five* drinks on one occasion at least once per month during the past 12 months.
- For modelling purposes, unhealthy alcohol use in the general population is defined as any individuals with hazardous or harmful alcohol consumption levels *and* binge drinkers within the low consumption category.
- In a BC birth cohort of 40,000, an estimated 26.2% of life years lived between the ages of 18 and 84 (633,294 of 2,419,325) are lived with unhealthy alcohol use. The proportion is lower for females (21.5% or 266,833 of 1,242,083) than for males (31.1% or 366,461 of 1,177,243) (see Table 2).

- The life years lived with unhealthy alcohol use by category and sex as identified in Table 2 are used for modelling purposes.

[1486] O'Connor E, Perdue L, Senger C et al. Screening and behavioral counseling interventions to reduce unhealthy alcohol use in adolescents and adults: Updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2018: 320(18); 1910-28.
[1487] Taylor B, Rehm J, Patra J et al. Alcohol-attributable morbidity and resulting health care costs in Canada in 2002: recommendations for policy and prevention. *Journal of Studies on Alcohol and Drugs*. 2007; 68(1): 36-47.
[1488] Krueger H, Koot J, Andres E. The economic benefits of fruit and vegetable consumption in Canada. *Canadian Journal of Public Health*. 2017: 108(2); e152-61.
[1489] This analysis is based on the Statistics Canada's Canadian Community Health 2014 Public Use Microdata File. All computations, use and interpretation of these data are entirely that of H. Krueger & Associates Inc.
[1490] Boniface S, Kneale J and Shelton N. Actual and perceived units of alcohol in a self-defined "usual glass" of alcoholic drinks in England. *Alcoholism: Clinical and Experimental Research*. 2013; 37(6): 978-83.
[1491] Kerr WC and Stockwell T. Understanding standard drinks and drinking guidelines. *Drug and Alcohol Review*. 2012; 31(2): 200-5.
[1492] White AM, Kraus CL, Flom JD et al. College students lack knowledge of standard drink volumes: implications for definitions of risky drinking based on survey data. *Alcoholism: Clinical and Experimental Research*. 2005; 29(4): 631-8.

Table 2: Years of Life Lived with Unhealthy Alcohol Use

Between the Ages of 18 and 84

in a British Columbia Birth Cohort of 40,000

Age Group	*% of BC **Female** Pop by Alcohol Use Status*					*% of BC **Male** Pop by Alcohol Use Status*				
	Low	Low-Binge	Hazardous	Harmful	Total	Low	Low-Binge	Hazardo	Harmful	Total
18-19	52.3%	26.1%	5.1%	3.8%		55.4%	30.5%	7.0%	7.3%	
20-24	52.3%	26.1%	5.1%	3.8%		55.4%	30.5%	7.0%	7.3%	
25-29	52.3%	26.1%	5.1%	3.8%		55.4%	30.5%	7.0%	7.3%	
30-34	51.2%	13.0%	4.7%	3.0%		59.3%	21.4%	8.2%	7.9%	
35-39	51.2%	13.0%	4.7%	3.0%		59.3%	21.4%	8.2%	7.9%	
40-44	51.2%	13.0%	4.7%	3.0%		59.3%	21.4%	8.2%	7.9%	
45-49	51.9%	11.6%	6.0%	2.3%		58.5%	16.6%	6.7%	6.1%	
50-54	51.9%	11.6%	6.0%	2.3%		58.5%	16.6%	6.7%	6.1%	
55-59	51.9%	11.6%	6.0%	2.3%		58.5%	16.6%	6.7%	6.1%	
60-64	44.4%	4.0%	7.4%	2.0%		58.7%	10.5%	7.4%	5.5%	
65-69	44.4%	4.0%	7.4%	2.0%		58.7%	10.5%	7.4%	5.5%	
70-74	39.7%	2.3%	10.9%	2.2%		50.5%	4.5%	5.7%	3.9%	
75-79	39.7%	2.3%	10.9%	2.2%		50.5%	4.5%	5.7%	3.9%	
80-84	21.7%	2.2%	17.1%	2.3%		43.8%	1.0%	9.7%	5.7%	
18-19		10,395	2,020	1,506	**13,921**		12,122	2,782	2,896	**17,800**
20-24		25,955	5,043	3,760	**34,758**		30,214	6,934	7,218	**44,366**
25-29		25,899	5,032	3,752	**34,684**		30,036	6,893	7,176	**44,105**
30-34		12,814	4,690	2,933	**20,437**		20,938	8,001	7,701	**36,640**
35-39		12,770	4,674	2,923	**20,368**		20,768	7,936	7,639	**36,343**
40-44		12,715	4,654	2,910	**20,279**		20,567	7,859	7,564	**35,990**
45-49		11,312	5,801	2,224	**19,337**		15,696	6,325	5,771	**27,792**
50-54		11,216	5,751	2,205	**19,172**		15,437	6,221	5,675	**27,333**
55-59		11,076	5,679	2,177	**18,932**		15,077	6,076	5,543	**26,696**
60-64		3,725	6,886	1,860	**12,471**		9,240	6,506	4,856	**20,601**
65-69		3,615	6,681	1,804	**12,101**		8,769	6,174	4,608	**19,551**
70-74		1,992	9,440	1,874	**13,306**		3,437	4,419	2,987	**10,843**
75-79		1,832	8,678	1,723	**12,233**		3,013	3,874	2,619	**9,505**
80-84		1,503	11,731	1,599	**14,833**		546	5,240	3,111	**8,896**
Total		**146,822**	**86,762**	**33,249**	**266,833**		**205,858**	**85,240**	**75,363**	**366,461**
				% of Total Life Years Lived	**21.5%**				% of Total Life Years Lived	**31.1%**

- An alternate to calculating unhealthy alcohol consumption is to use the Canadian Centre on Substance Abuse (CCSA) low risk drinking guidelines, including both acute and chronic risk categories.[1493] The CCSA identifies a chronic risk when more than 10 (female) or 15 (male) drinks are consumed in one week or if an average in excess of 2 (female) or 3 (male) drinks are consumed per day. An acute risk (for injury, motor vehicle accident, etc.) presents itself when more than 3 (women) or 4 (men) drinks are consumed in a day.
- The CCHS asks a series of alcohol-related questions of respondents including drinking frequency, and whether alcohol was consumed in the past week or year. BC data also includes the number of drinks each day in the past week. Individual respondent data from the 2017/2018 cycle of the CCHS was weighted (using CCHS variable WTS_M) and categorized into three mutually exclusive unhealthy alcohol use categories: acute risk only, chronic risk only, and both acute and chronic risk.[1494]
- Individuals were classified in the acute risk only category if they reported drinking in excess of 3 (women) or 4 (men) drinks in one day in the past week or if they reported drinking in excess of 3 (women) or 4 (men) drinks once a month or more in the previous 12 months, but did not meet the criteria for chronic risk.
- Individuals were classified in the chronic risk only category if the number of drinks they reported consuming in the past week was greater than 10 (women) or 15 (men), but they did not meet the criteria for acute risk.
- Individuals were classified in the acute and chronic risk category if they met the criteria for both.
- Using this alternative approach in a BC birth cohort of 40,000, an estimated 22.7% of life years lived between the ages of 18 and 84 (548,601 of 2,419,325) are lived with unhealthy alcohol use. The proportion is lower for females (18.1% or 224,668 of 1,242,083) than for males (27.5% or 323,933 of 1,177,243) (see Table 3). ***Note that these proportions are not adjusted for underreporting of alcohol consumption.***

[1493] Butt P, Beirness D, Gliksman L et al. *Alcohol and health in Canada: A summary of evidence and guidelines for low risk drinking*. 2011. Ottawa, ON: Canadian Centre on Substance Abuse.

[1494] This analysis is based on the Statistics Canada's Canadian Community Health 2017/18 Public Use Microdata File. All computations, use and interpretation of these data are entirely that of H. Krueger & Associates Inc.

Table 3: Years of Life Lived with Unhealthy Alcohol Use

Between the Ages of 18 and 84

in a British Columbia Birth Cohort of 40,000

Age Group	*% of BC **Female** Pop by Alcohol Use Status*					*% of BC **Male** Pop by Alcohol Use Status*				
	Low Risk	Acute Risk Only	Chronic Risk Only	Acute & Chronic	Total	Low Risk	Acute Risk Only	Chronic Risk Only	Acute & Chronic	Total
18-19	81.3%	14.6%	0.0%	4.1%		77.8%	18.7%	0.0%	3.4%	
20-24	72.5%	22.5%	0.0%	5.1%		67.8%	25.7%	0.0%	6.5%	
25-29	63.4%	29.3%	0.0%	7.3%		55.9%	34.6%	0.0%	9.5%	
30-34	76.4%	15.7%	0.0%	7.9%		53.8%	37.8%	0.0%	8.4%	
35-39	77.9%	15.6%	0.1%	6.4%		67.1%	22.1%	0.0%	10.8%	
40-44	84.3%	11.5%	0.1%	4.1%		73.5%	17.5%	0.2%	8.8%	
45-49	82.3%	13.0%	0.4%	4.2%		72.4%	18.9%	0.9%	7.9%	
50-54	78.9%	16.2%	1.5%	3.5%		75.0%	16.4%	1.6%	7.1%	
55-59	85.2%	10.5%	0.8%	3.5%		70.7%	17.9%	1.6%	9.9%	
60-64	83.1%	11.5%	2.2%	3.3%		77.2%	15.8%	0.9%	6.1%	
65-69	88.0%	5.1%	4.6%	2.4%		81.3%	9.7%	1.5%	7.4%	
70-74	91.2%	2.5%	3.3%	3.0%		82.2%	9.6%	3.8%	4.4%	
75-79	92.9%	1.6%	3.8%	1.7%		87.7%	6.0%	2.5%	3.8%	
80-84	98.0%	0.3%	1.5%	0.2%		93.7%	3.5%	2.3%	0.5%	
18-19		5,814	-	1,614	**7,428**		7,439	-	1,366	**8,806**
20-24		22,335	-	5,018	**27,353**		25,430	-	6,459	**31,889**
25-29		29,038	-	7,216	**36,255**		34,088	-	9,345	**43,433**
30-34		15,566	-	7,782	**23,349**		36,933	25	8,165	**45,124**
35-39		15,351	74	6,298	**21,723**		21,467	-	10,425	**31,891**
40-44		11,315	108	3,986	**15,409**		16,792	160	8,476	**25,429**
45-49		12,719	370	4,119	**17,208**		17,902	860	7,457	**26,219**
50-54		15,638	1,431	3,347	**20,416**		15,262	1,450	6,617	**23,329**
55-59		10,041	738	3,383	**14,161**		16,273	1,454	8,974	**26,701**
60-64		10,731	2,055	3,062	**15,848**		13,904	816	5,351	**20,071**
65-69		4,632	4,157	2,137	**10,926**		8,133	1,293	6,189	**15,615**
70-74		2,154	2,874	2,563	**7,591**		7,365	2,958	3,373	**13,696**
75-79		1,268	3,027	1,364	**5,659**		4,032	1,695	2,594	**8,321**
80-84		176	1,047	119	**1,342**		1,900	1,226	283	**3,409**
Total		**156,780**	**15,881**	**52,008**	**224,668**		**226,922**	**11,937**	**85,074**	**323,933**
		% of Total Life Years Lived			**18.1%**		% of Total Life Years Lived			**27.5%**

- While the majority of women of child-bearing age consume some level of alcohol, most appear to refrain from using alcohol while pregnant.
- An analysis of the 2005/06 Maternity Experience Survey suggests that 10.8% of Canadian women drank alcohol at some point during their pregnancies. Prevalence of drinking alcohol during pregnancy was 13.8% in Eastern-Central provinces, 7.8% in Western Provinces-British Columbia, 4.1% in Eastern-Atlantic provinces and 4.0% in Western-Prairie Provinces.[1495]
- Based on ***2007/8*** CCHS *self-reported data*, an estimated 7.2% of pregnant women in B.C. reported consuming alcohol while pregnant.[1496] According to the ***2017/18*** CCHS, 3.0% of women who became pregnant in the last five years reported consuming alcohol after becoming aware that they were pregnant.[1497]
- The prevalence of any alcohol use during pregnancy in Canada is estimated at 10.0% (95% CI of 5.2% to 16.2%). This is substantially lower than many others countries, including the US (14.8%), Australia (35.6%) and the UK (41.3%).[1498]
- Using self-report data such as the CCHS likely represents an underestimate of a 'negative' behaviour, such as alcohol consumption during pregnancy. When responding to surveys, individuals tend to underestimate their actual alcohol consumption,[1499] particularly those who consume a higher volume of drinks.[1500] Furthermore, the CCHS excludes women who live in group shelters or on the streets and who are at a higher risk of consuming alcohol during pregnancy than the general population, thus underestimating overall prevalence.[1501,1502]
- This underestimate of self-reported alcohol consumption in pregnant women is supported by the research of Ethan and colleagues.[1503] Based on eight telephone interviews spread over a 12-month period (from three months prior to conception to delivery), they found that 30.3% of women in their US-based study drank any alcohol during pregnancy and that 8.3% binge drank during pregnancy. This compares to other US surveys completed during the same time period (1997 – 2002) that enquired about alcohol consumption during the month prior to the interview which found that

[1495] Walker MJ, Al-Sahab B, Islam F et al. The epidemiology of alcohol utilization during pregnancy: an analysis of the Canadian Maternity Experiences Survey (MES). *BMC Pregnancy and Childbirth*. 2011; 11(1): 52.
[1496] Thanh NX and Jonsson E. Drinking alcohol during pregnancy: evidence from Canadian Community Health Survey 2007/2008. *Canadian Journal of Clinical Pharmacology*. 2010; 17(2): e302-7.
[1497] This analysis is based on the Statistics Canada's Canadian Community Health Survey 2017/18 Public Use Microdata File. All computations, use and interpretation is entirely that of H. Krueger & Associates Inc.
[1498] Popova S, Lange S, Probst C et al. Estimation of national, regional, and global prevalence of alcohol use during pregnancy and fetal alcohol syndrome: A systematic review and meta-analysis. *The Lancet*. 2017; 5: e290-9.
[1499] Stockwell T, Donath S, Cooper-Stanbury M et al. Under-reporting of alcohol consumption in household surveys: a comparison of quantity-frequency, graduated-frequency and recent recall. *Addiction*. 2004; 99(8): 1024-33.
[1500] Taylor B, Rehm J, Patra J et al. Alcohol-attributable morbidity and resulting health care costs in Canada in 2002: recommendations for policy and prevention. *Journal of Studies on Alcohol and Drugs*. 2007; 68(1): 36-47.
[1501] Thanh NX and Jonsson E. Drinking alcohol during pregnancy: evidence from Canadian Community Health Survey 2007/2008. *Canadian Journal of Clinical Pharmacology*. 2010; 17(2): e302-7
[1502] Public Health Agency of Canada. *Alcohol Use and Pregnancy: An Important Canadian Public Health and Social Issue*. 2005. Available at http://www.addictionresearchchair.ca/wp-content/uploads/Alcohol-Use-and-Pregnancy-An-Important-Canadian-Health-and-Social-Issue.pdf. Accessed April 2020.
[1503] Ethen MK, Ramadhani TA, Scheuerle AE et al. Alcohol consumption by women before and during pregnancy. *Maternal and Child Health Journal*. 2009; 13(2): 274-85.

between 9.8% and 10.1% of women drank any alcohol during pregnancy and that between 1.9% and 4.1% binge drank during pregnancy.

- Alvik et al. used a longitudinal approach to ask about alcohol consumption at 17 and 30 weeks of pregnancy and 6 months after term.[1504] They found that concurrently reported alcohol consumption during pregnancy is just under half that retrospectively reported 6 months after term. That is, once the baby was six months old, women admitted to consuming almost twice as much alcohol during their pregnancy than they admitted to while pregnant. "A possible explanation is that the birth of a presumably healthy child may have diminished the feelings of anxiety and guilt caused by alcohol use during pregnancy."
- A recent Canadian study using an analysis based on meconium fatty acid ethyl esters (FAEE) found heavy fetal alcohol exposure (more than 2 standard drinks per week during pregnancy) in 1.16% to 2.40% of newborns. Based on self-reported alcohol consumption, only 0.24% of the women reported more than 2 standard drinks per week during pregnancy. That is, the analysis based on meconium FAEE found that heavy fetal alcohol exposure was 10 times that estimated by self-report.[1505]

- For modelling purposes, we have assumed that the 2017/18 CCHS finding that 3.0% of BC women consume alcohol after becoming aware that they were pregnant is under-reported by a factor of 3. We therefore assume that 9.0% of pregnant women in BC consume some alcohol, and reduce this to 3.0% in the sensitivity analysis.

Prevalence of FASD / FAS

- "Alcohol consumed by a pregnant woman interferes with normal developmental progression of the fetus resulting in CNS and physical damage that subsequently has several lifelong health consequences. This damage leads to fetal alcohol spectrum disorder (FASD; an umbrella term used to describe individuals who experience disability as a result of prenatal alcohol exposure). FASD includes fetal alcohol syndrome (FAS), partial FAS, and alcohol-related neurodevelopmental disorder."[1506]
- 428 comorbid conditions co-occurring in individuals with FASD, the most common of which are abnormal results of function studies of peripheral nervous system and special senses, conduct disorder, receptive language disorder, chronic serous otitis media and expressive language disorder.[1507]
- Globally, the prevalence of FASD in children and youth is estimated at 7.7 per 1,000 population (or 0.77%), ranging to as high as 111.1 per 1,000 in South Africa. The estimated rate for Canada is 7.9 per 1,000 (95% CI of 2.8 to 14.5).[1508]
- An estimated one of every 13 pregnant women who consumed alcohol during pregnancy delivered a child with FASD.[1509]

[1504] Alvik A, Haldorsen T, Groholt B et al. Alcohol consumption before and during pregnancy comparing concurrent and retrospective reports. *Alcoholism: Clinical and Experimental Research*. 2006; 30(3): 510-5.
[1505] Delano K, Koren G, Zack M et al. Prevalence of fetal alcohol exposure by analysis of meconium fatty acid ethyl esters: A national Canadian study. *Scientific Reports*. 2019; 9.
[1506] Popova S, Lange S, Shield K et al. Comorbidity of fetal alcohol spectrum disorder: A systematic review and meta-analysis. *The Lancet*. 2016.
[1507] Popova S, Lange S, Shield K et al. Comorbidity of fetal alcohol spectrum disorder: A systematic review and meta-analysis. *The Lancet*. 2016.
[1508] Lange S, Probst C, Gmel G et al. Global prevalence of fetal alcohol spectrum disorder among children and youth: A systematic review and meta-analysis. *JAMA Pediatrics*. 2017: 171(10): 948-56.
[1509] Ibid.

- Globally, the prevalence of FAS, the most severe and visibly identifiable form of FASD, in the general population is 14.6 per 10,000 population (or 0.146%). The prevalence of FAS in Canada is estimated at 10.5 per 10,000 (95% CI of 0.0 to 34.9).[1510]
- An estimated one out of every 67 women who consume alcohol during pregnancy will deliver a child with FAS.[1511]
- Rates of FASD tend to be 10 – 40 times higher in specific subpopulations, such as children in care, correctional institutions, special education, specialized clinical and Aboriginal population compared with the general population.[1512]
- In a recent **population-based study using active case ascertainment** of students ages 7 – 9 years of age in the Greater Toronto school system, Popova and colleagues found a prevalence of FASD of between 18.1 and 29.3 per 1,000 (or 1.81% to 2.93%). This is approximately two to three times higher than their previous crude estimates for Canada.[1513]
- To estimate the prevalence of FASD and FAS in the birth cohort, we first need to estimate the number of potential births in the cohort. Based on population and birth data from 2013 to 2015 in BC, we calculated the fertility rate per 1,000 females by age cohort (see Table 4).
- The calculated fertility rate from Table 4 was used to estimate that there would be approximately 27,034 births in a BC birth cohort of 20,000 females (see Table 5).
- The number of births in the birth cohort were multiplied by 1.81% and 2.93%[1514] to estimate the number of children born with FASD, with the 1.81% used in our base model and the 2.93% used in the sensitivity analysis. The results in Table 5 suggest 489 of the 27,034 (1.81%) births would have FASD.
- Globally, the prevalence of FASD in children and youth is estimated at 0.77%[1515] while the prevalence of FAS is estimated at 0.146%,[1516] suggesting that approximately 19.0% of children born with FASD have the more severe FAS (0.77% / 0.146%). The results in Table 5 suggest that 93 of the 489 births with FASD would have FAS.

- For modelling purposes, we assumed that 1.81% (Table 14, row *af*) of births in the birth cohort would have FASD (and ranged this to 2.93% in the sensitivity analysis), with 19% of births with FASD having the more severe FAS (Table 14, row *ag*).

[1510] Popova S, Lange S, Probst C et al. Estimation of national, regional, and global prevalence of alcohol use during pregnancy and fetal alcohol syndrome: A systematic review and meta-analysis. *The Lancet*. 2017; 5: e290-9.
[1511] Ibid.
[1512] Popova S, Lange S, Shield K et al. Prevalence of fetal alcohol spectrum disorder among special populations: A systematic review and meta-analysis. *Addiction*. 2019; 114: 1150-72.
[1513] Popova S, Lange S, Poznyak V et al. Population-based prevalence of fetal alcohol spectrum disorder in Canada. *BMC Public Health*. 2019.
[1514] Ibid.
[1515] Lange S, Probst C, Gmel G et al. Global prevalence of fetal alcohol spectrum disorder among children and youth: A systematic review and meta-analysis. *JAMA Pediatrics*. 2017: 171(10): 948-56.
[1516] Popova S, Lange S, Probst C et al. Estimation of national, regional, and global prevalence of alcohol use during pregnancy and fetal alcohol syndrome: A systematic review and meta-analysis. *The Lancet*. 2017; 5: e290-9.

Table 4: Number of Births and Fertility Rates of Women Aged 15-49

British Columbia, 2013 to 2015

Year	15-19	20-24	25-29	30-34	35-39	40-44	45-49	Total
				Number of Women*				
2013	131,378	152,798	159,870	158,541	150,258	165,004	173,233	1,091,082
2014	130,517	153,991	162,005	163,346	152,477	163,392	172,241	1,097,969
2015	130,179	152,108	163,734	166,612	155,270	161,338	173,302	1,102,543
Mean	**130,691**	**152,966**	**161,870**	**162,833**	**152,668**	**163,245**	**172,925**	**1,097,198**
				Fertility Rate per 1,000				
2013	7.6	30.8	73.5	98.6	56.7	11.9	0.8	10.3
2014	6.8	29.6	72.2	100.0	57.2	11.7	0.8	11.1
2015	6.2	28.8	69.3	100.0	57.3	12.3	0.8	10.9
Mean	**6.8**	**29.7**	**71.6**	**99.5**	**57.1**	**12.0**	**0.8**	**40.1**
				Annual # of Live Births				
2013**	993	4,711	11,747	15,628	8,515	1,966	130	43,690
2014***	889	4,553	11,702	16,336	8,725	1,915	141	44,261
2015****	802	4,385	11,339	16,654	8,894	1,984	137	44,195
Mean	**895**	**4,550**	**11,596**	**16,206**	**8,711**	**1,955**	**136**	**44,049**

*BC Stats. Population Estimates 2019. Available at https://bcstats.shinyapps.io/popApp/. Accessed April 2020.

** BC Vital Statistics Agency. *Annual Report 2013* - Table 3. Available online athttps://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2013/pdf/annual-report-2013.pdf. Accessed April 2020.

*** BC Vital Statistics Agency. *Annual Report 2014* - Table 3. Available online at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2014/pdf/annual-report-2014.pdf. Accessed April 2020.

**** BC Vital Statistics Agency. *Annual Report 2015* - Table 3. Available online at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2015/pdf/annual-report-2015.pdf. Accessed April 2020.

Table 5: Expected Live Births and Births with FASD/FAS

in the Birth Cohort of 40,000

Age Group	# of Life Years Lived Females	Fertility Rate / 1,000	Expected Births	Expected Births with FASD 1.81%	Expected Births with FASD 2.93%	Expected Births with FAS	Expected Births with FAS
18-19	39,776	6.85	272	4.9	8.0	0.9	1.5
20-24	99,314	29.74	2,954	53.5	86.5	10.1	16.4
25-29	99,101	71.64	7,099	128.5	208.0	24.4	39.4
30-34	98,834	99.53	9,837	178.0	288.2	33.8	54.6
35-39	98,499	57.06	5,620	101.7	164.7	19.3	31.2
40-44	98,068	11.98	1,174	21.3	34.4	4.0	6.5
45-49	97,478	0.79	77	1.4	2.2	0.3	0.4
Total	**631,069**		**27,034**	**489**	**792**	**93**	**150**

- Alcohol misuse results in life years lost due to both chronic and acute (binge drinking) conditions. Solberg and colleagues estimated that life years lost due to acute conditions are 2.14 times that of chronic conditions.[1517]
- Stahre et al. reported similar results. Between 2006 and 2010, 33% of the years of potential life lost were due to chronic conditions while 67% were due to acute conditions. In terms of deaths, 44% of alcohol attributable deaths are due to chronic conditions while 56% are due to acute conditions.[1518]
- The Global Burden of Disease 2016 Alcohol Collaborators released a systematic analysis of alcohol use and burden in 195 countries, including Canada. The proportion of deaths attributable to alcohol use by age and sex are shown in Table 6.[1519]

Table 6: Proportion of Deaths Attributable to Alcohol Use
By Age and Sex
Canada, 2016

Age Group	Females	Males
15-19	3.0%	5.9%
20-24	5.0%	12.0%
25-29	4.6%	11.0%
30-34	4.4%	9.8%
35-39	4.3%	8.8%
40-44	4.6%	8.5%
45-49	4.8%	8.1%
50-54	4.7%	7.6%
55-59	4.1%	6.4%
60-64	3.1%	4.9%
65-69	2.3%	3.6%
70-74	1.5%	2.4%
75-79	0.9%	1.4%
80-84	0.6%	0.8%

- Applying the proportions from Table 6 to the expected annual deaths by age and sex in the BC birth cohort of 40,000 results in an estimated 11,814 life years lost (3,016 in females [Table 14, row *o*] and 8,798 in males [Table 14, row *p*]) due to unhealthy alcohol use (see Table 7).

[1517] Solberg M, Maciosek M, Edwards N. Primary care interventions to reduce alcohol misuse: Ranking its health impact and cost-effectiveness. *American Journal of Preventive Medicine*. 2008; 34(2): 143-152.
[1518] Stahre M, Roeber J, Kanny D et al. Contribution of excessive alcohol consumption to deaths and years of potential life lost in the United States. *Preventing Chronic Disease*. 2014; 11.
[1519] GBD 2016 Alcohol Collaborators. Alcohol use and burden for 195 countries and territories, 1990–2016: A systematic analysis for the Global Burden of Disease Study 2016. *Lancet*. 2018; 392: 1015-35.

Table 7: Life Years Lost Resulting from Deaths Attributable to Alcohol Use

Between the Ages of 18 and 84

in a British Columbia Birth Cohort of 40,000

	Females				*Males*			
Age	Deaths in Birth Cohort	Proportion of Deaths Attributable to Alcohol Use	Life Expectancy	Life Years Lost Attributable to Alcohol Use	Deaths in Birth Cohort	Proportion of Deaths Attributable to Alcohol Use	Life Expectancy	Life Years Lost Attributable to Alcohol Use
18	6.2	3.0%	67.4	12.5	11.4	5.9%	62.4	42.0
19	6.6	3.0%	66.4	13.1	13.6	5.9%	61.4	49.3
20	7.0	5.0%	65.4	22.9	16.0	12.0%	60.5	116.1
21	7.4	5.0%	64.4	23.8	18.2	12.0%	59.5	130.0
22	7.6	5.0%	63.5	24.1	20.2	12.0%	58.6	142.0
23	8.0	5.0%	62.5	25.0	22.0	12.0%	57.7	152.2
24	8.4	5.0%	61.5	25.8	23.2	12.0%	56.7	157.9
25	8.6	4.6%	60.5	23.9	24.2	11.0%	55.8	148.5
26	9.0	4.6%	59.6	24.7	25.2	11.0%	54.8	152.0
27	9.4	4.6%	58.6	25.3	26.0	11.0%	53.9	154.2
28	9.8	4.6%	57.6	26.0	26.8	11.0%	53.0	156.2
29	10.4	4.6%	56.6	27.1	27.6	11.0%	52.1	158.0
30	10.8	4.4%	55.7	26.4	28.2	9.8%	51.1	141.3
31	11.4	4.4%	54.7	27.4	28.8	9.8%	50.2	141.7
32	12.0	4.4%	53.7	28.4	29.4	9.8%	49.3	142.0
33	12.6	4.4%	52.8	29.3	30.2	9.8%	48.4	143.1
34	13.2	4.4%	51.8	30.1	31.0	9.8%	47.4	144.1
35	13.6	4.3%	50.8	29.7	32.0	8.8%	46.5	130.9
36	14.2	4.3%	49.9	30.4	33.0	8.8%	45.6	132.3
37	14.8	4.3%	48.9	31.1	34.2	8.8%	44.7	134.4
38	15.6	4.3%	47.9	32.2	35.4	8.8%	43.7	136.2
39	16.4	4.3%	47.0	33.1	36.8	8.8%	42.8	138.6
40	17.6	4.6%	46.0	37.2	38.2	8.5%	41.9	136.0
41	18.6	4.6%	45.1	38.5	39.6	8.5%	41.0	137.9
42	19.8	4.6%	44.1	40.2	41.4	8.5%	40.1	140.9
43	21.2	4.6%	43.1	42.1	43.4	8.5%	39.1	144.4
44	22.6	4.6%	42.2	43.9	45.4	8.5%	38.2	147.5
45	24.2	4.8%	41.2	47.9	47.8	8.1%	37.3	144.5
46	25.8	4.8%	40.3	49.9	50.4	8.1%	36.4	148.6
47	27.6	4.8%	39.3	52.1	53.2	8.1%	35.5	153.0
48	29.6	4.8%	38.4	54.5	56.4	8.1%	34.6	158.1
49	31.8	4.8%	37.4	57.1	60.0	8.1%	33.7	163.8
50	34.0	4.7%	36.5	58.3	63.8	7.6%	32.8	159.1
51	36.6	4.7%	35.6	61.2	68.0	7.6%	31.9	165.0
52	39.4	4.7%	34.6	64.1	72.6	7.6%	31.0	171.2
53	42.4	4.7%	33.7	67.2	77.6	7.6%	30.2	177.8
54	45.8	4.7%	32.8	70.6	83.0	7.6%	29.3	184.6
55	49.4	4.1%	31.9	64.5	89.0	6.4%	28.4	161.8
56	53.6	4.1%	30.9	68.0	95.4	6.4%	27.5	168.1
57	58.0	4.1%	30.0	71.4	102.2	6.4%	26.7	174.5
58	62.8	4.1%	29.1	75.0	109.8	6.4%	25.8	181.5
59	68.2	4.1%	28.2	78.9	118.0	6.4%	25.0	188.6
60	74.2	3.1%	27.3	62.8	126.8	4.9%	24.1	150.0
61	80.6	3.1%	26.4	66.0	136.4	4.9%	23.3	155.8
62	87.8	3.1%	25.5	69.5	147.0	4.9%	22.5	162.0
63	95.8	3.1%	24.6	73.2	158.2	4.9%	21.7	168.0
64	104.6	3.1%	23.8	77.0	170.6	4.9%	20.9	174.4
65	114.2	2.3%	22.9	60.1	184.0	3.6%	20.1	132.9
66	125.0	2.3%	22.0	63.3	198.4	3.6%	19.3	137.7
67	136.8	2.3%	21.2	66.6	214.0	3.6%	18.5	142.5
68	149.8	2.3%	20.3	70.1	231.0	3.6%	17.7	147.4
69	164.2	2.3%	19.5	73.6	249.2	3.6%	17.0	152.2
70	180.2	1.5%	18.7	50.5	268.8	2.4%	16.2	104.7
71	197.6	1.5%	17.9	52.9	290.0	2.4%	15.5	107.8
72	217.0	1.5%	17.1	55.5	312.8	2.4%	14.8	110.9
73	238.2	1.5%	16.3	58.1	337.0	2.4%	14.1	113.8
74	261.6	1.5%	15.5	60.8	362.8	2.4%	13.4	116.4
75	287.0	0.9%	14.7	35.9	390.2	1.4%	12.7	69.3
76	315.0	0.9%	14.0	37.4	419.2	1.4%	12.0	70.6
77	345.6	0.9%	13.2	38.9	449.6	1.4%	11.4	71.6
78	378.8	0.9%	12.5	40.3	481.2	1.4%	10.8	72.4
79	414.6	0.9%	11.8	41.6	513.8	1.4%	10.1	72.9
80	453.0	0.6%	11.1	28.2	547.0	0.8%	9.5	43.8
81	494.2	0.6%	10.5	28.9	580.6	0.8%	9.0	43.6
82	537.8	0.6%	9.8	29.5	613.6	0.8%	8.4	43.2
83	583.4	0.6%	9.2	30.0	645.6	0.8%	7.9	42.6
84	630.6	0.6%	8.6	30.3	675.8	0.8%	7.3	41.6
Total				***3,016***				***8,798***

- The life expectancy at birth of people with FAS (in Alberta) is 34 years (95% CI, 31 – 37) or about 42% of that of the general population. The leading causes of death for people with FAS are "external causes" (44%), which include suicide (15%), accidents (14%) and poisoning by illegal drugs or alcohol (7%).[1520]
- A review of 55 deaths in individuals with FASD found that 54.5% (30 of 55) of the deaths occurred in the first year of life. The most common causes of death were due to malformations of the heart and brain.[1521]
- Life years lost attributable to any intellectual disability (ID) are higher for females than males. Research evidence suggests a range of 8.6 to 32.0 life years lost for females with ID and a range from 6.4 to 23.0 life years lost for males with ID.[1522,1523,1524,1525,1526,1527,1528]
- For modelling purposes, we assumed an average of 17.5 life years lost associated with all FASD but excluding FAS, calculated based on the mean of the midpoint for females and males with ID noted above; ((8.6 + 32.0)/2)+((6.4 + 23.0)/2)/2). FAS is associated with 48.2 life years lost (i.e., 82.2, the average life expectancy at birth in BC – 34.0, the average life expectancy at birth of people with FAS in Alberta).
- Based on the estimated 489 births with FASD (of whom 93 would have FAS) born to a BC birth cohort of 40,000 (see Table 5 and Table 14, rows *ah* and *ai*), we estimate that 11,411 life years would be lost, 4,472 in children born with FAS (Table 14, row *ak*) and 6,939 in all other children born with FASD (see Table 8 and Table 14, row *al*).

[1520] Thanh NX and Jonsson E. Life expectancy of people with fetal alcohol syndrome. *Journal of Population Therapeutics and Clinical Pharmacology*. 2016; 23(1):

[1521] Thompson A, Hackman D, Burd L. Mortality in fetal alcohol spectrum disorder. *Open Journal of Paediatrics*. 2014; 4: 21-33.

[1522] Heslop P, Blair P, Fleming P et al. The Confidential Inquiry into premature deaths of people with intellectual disabilities in the UK: A population-based study. *Lancet*. 2014; 383: 889-895.

[1523] McCarron M, Carroll R, Kelly C et al. Mortality rates in the general Irish population compared to those with an intellectual disability from 2003 to 2012. *Journal of Applied Research in Intellectual Disabilities*. 2015; 28: 406-413.

[1524] Lauer E & McCallion P. Mortality of people with intellectual and developmental disabilities from select US state disability service systems and medical claims data. *Journal of Applied Research in Intellectual Disabilities*. 2015; 28: 394-405.

[1525] Trollor J, Srasuebkul P, Xu H et al. Cause of death and potentially avoidable deaths in Australian adults with intellectual disability using retrospective linked data. *BMJ Open*. 2017; 7: e013489.

[1526] Ng N, Flygare Wallén E & Ahlström G. Mortality patterns and risk among older men and women with intellectual disability: a Swedish national retrospective cohort study. *BMC Geriatrics*. 2017; 17: 269-269.

[1527] Glover G, Williams R, Heslop P et al. Mortality in people with intellectual disabilities in England. *Journal of Intellectual Disability Research*. 2017; 61: 62-74.

[1528] Arvio M, Salokivi T & Bjelogrlic-Laakso N. Age at death in individuals with intellectual disabilities. *Journal of Applied Research in Intellectual Disabilities*. 2017; 30: 782-785.

Table 8: Life Years Lost Resulting from FASD

In Children Born to Women between the Ages of 18 and 49

In a BC Birth Cohort of 40,000

Age	Life Years for Females	Average Fertility Rate / 1,000	Expected Births	Births with FASD (1.81%)	Births with FAS (19.0% of FASD)	Life Years Lost FASD (excl FAS)	Life Years Lost FAS
18	19,891	6.85	136	2.5	0.5	35.0	22.5
19	19,885	6.85	136	2.5	0.5	34.9	22.5
20	19,878	29.74	591	10.7	2.0	151.8	97.8
21	19,871	29.74	591	10.7	2.0	151.7	97.8
22	19,863	29.74	591	10.7	2.0	151.7	97.7
23	19,855	29.74	591	10.7	2.0	151.6	97.7
24	19,847	29.74	590	10.7	2.0	151.5	97.6
25	19,839	71.64	1,421	25.7	4.9	364.8	235.1
26	19,830	71.64	1,421	25.7	4.9	364.6	235.0
27	19,821	71.64	1,420	25.7	4.9	364.5	234.9
28	19,811	71.64	1,419	25.7	4.9	364.3	234.8
29	19,801	71.64	1,418	25.7	4.9	364.1	234.6
30	19,790	99.53	1,970	35.7	6.8	505.6	325.8
31	19,779	99.53	1,969	35.6	6.8	505.3	325.6
32	19,767	99.53	1,967	35.6	6.8	505.0	325.4
33	19,755	99.53	1,966	35.6	6.7	504.7	325.2
34	19,742	99.53	1,965	35.6	6.7	504.4	325.0
35	19,729	57.06	1,126	20.4	3.9	289.0	186.2
36	19,715	57.06	1,125	20.4	3.9	288.8	186.1
37	19,700	57.06	1,124	20.3	3.9	288.6	186.0
38	19,685	57.06	1,123	20.3	3.9	288.3	185.8
39	19,669	57.06	1,122	20.3	3.9	288.1	185.7
40	19,652	11.98	235	4.3	0.8	60.4	38.9
41	19,634	11.98	235	4.3	0.8	60.4	38.9
42	19,615	11.98	235	4.3	0.8	60.3	38.9
43	19,594	11.98	235	4.2	0.8	60.2	38.8
44	19,572	11.98	234	4.2	0.8	60.2	38.8
45	19,549	0.79	15	0.3	0.1	3.9	2.5
46	19,524	0.79	15	0.3	0.1	3.9	2.5
47	19,497	0.79	15	0.3	0.1	3.9	2.5
48	19,469	0.79	15	0.3	0.1	3.9	2.5
49	19,438	0.79	15	0.3	0.1	3.9	2.5
Total			**27,034**	**489**	**93**	**6,939**	**4,472**

- Based on using the time trade-off (TTO) and standard gamble (SG) approaches to assessing QoL with 200 adults, Kraemer and colleagues found that at-risk drinking,[1529] alcohol abuse[1530] and alcohol dependence[1531] were associated with a reduction in quality of life of 13.4% (TTO)/11.8% (SG), 25.8% (TTO)/19.4% (SG) and 44.3% (TTO)/28.0% (SG), respectively.[1532]
- Based on feedback from 300 adults in Spain, researchers estimated changes in QoL using the four dimensions of family, physical health, psychological and social consequences associated with unhealthy alcohol use. For example, "moderate family problems such as frequent arguments, distrust, verbal abuse, and/or cohabitation problems" but no physical health, psychological and social consequences was associated with a reduction in QoL of 14.4%. "Moderate family problems such as frequent arguments, distrust, verbal abuse, and/or cohabitation problems" together with "moderate health problems such as falls and/or liver inflammation", "moderate psychological problems such as guilt or shame, low self-esteem, minor depression, and/or memory problems" and "moderate social problems such as difficulty relating to other persons and/or loss of interest in hobbies" was associated with a reduction in QoL of 37.0%.[1533]
- The GBD study found that a very mild alcohol use disorder[1534] is associated with a *disutility* of 0.123 (95% CI of 0.082 to 0.177), a mild alcohol use disorder[1535] is associated with a *disutility* of 0.235 (95% CI of 0.160 to 0.327), a moderate alcohol use disorder[1536] is associated with a disutility of 0.373 (95% CI of 0.248 to 0.508) and

[1529] **At-risk drinker** – "Imagine that you drink alcohol. Although you don't drink very often at home, when you go out with your friends, you have about 5 or 6 drinks. Usually you drink on weekend nights, but in the summer you drink about 3 times per week. Drinking has never harmed your health, mood, social life or family life. You have taken a few chances that you would not take if you were sober, such as getting rides home from friends who have been drinking. You haven't missed any work, although you are less productive at work the days after you have been drinking."

[1530] **Alcohol abuse** – "Imagine that you drink alcohol. Your friend thinks you drink too much and the two of you argue about your drinking frequently. Sometimes you have driven drunk, and several times you have been late for work the morning after you've been drinking. Sometimes after drinking you feel a burning in your stomach that lasts for days. You continue to drink even though you think alcohol might be causing some problems for you."

[1531] **Alcohol dependence** – "Imagine you drink alcohol. You need to drink to get rid of the shakes, to calm your nerves, and to get any sleep. You need to drink a lot just to feel the effects. Even though you know alcohol is hurting you, you can't seem to stop. You miss important family events because of your drinking. Your doctor has told you that drinking has damaged your liver. Several times in the past year drinking has caused indigestion, upper stomach pain, nausea, and vomiting."

[1532] Kraemer K, Roberts M, Horton N et al. Health utility ratings for a spectrum of alcohol-related health states. *Medical Care*. 2005; 43(6): 541-50.

[1533] Rodriguez-Miguez E and Nogueira J. Measuring the impact of alcohol-related disorders on quality of life through general population preferences. *Gaceta Sanitaria*. 2017; 31(2): 89-94.

[1534] **Very mild alcohol use disorder** – "Drinks alcohol daily and has difficulty controlling the urge to drink. When sober, the person functions normally."

[1535] **Mild alcohol use disorder** – "Drinks a lot of alcohol and sometimes has difficulty controlling the urge to drink. While intoxicated, the person has difficulty performing daily activities."

[1536] **Moderate alcohol use disorder** – "Drinks a lot, gets drunk almost every week and has great difficulty controlling the urge to drink. Drinking and recovering cause great difficulty in daily activities, sleep loss and fatigue."

a severe alcohol use disorder[1537] is associated with a disutility of 0.570 (95% CI of 0.396 to 0.732).[1538]

- While the goal for most alcohol use disorder treatment programs may be abstinence, numerous studies have indicated a significant improvement in health and quality of life of a reduction in alcohol consumption that may not achieve abstinence (e.g. moving from the harmful to the hazardous or low drinking categories or from the hazardous to the low drinking category).[1539,1540]
- Binge drinking (BD) is associated with a reduced quality of life. Using a recently developed and validated scale specifically exploring alcohol-related quality of life (the Alcohol Quality of Life Scale or AQoLS), Dormal et al assessed the QoL of 15,020 European students (mean age of 21.9 years). They found that the presence of BD was positively associated with a reduced QoL, regardless of the intensity of the BD experiences.[1541]
- For modelling purposes, we have assumed the following QoL reductions:
    - **Binge drinking** - equivalent to the GBD very mild alcohol use disorder (0.123 with a 95% CI of 0.082 to 0.177). (Table 14, row *q*)
    - **Hazardous** consumption - equivalent to the midpoint between the GBD very mild and mild alcohol use disorder (0.179 with a 95% CI of 0.121 to 0.252). (Table 14, row *r*)
    - **Harmful** consumption - equivalent to the midpoint between the GBD mild and moderate alcohol use disorder (0.304 with a 95% CI of 0.204 to 0.418). (Table 14, row *s*)
- Table 9 provides information on the estimated number of life years lived with low-binge, hazardous or harmful alcohol use in the BC birth cohort of 40,000, for both females and males. In total, unhealthy alcohol use is associated with 126,584 QALYs lost, with 51,996 QALYs lost in females (Table 14, row *w*) and 74,587 QALYs lost in males (Table 14, row *aa*).

[1537] **Severe alcohol use disorder** – "Gets drunk almost every day and is unable to control the urge to drink. Drinking and recovering replace most daily activities. The person has difficulty thinking, remembering and communicating, and feels constant pain and fatigue."

[1538] Institute for Health Metrics and Evaluation. *GBD 2016 sequelae, health states, health state lay descriptions, and disability weights*. Available online at http://ghdx.healthdata.org/record/global-burden-disease-study-2016-gbd-2016-disability-weights. Accessed April 2020.

[1539] Witkiewitz K, Roos C, Pearson M et al. How much is too much? Patterns of drinking during alcohol treatment and associations with post-treatment outcomes across three alcohol clinical trials. *Journal of Studies on Alcohol and Drugs*. 2017; 78: 59-69.

[1540] Witkiewitz K, Kranzler H, Hallgren K et al. Drinking risk level reductions associated with improvements in physical health and quality of life among individuals with alcohol use disorder. *Alcoholism: Clinical and Experimental Research*. 2018; 42(12): 2453-65.

[1541] Dormal V, Bremhorst V, Lannoy S et al. Binge drinking is associated with reduced quality of life in young students: A pan-European study. *Drug and Alcohol Dependence*. 2018; 193: 48-54.

Table 9: Quality Adjusted Life Years Lost Living with Unhealthy Alcohol Use

Between the Ages of 18 and 84

In a British Columbia Birth Cohort of 40,000

	Female								*Male*							
	Total Life	**Life Years by Unhealthy Alcohol Use**			**QALYs Lost Due to Unhealthy Alcohol Use**				**Total Life**	**Life Years by Unhealthy Alcohol Use**			**QALYs Lost Due to Unhealthy Alcohol Use**			
Age	**Years**	Low-Binge	Hazardous	Harmful	Low-Binge	Hazardous	Harmful	**Total**	**Years**	Low-Binge	Hazardous	Harmful	Low-Binge	Hazardous	Harmful	**Total**
18	19,891	5,198	1,010	753	700	198	250	1,148	19,870	6,063	1,391	1,448	816	273	482	1,570
19	19,885	5,197	1,010	753	699	198	250	1,147	19,858	6,059	1,391	1,448	815	272	481	1,569
20	19,878	5,195	1,009	753	699	198	250	1,147	19,843	6,054	1,390	1,446	815	272	481	1,568
21	19,871	5,193	1,009	752	699	198	250	1,147	19,826	6,049	1,388	1,445	814	272	481	1,567
22	19,863	5,191	1,009	752	699	198	250	1,146	19,807	6,043	1,387	1,444	813	272	480	1,565
23	19,855	5,189	1,008	752	698	197	250	1,146	19,786	6,037	1,386	1,442	812	271	480	1,563
24	19,847	5,187	1,008	751	698	197	250	1,145	19,763	6,030	1,384	1,441	811	271	479	1,562
25	19,839	5,185	1,007	751	698	197	250	1,145	19,739	6,023	1,382	1,439	811	271	479	1,560
26	19,830	5,182	1,007	751	697	197	250	1,144	19,714	6,015	1,381	1,437	809	270	478	1,558
27	19,821	5,180	1,006	750	697	197	250	1,144	19,689	6,007	1,379	1,435	808	270	477	1,556
28	19,811	5,178	1,006	750	697	197	249	1,143	19,662	5,999	1,377	1,433	807	270	477	1,554
29	19,801	5,175	1,005	750	696	197	249	1,143	19,635	5,991	1,375	1,431	806	269	476	1,552
30	19,790	2,566	939	587	355	189	201	744	19,607	4,200	1,605	1,545	580	323	528	1,431
31	19,779	2,564	939	587	354	189	200	744	19,579	4,194	1,603	1,543	580	322	527	1,429
32	19,767	2,563	938	587	354	189	200	743	19,550	4,188	1,600	1,540	579	322	526	1,427
33	19,755	2,561	938	586	354	189	200	743	19,520	4,181	1,598	1,538	578	321	525	1,425
34	19,742	2,560	937	586	354	188	200	742	19,489	4,175	1,595	1,535	577	321	524	1,422
35	19,729	2,558	936	585	354	188	200	742	19,458	4,168	1,593	1,533	576	320	524	1,420
36	19,715	2,556	936	585	353	188	200	741	19,425	4,161	1,590	1,530	575	320	523	1,418
37	19,700	2,554	935	585	353	188	200	741	19,392	4,154	1,587	1,528	574	319	522	1,415
38	19,685	2,552	934	584	353	188	200	740	19,357	4,146	1,585	1,525	573	319	521	1,413
39	19,669	2,550	933	584	352	188	199	740	19,321	4,139	1,582	1,522	572	318	520	1,410
40	19,652	2,548	933	583	367	195	208	770	19,283	4,131	1,578	1,519	595	331	541	1,467
41	19,634	2,546	932	583	367	195	207	769	19,245	4,122	1,575	1,516	594	330	540	1,464
42	19,615	2,543	931	582	366	195	207	769	19,204	4,114	1,572	1,513	592	329	539	1,461
43	19,594	2,540	930	581	366	195	207	768	19,162	4,105	1,569	1,510	591	329	537	1,457
44	19,572	2,538	929	581	365	195	207	767	19,117	4,095	1,565	1,506	590	328	536	1,454
45	19,549	2,269	1,163	446	327	244	159	729	19,071	3,156	1,272	1,160	455	267	413	1,134
46	19,524	2,266	1,162	445	326	244	159	728	19,022	3,148	1,269	1,157	453	266	412	1,131
47	19,497	2,263	1,160	445	326	243	158	727	18,970	3,140	1,265	1,154	452	265	411	1,128
48	19,469	2,259	1,159	444	325	243	158	726	18,915	3,131	1,262	1,151	451	264	410	1,125
49	19,438	2,256	1,157	443	325	242	158	725	18,857	3,121	1,258	1,147	450	264	408	1,122
50	19,405	2,252	1,155	443	338	252	164	754	18,795	3,111	1,254	1,144	467	274	424	1,164
51	19,370	2,248	1,153	442	337	252	164	753	18,729	3,100	1,249	1,140	465	273	423	1,160
52	19,332	2,243	1,150	441	337	251	163	751	18,659	3,088	1,244	1,135	463	272	421	1,156
53	19,291	2,239	1,148	440	336	251	163	750	18,583	3,076	1,239	1,131	461	271	419	1,151
54	19,247	2,234	1,145	439	335	250	163	748	18,503	3,062	1,234	1,126	459	269	417	1,146
55	19,199	2,228	1,143	438	334	249	162	746	18,417	3,048	1,228	1,121	457	268	415	1,141
56	19,148	2,222	1,139	437	333	249	162	744	18,325	3,033	1,222	1,115	455	267	413	1,135
57	19,092	2,216	1,136	436	332	248	161	742	18,226	3,017	1,216	1,109	452	265	411	1,129
58	19,032	2,209	1,133	434	331	247	161	739	18,120	2,999	1,209	1,103	450	264	409	1,122
59	18,966	2,201	1,129	433	330	246	160	737	18,006	2,980	1,201	1,096	447	262	406	1,115
60	18,895	752	1,390	375	116	311	143	570	17,884	1,878	1,322	987	289	296	375	961
61	18,817	749	1,384	374	115	310	142	568	17,752	1,864	1,312	980	287	294	373	954
62	18,733	745	1,378	372	115	309	142	565	17,610	1,849	1,302	972	285	292	370	946
63	18,641	742	1,371	370	114	307	141	562	17,458	1,833	1,291	963	282	289	367	938
64	18,541	738	1,364	368	114	306	140	559	17,293	1,816	1,279	954	280	286	363	929
65	18,432	733	1,356	366	113	304	139	556	17,116	1,797	1,265	944	277	283	359	919
66	18,312	729	1,347	364	112	302	138	552	16,925	1,777	1,251	934	274	280	355	909
67	18,181	723	1,337	361	111	300	137	548	16,719	1,755	1,236	923	270	277	351	898
68	18,038	718	1,327	358	110	297	136	544	16,496	1,732	1,220	910	267	273	346	886
69	17,881	711	1,315	355	110	295	135	539	16,256	1,707	1,202	897	263	269	341	873
70	17,709	408	1,933	384	66	457	154	678	15,997	714	919	621	116	217	249	583
71	17,520	404	1,913	380	66	452	152	670	15,718	702	902	610	114	213	245	572
72	17,313	399	1,890	375	65	447	151	662	15,416	688	885	598	112	209	240	561
73	17,085	394	1,865	370	64	441	149	654	15,092	674	867	586	110	205	235	550
74	16,835	388	1,838	365	63	435	147	644	14,742	658	846	572	107	200	230	537
75	16,561	382	1,808	359	62	428	144	634	14,365	641	825	557	104	195	224	523
76	16,260	375	1,775	352	61	420	142	622	13,960	623	802	542	101	190	218	508
77	15,929	367	1,739	345	60	411	139	610	13,526	604	777	525	98	184	211	493
78	15,567	359	1,700	337	58	402	135	596	13,061	583	750	507	95	177	204	476
79	15,171	350	1,656	329	57	392	132	580	12,563	561	721	488	91	171	196	458
80	14,737	323	2,523	344	57	648	150	855	12,033	121	1,163	691	21	299	301	621
81	14,263	313	2,442	333	55	627	145	828	11,469	116	1,109	658	20	285	287	592
82	13,747	302	2,354	321	53	604	140	798	10,872	109	1,051	624	19	270	272	561
83	13,186	289	2,258	308	51	580	134	765	10,242	103	990	588	18	254	256	529
84	12,579	276	2,154	294	49	553	128	730	9,582	96	926	550	17	238	240	495
Total	***1,242,083***	***146,820***	***86,762***	***33,249***	***20,734***	***19,275***	***11,987***	***51,996***	***1,177,243***	***205,859***	***85,240***	***75,363***	***29,220***	***18,263***	***27,105***	***74,587***

- FASD can have a significant impact on the day to day activities and quality of life of those living with the diagnosis.[1542] Stade et al. attempted to quantify this impact by receiving input from 126 Canadian children and adolescents with FASD. A high proportion (44.4%) of the children/adolescents participating were diagnosed with FAS. The mean health related quality of life for this group was 0.47 (95% CI of 0.42 – 0.52), compared to 0.93 (95% CI of 0.92 – 0.94) for the general Canadian population of children and adolescents. Children/adolescents with FAS demonstrated a lower mean QoL score (0.44, 95% CI of 0.37 - 0.52) than those with FASD (excluding FAS) (0.50, 95% CI of 0.44 - 0.57) although the difference was not statistically significant.[1543]
- The GBD study found that **mild fetal alcohol syndrome**[1544] is associated with a disutility of 0.016 (95% CI of 0.008 to 0.030), **moderate fetal alcohol syndrome**[1545] is associated with a disutility of 0.056 (95% CI of 0.035 to 0.083) and **severe fetal alcohol syndrome**[1546] is associated with a disutility of 0.179 (95% CI of 0.119 to 0.257).[1547]
- Lamsal and colleagues recently published a review of literature on the QoL in children with a variety of neurodevelopmental disorders.[1548] The study by Stade et al was the only one identified for FASD.[1549] The review found, however, that the QoL associated with attention deficit hyperactivity disorder was 0.79,[1550] autism spectrum disorder was 0.60[1551] and neurodevelopmental impairment ranged from 0.87 for a mild impairment, 0.80 for a moderate impairment and 0.63 for a severe impairment.
- For modelling purposes, we assume an absolute reduction in QoL of 0.43 (0.93 – 0.50) for those with FASD, excluding FAS, and an absolute reduction in QoL of 0.49 (0.93 – 0.44) for those with FAS. (Table 10)
- In total, 12,578 QALYs are lost due to a reduction in the QoL of living with FASD, 1,548 in those living with FAS (Table 14, row *am*) and 11,032 in those living with FASD, excluding FAS (see Table 10 and Table 14, row *an*).

[1542] Stade B, Beyene J, Buller K et al. Feeling different: the experience of living with fetal alcohol spectrum disorder. *Canadian Journal of Clinical Pharmacology*. 2011; 18(3): e475-85.
[1543] Stade BC, Stevens B, Ungar WJ et al. Health-related quality of life of Canadian children and youth prenatally exposed to alcohol. *Health and Quality of Life Outcomes*. 2006; 4: 81.
[1544] **Mild fetal alcohol syndrome** – "is a little slow in developing physically and mentally, which causes some difficulty in learning but no other difficulties in daily activities."
[1545] **Moderate fetal alcohol syndrome** – "is slow in developing physically and mentally, which causes some difficulty in daily activities."
[1546] **Severe fetal alcohol syndrome** – "is very slow in developing physically and mentally, which causes great difficulty in daily activities."
[1547] Institute for Health Metrics and Evaluation. *GBD 2016 sequelae, health states, health state lay descriptions, and disability weights*. Available online at http://ghdx.healthdata.org/record/global-burden-disease-study-2016-gbd-2016-disability-weights. Accessed April 2020.
[1548] Lamsal R, Finlay B, Whitehurst D et al. Generic preference-based health-related quality of life in children with neurodevelopmental disorders: A scoping review. *Developmental Medicine & Child Neurology*. 2020; 62: 169-177.
[1549] Stade BC, Stevens B, Ungar WJ et al. Health-related quality of life of Canadian children and youth prenatally exposed to alcohol. *Health and Quality of Life Outcomes*. 2006; 4: 81.
[1550] Based on a weighted average of identified studies.
[1551] Based on a weighted average of identified studies.

Table 10: Quality Adjusted Life Years Lost Resulting from FASD

In Children Born to Women between the Ages of 18 and 49

In a BC Birth Cohort of 40,000

Age	Life Years for Females	Births with FASD (1.81%)	Births with FAS (19.0% of FASD)	Life Expectency FASD (excl FAS)	Life Expectency FAS	Absolute QoL Decrement FASD (excl FAS)	Absolute QoL Decrement FASD (excl FAS)	QALYs Lost FASD (excl FAS)	QALYs Lost FAS
18	19,891	2.5	0.5	64.7	34.0	0.43	0.49	55.6	7.8
19	19,885	2.5	0.5	64.7	34.0	0.43	0.49	55.5	7.8
20	19,878	10.7	2.0	64.7	34.0	0.43	0.49	241.3	33.8
21	19,871	10.7	2.0	64.7	34.0	0.43	0.49	241.2	33.8
22	19,863	10.7	2.0	64.7	34.0	0.43	0.49	241.1	33.8
23	19,855	10.7	2.0	64.7	34.0	0.43	0.49	241.0	33.8
24	19,847	10.7	2.0	64.7	34.0	0.43	0.49	240.9	33.8
25	19,839	25.7	4.9	64.7	34.0	0.43	0.49	580.0	81.3
26	19,830	25.7	4.9	64.7	34.0	0.43	0.49	579.7	81.2
27	19,821	25.7	4.9	64.7	34.0	0.43	0.49	579.4	81.2
28	19,811	25.7	4.9	64.7	34.0	0.43	0.49	579.2	81.1
29	19,801	25.7	4.9	64.7	34.0	0.43	0.49	578.9	81.1
30	19,790	35.7	6.8	64.7	34.0	0.43	0.49	803.8	112.6
31	19,779	35.6	6.8	64.7	34.0	0.43	0.49	803.3	112.6
32	19,767	35.6	6.8	64.7	34.0	0.43	0.49	802.8	112.5
33	19,755	35.6	6.7	64.7	34.0	0.43	0.49	802.3	112.4
34	19,742	35.6	6.7	64.7	34.0	0.43	0.49	801.8	112.3
35	19,729	20.4	3.9	64.7	34.0	0.43	0.49	459.4	64.4
36	19,715	20.4	3.9	64.7	34.0	0.43	0.49	459.1	64.3
37	19,700	20.3	3.9	64.7	34.0	0.43	0.49	458.7	64.3
38	19,685	20.3	3.9	64.7	34.0	0.43	0.49	458.4	64.2
39	19,669	20.3	3.9	64.7	34.0	0.43	0.49	458.0	64.2
40	19,652	4.3	0.8	64.7	34.0	0.43	0.49	96.0	13.5
41	19,634	4.3	0.8	64.7	34.0	0.43	0.49	96.0	13.4
42	19,615	4.3	0.8	64.7	34.0	0.43	0.49	95.9	13.4
43	19,594	4.2	0.8	64.7	34.0	0.43	0.49	95.8	13.4
44	19,572	4.2	0.8	64.7	34.0	0.43	0.49	95.7	13.4
45	19,549	0.3	0.1	64.7	34.0	0.43	0.49	6.3	0.9
46	19,524	0.3	0.1	64.7	34.0	0.43	0.49	6.3	0.9
47	19,497	0.3	0.1	64.7	34.0	0.43	0.49	6.3	0.9
48	19,469	0.3	0.1	64.7	34.0	0.43	0.49	6.2	0.9
49	19,438	0.3	0.1	64.7	34.0	0.43	0.49	6.2	0.9
Total		**490**	**93**					**11,032**	**1,546**

Annual Visits to a General Practitioner

- The Canadian Community Health Survey includes questions related to access to primary care providers (PCP). Table 11 presents weighted data for BC in 2015/16[1552] on the proportion of those surveyed who had consulted with a general practitioner or family doctor in the last 12 months. On average, 67.2% of males have visited a PCP in the past 12 months, compared with 79.9% of females. The proportion also varies by age, with a higher proportion of the population seeing a PCP with increasing age.

Table 11: Consultations with General Practitioner or Family Doctor in Last 12 Months

British Columbia, by Sex and Age Group

Age Group	Female %	Male %	Total %
18 - 19	65.0%	53.0%	59.1%
20 - 24	66.0%	45.8%	54.8%
25 - 29	79.5%	52.4%	66.6%
30 - 34	81.7%	51.7%	67.0%
35 - 39	79.8%	63.1%	71.7%
40 - 44	76.4%	62.8%	69.9%
45 - 49	78.3%	68.5%	73.2%
50 - 54	81.5%	65.6%	73.4%
55 - 59	82.0%	72.8%	77.5%
60 - 64	80.9%	82.5%	81.6%
65 - 69	86.7%	84.7%	85.7%
70 - 74	84.8%	85.9%	85.3%
75 - 79	85.8%	90.4%	88.0%
80+	85.7%	86.7%	86.1%
	79.9%	67.2%	73.7%

Source: Canadian Community Health Survey 2015/16 Public Use Microdata File (PUMF). All data interpretation by H. Krueger & Associates Inc.

- We assume that all females who are pregnant consult with a primary care provider. That is, the consultation rate for pregnant women is assumed to be 100%.

Effectiveness of the Intervention - Screening

- The USPSTF determined that 1-item to 3-item screening instruments have the best accuracy for assessing unhealthy alcohol use in adults 18 years and older. This includes the abbreviated Alcohol Use Disorders Identification Test - Consumption (AUDIT-C) and the Single Alcohol Screening Question (SASQ). The AUDIT-C has 3 questions about frequency of alcohol use, typical amount of alcohol use, and occasions of heavy use, and takes 1 to 2 minutes to administer. The SASQ requires less than 1 minute to administer, asking "How many times in the past year have you

[1552] The question regarding consultations with care providers in the last 12 months was not included in the 2017/18 CCHS survey. The age- and sex-specific rates of individuals with a primary care provider were similar between the 2015/16 survey and the 2017/18 survey.

had 5 [for men] or 4 [for women and all adults older than 65 years] or more drinks in a day?"[1553]

- The SASQ had a sensitivity (true positives) range of 0.73 – 0.88 (95% CI, 0.65 – 0.89) and a specificity (true negatives) range of 0.74 – 1.00 (95% CI, 0.69 – 1.00), while other one or two question instruments generally showed a sensitivity of 0.70 or higher. [1554]
- The AUDIT-C had similar sensitivity, ranging from 0.73 – 0.97 (95% CI, 0.62 – 0.99) for females and 0.82 – 1.00 (95% CI, 0.75 – 1.00) for males, but a much wider range of specificity, ranging from 0.28 – 0.91 (95% CI, 0.21 – 0.93) and 0.34 – 0.89 (95% CI, 0.25 – 0.92) for females and males respectively. [1555]
- The BC Provincial Guideline for the Clinical Management of High-Risk Drinking and Alcohol Use Disorder endorses the SASQ for screening of adults for risky drinking.[1556]
- The Cut down, Annoyed, Guilty, Eyeopener (CAGE) tool is well known but only detects alcohol dependence rather than the full spectrum of unhealthy alcohol use.[1557]
- When patients screen positive on a brief screening instrument, primary care providers should ensure follow-up with a more in-depth risk assessment such as the full, 10 question AUDIT, requiring approximately 2 to 5 minutes to administer.[1558]
- Screening instruments specifically for pregnant women include Tolerance, Worried, Eye-opener, Amnesia, Kut down (TWEAK); Tolerance, Annoyed, Cut down, Eye-opener (T-ACE); Parents, Partner, Past, Present Pregnancy (4P's Plus); and Normal drinker, Eye-opener, Tolerance (NET).[1559]
- There is no evidence that screening by itself leads to reduced unhealthy alcohol use.[1560]

- We assume that the AUDIT-C and SASQ are representative of verified short screening instruments for unhealthy alcohol use and model a sensitivity of 0.84 (Table 14, rows *as* & *bb*) and a specificity of 0.74 (the weighted average of AUDIT C and SASQ results). In our sensitivity analysis we consider the most optimistic scenario to be a sensitivity of 0.94 and a specificity of 0.88 and the most pessimistic scenario to be a sensitivity of 0.67 and a specificity of 0.46 (based on the weighted average of the 95% CIs).

[1553] O'Connor E, Perdue L, Senger C et al. Screening and behavioral counseling interventions to reduce unhealthy alcohol use in adolescents and adults: Updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2018: 320(18); 1910-28.
[1554] Curry SJ, Krist AH, Owens DK et al. Screening and behavioral counseling interventions to reduce unhealthy alcohol use in adolescents and adults: US Preventive Services Task Force recommendation statement. *Journal of the American Medical Association.* 2018; 320(18): 1899-909.
[1555] Ibid.
[1556] British Columbia Centre on Substance Use (BCCSU), B.C. Ministry of Health and B.C. Ministry of Mental Health and Addictions. *Provincial Guideline for the Clinical Management of High-Risk Drinking and Alcohol Use Disorder*. 2019. Available at https://www.bccsu.ca/aud-guideline/ Accessed April 2020.
[1557] O'Connor E, Perdue L, Senger C et al. Screening and behavioral counseling interventions to reduce unhealthy alcohol use in adolescents and adults: Updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2018: 320(18); 1910-28.
[1558] Ibid.
[1559] Ibid.
[1560] Ibid.

Screening Frequency

- The USPSTF did not find adequate evidence to recommend an optimal screening interval.[1561]
- In the absence of this evidence, the British Columbia Centre on Substance Use (BCCSU) recommends annual screening. This is at least partially for "reasons of convenience - alcohol screening can be combined with other components of a routine medical exam or preventive health screening - and to detect changes, as an individual's alcohol use can shift from low- to high-risk over a one-year period." [1562] They cite a US study which found that 3.4% of patients who screened **negative** for high-risk alcohol use, screened **positive** a year later.[1563]
- Economic evaluations have assumed that screening would occur anywhere from at least once a year to at least once every 10 years.[1564,1565,1566]

- For modelling purposes, we assumed that screening for unhealthy alcohol use would occur annually and modified this to once every 5 years in the sensitivity analysis (Table 14, row *ap*).
- We assume that changing the frequency of screening has no impact on CPB, since the benefits come from participating in a brief intervention, which we model as recurring on a regular basis (see Effectiveness of the Intervention below).

Effectiveness of the Intervention – Brief Counselling

- Most interventions involve one or two sessions (90% involved 4 or fewer sessions) with a median contact time of 30 minutes (88% involved 2 hours of contact or less) that include basic information such as how the participant's drinking compared with recommended limits and how to reduce alcohol use. Motivational techniques are also commonly used.[1567]

- For modelling purposes, we assumed that 3 10-minute sessions would be required, for a total contact time of 30 minutes per brief intervention. (Table 23, row *ai*)

- The meta-analysis for the USPSTF found an absolute increase of 13.9% more participants drinking within recommended limits. A total of 7 adults would need to be

[1561] Ibid.
[1562] British Columbia Centre on Substance Use (BCCSU), B.C. Ministry of Health and B.C. Ministry of Mental Health and Addictions. *Provincial Guideline for the Clinical Management of High-Risk Drinking and Alcohol Use Disorder*. 2019. Available at https://www.bccsu.ca/aud-guideline/ Accessed April 2020.
[1563] Alford D, Almeida A, Saitz R et al. Should adults who screen negative for unhealthy substance use be rescreened annually? *Journal of General Internal Medicine*. 2009: 24: 169-170.
[1564] Purshouse R, Brennan A, Rafia R et al. Modelling the cost-effectiveness of alcohol screening and brief interventions in primary care in England. *Alcohol and Alcoholism*. 2012; 48(2): 180-8.
[1565] Angus C, Scafato E, Ghirini S et al. Cost-effectiveness of a programme of screening and brief interventions for alcohol in primary care in Italy. *BioMed Central Family Practice*. 2014; 15(1): 1-26.
[1566] Zur R and Zaric G. A microsimulation cost–utility analysis of alcohol screening and brief intervention to reduce heavy alcohol consumption in Canada. *Addiction*. 2016; 111(5): 817-31.
[1567] O'Connor E, Perdue L, Senger C et al. Screening and behavioral counseling interventions to reduce unhealthy alcohol use in adolescents and adults: Updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2018: 320(18); 1910-28.

treated to achieve 1 adult drinking within the recommended limits. (Number needed to treat, 7.2 [95% CI, 6.2 – 11.5]).[1568]

- Brief counselling is associated with a reduction in alcohol consumption of 1.6 drinks per week (95% CI of 1.0 to 2.2).[1569]
- Brief counselling is associated with a 40% reduction in the proportion of individuals exceeding recommended drinking levels (OR of 0.60; 95% CI of 0.53 to 0.67).[1570]
- Brief counselling is associated with a 33% reduction in the proportion of individuals reporting a heavy use episode (OR of 0.67; 95% CI of 0.58 to 0.77).[1571]
- For **pregnant women**, brief counselling increased the proportion of pregnant women reporting abstinence (odds ratio 2.26 [95% CI, 1.43 – 3.56]). The number needed to treat was 6.0 (95% CI, 4.3 – 12.5).[1572]

- For modelling purposes, we assumed that 7.2 adults would need to receive a brief intervention for one adult to shift from unhealthy to lower risk alcohol use. That is, 1 in every 7.2 (13.9%) individuals in the general treated would cease unhealthy alcohol use (Table 14, row *au*). We range this number from 8.7% (1 in 11.5) to 16.1% (1 in 6.2) in our sensitivity analysis.
- We also assumed that 6.0 pregnant women would need to receive a brief intervention for one pregnant woman to shift from alcohol use to no alcohol use. That is, 1 in every 6.0 (16.7%) pregnant women treated would cease unhealthy alcohol use (Table 14, row *bd*). We range this number from 8.0% (1 in 12.5) to 23.3% (1 in 4.3) in our sensitivity analysis.

- The benefits of brief counselling continued to 24 months (or beyond) in 4 of 7 trials reporting longer-term outcomes, with "very limited" data suggesting benefits from alcohol interventions can be maintained over 2 – 4 years.[1573]

- For modelling purposes, we assumed that a brief intervention would be required every three years (ranging this from two to four years in the sensitivity analysis) to maintain the benefits associated with the brief intervention. (Table 23, row *ae*)

[1568] Curry SJ, Krist AH, Owens DK et al. Screening and behavioral counseling interventions to reduce unhealthy alcohol use in adolescents and adults: US Preventive Services Task Force recommendation statement. *Journal of the American Medical Association.* 2018; 320(18): 1899-909.
[1569] O'Connor E, Perdue L, Senger C et al. Screening and behavioral counseling interventions to reduce unhealthy alcohol use in adolescents and adults: Updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2018: 320(18); 1910-28.
[1570] O'Connor E, Perdue L, Senger C et al. Screening and behavioral counseling interventions to reduce unhealthy alcohol use in adolescents and adults: Updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2018: 320(18); 1910-28.
[1571] Ibid.
[1572] Curry SJ, Krist AH, Owens DK et al. Screening and behavioral counseling interventions to reduce unhealthy alcohol use in adolescents and adults: US Preventive Services Task Force recommendation statement. *Journal of the American Medical Association.* 2018; 320(18): 1899-909.
[1573] Ibid.

- We calculate the potential QALYs gained due to screening and behavioural counseling interventions to reduce unhealthy alcohol use in adults 18 years or older in a British Columbia birth cohort of 40,000 for both females (Table 12) and males (Table 13).
- The results in Table 12 and 13 are based on the following calculations for each age group. An estimated 19,891 of the 20,000 females in the birth cohort would survive to age 18, generating 19,891 life years for this cohort (see Table 12). Of these 19,891 18-year olds, 65.0% would see a PCP that year, or 12,931. Of the 12,931 who see a PCP, 93% or 12,026 would be screened for unhealthy alcohol use. Given the sensitivity of the screening test, 84% of 18-year olds with unhealthy alcohol use would be identified as (true) positives, or 10,102 (at this point we are basing our calculation using the assumption that the entire cohort has unhealthy alcohol use but are doing so to generate a proportion for use a bit further along in the table). Of the 10,102, 41% (4,142) would accept a brief intervention. The brief intervention would result in a reduction in unhealthy alcohol use in 1 of every 7.2 individuals, or 13.9%. Multiplying 4,142 by 13.9% indicates that 575 of the 19,981 life years lived in the cohort would no longer have unhealthy alcohol use. If we divide 575 life years by the total (19,981) we get a proportion of 2.9%. That is, screening and behavioural counseling interventions to reduce unhealthy alcohol use in 18 years females would reduce unhealthy alcohol use by 2.9% that year. This 2.9% is then applied to our previous calculation (see Table 7) of 12.5 life years lost due to unhealthy alcohol use in female 18-year olds in the cohort for a gain of 0.36(2.9% * 12.5) life years associated with the brief intervention. In addition, the 2.9% is also applied to our previous calculation (see Table 9) of 1,148 QALYs lost due to unhealthy alcohol use in the female 18-year olds in the cohort for a gain of 33 (2.9% * 1,148) QALYs associated with the brief intervention. This process is repeated for each age group.
- Based on this approach, we calculated that screening and behavioural counseling interventions to reduce unhealthy alcohol use in a British Columbia birth cohort of 40,000 for females would result in 109 life years gained and an additional 1,832 QALYs gained (Table 12 and Table 14, rows *av* and *aw*) and males would result in 266 life years gained and an additional 2,161 QALYs gained (Table 13 and Table 14, rows *ax* and *ay*).

Table 12: Quality Adjusted Life Years Gained Through Brief Interventions

Females, between the Ages of 18 and 84

In a British Columbia Birth Cohort of 40,000

Age	Total Life Years	Annual GP Visits % (Table 11)	Annual GP Visits #	Screened at GP %	Screened at GP #	Sensitivity of Screen %	Sensitivity of Screen #	Accepting BI %	Accepting BI #	Reduction in Unhealthy Alcohol Use with BI %	Reduction in Unhealthy Alcohol Use with BI #	Benefit of Screening and BI	Total Life Years Lost (Table 7)	Life Years Gained via BI	Total QALYs Lost (Table 9)	QALYs Gained via BI
18	19,891	65.0%	12,931	93%	12,026	84%	10,102	41%	4,142	13.9%	575	2.9%	12.5	0.4	1,148	33
19	19,885	65.0%	12,927	93%	12,022	84%	10,098	41%	4,140	13.9%	575	2.9%	13.1	0.4	1,147	33
20	19,878	66.0%	13,117	93%	12,199	84%	10,247	41%	4,201	13.9%	584	2.9%	22.9	0.7	1,147	34
21	19,871	66.0%	13,113	93%	12,195	84%	10,244	41%	4,200	13.9%	583	2.9%	23.8	0.7	1,147	34
22	19,863	66.0%	13,108	93%	12,190	84%	10,240	41%	4,198	13.9%	583	2.9%	24.1	0.7	1,146	34
23	19,855	66.0%	13,102	93%	12,185	84%	10,236	41%	4,197	13.9%	583	2.9%	25.0	0.7	1,146	34
24	19,847	66.0%	13,097	93%	12,180	84%	10,231	41%	4,195	13.9%	583	2.9%	25.8	0.8	1,145	34
25	19,839	79.5%	15,767	93%	14,664	84%	12,317	41%	5,050	13.9%	701	3.5%	23.9	0.8	1,145	40
26	19,830	79.5%	15,760	93%	14,657	84%	12,312	41%	5,048	13.9%	701	3.5%	24.7	0.9	1,144	40
27	19,821	79.5%	15,753	93%	14,650	84%	12,306	41%	5,046	13.9%	701	3.5%	25.3	0.9	1,144	40
28	19,811	79.5%	15,745	93%	14,643	84%	12,300	41%	5,043	13.9%	700	3.5%	26.0	0.9	1,143	40
29	19,801	79.5%	15,737	93%	14,636	84%	12,294	41%	5,041	13.9%	700	3.5%	27.1	1.0	1,143	40
30	19,790	81.7%	16,168	93%	15,036	84%	12,630	41%	5,179	13.9%	719	3.6%	26.4	1.0	744	27
31	19,779	81.7%	16,159	93%	15,028	84%	12,623	41%	5,176	13.9%	719	3.6%	27.4	1.0	744	27
32	19,767	81.7%	16,149	93%	15,019	84%	12,616	41%	5,173	13.9%	718	3.6%	28.4	1.0	743	27
33	19,755	81.7%	16,139	93%	15,010	84%	12,608	41%	5,169	13.9%	718	3.6%	29.3	1.1	743	27
34	19,742	81.7%	16,129	93%	15,000	84%	12,600	41%	5,166	13.9%	717	3.6%	30.1	1.1	742	27
35	19,729	79.8%	15,751	93%	14,648	84%	12,305	41%	5,045	13.9%	701	3.6%	29.7	1.1	742	26
36	19,715	79.8%	15,740	93%	14,638	84%	12,296	41%	5,041	13.9%	700	3.6%	30.4	1.1	741	26
37	19,700	79.8%	15,728	93%	14,627	84%	12,287	41%	5,038	13.9%	700	3.6%	31.1	1.1	741	26
38	19,685	79.8%	15,716	93%	14,616	84%	12,277	41%	5,034	13.9%	699	3.6%	32.2	1.1	740	26
39	19,669	79.8%	15,703	93%	14,604	84%	12,267	41%	5,030	13.9%	699	3.6%	33.1	1.2	740	26
40	19,652	76.4%	15,006	93%	13,955	84%	11,722	41%	4,806	13.9%	668	3.4%	37.2	1.3	770	26
41	19,634	76.4%	14,992	93%	13,942	84%	11,712	41%	4,802	13.9%	667	3.4%	38.5	1.3	769	26
42	19,615	76.4%	14,977	93%	13,929	84%	11,700	41%	4,797	13.9%	666	3.4%	40.2	1.4	769	26
43	19,594	76.4%	14,961	93%	13,914	84%	11,688	41%	4,792	13.9%	666	3.4%	42.1	1.4	768	26
44	19,572	76.4%	14,945	93%	13,898	84%	11,675	41%	4,787	13.9%	665	3.4%	43.9	1.5	767	26
45	19,549	78.3%	15,300	93%	14,229	84%	11,952	41%	4,900	13.9%	681	3.5%	47.9	1.7	729	25
46	19,524	78.3%	15,280	93%	14,211	84%	11,937	41%	4,894	13.9%	680	3.5%	49.9	1.7	728	25
47	19,497	78.3%	15,259	93%	14,191	84%	11,921	41%	4,887	13.9%	679	3.5%	52.1	1.8	727	25
48	19,469	78.3%	15,237	93%	14,170	84%	11,903	41%	4,880	13.9%	678	3.5%	54.5	1.9	726	25
49	19,438	78.3%	15,213	93%	14,148	84%	11,884	41%	4,873	13.9%	677	3.5%	57.1	2.0	725	25
50	19,405	81.5%	15,814	93%	14,707	84%	12,354	41%	5,065	13.9%	703	3.6%	58.3	2.1	754	27
51	19,370	81.5%	15,785	93%	14,680	84%	12,331	41%	5,056	13.9%	702	3.6%	61.2	2.2	753	27
52	19,332	81.5%	15,754	93%	14,651	84%	12,307	41%	5,046	13.9%	701	3.6%	64.1	2.3	751	27
53	19,291	81.5%	15,721	93%	14,620	84%	12,281	41%	5,035	13.9%	699	3.6%	67.2	2.4	750	27
54	19,247	81.5%	15,685	93%	14,587	84%	12,253	41%	5,024	13.9%	698	3.6%	70.6	2.6	748	27
55	19,199	82.0%	15,735	93%	14,633	84%	12,292	41%	5,040	13.9%	700	3.6%	64.5	2.4	746	27
56	19,148	82.0%	15,692	93%	14,594	84%	12,259	41%	5,026	13.9%	698	3.6%	68.0	2.5	744	27
57	19,092	82.0%	15,647	93%	14,552	84%	12,223	41%	5,012	13.9%	696	3.6%	71.4	2.6	742	27
58	19,032	82.0%	15,597	93%	14,506	84%	12,185	41%	4,996	13.9%	694	3.6%	75.0	2.7	739	27
59	18,966	82.0%	15,544	93%	14,456	84%	12,143	41%	4,978	13.9%	691	3.6%	78.9	2.9	737	27
60	18,895	80.9%	15,282	93%	14,212	84%	11,938	41%	4,895	13.9%	680	3.6%	62.8	2.3	570	21
61	18,817	80.9%	15,219	93%	14,154	84%	11,889	41%	4,875	13.9%	677	3.6%	66.0	2.4	568	20
62	18,733	80.9%	15,151	93%	14,090	84%	11,836	41%	4,853	13.9%	674	3.6%	69.5	2.5	565	20
63	18,641	80.9%	15,077	93%	14,021	84%	11,778	41%	4,829	13.9%	671	3.6%	73.2	2.6	562	20
64	18,541	80.9%	14,996	93%	13,946	84%	11,715	41%	4,803	13.9%	667	3.6%	77.0	2.8	559	20
65	18,432	86.7%	15,986	93%	14,867	84%	12,489	41%	5,120	13.9%	711	3.9%	60.1	2.3	556	21
66	18,312	86.7%	15,883	93%	14,771	84%	12,408	41%	5,087	13.9%	707	3.9%	63.3	2.4	552	21
67	18,181	86.7%	15,769	93%	14,665	84%	12,319	41%	5,051	13.9%	701	3.9%	66.6	2.6	548	21
68	18,038	86.7%	15,645	93%	14,550	84%	12,222	41%	5,011	13.9%	696	3.9%	70.1	2.7	544	21
69	17,881	86.7%	15,509	93%	14,423	84%	12,115	41%	4,967	13.9%	690	3.9%	73.6	2.8	539	21
70	17,709	84.8%	15,015	93%	13,964	84%	11,730	41%	4,809	13.9%	668	3.8%	50.5	1.9	678	26
71	17,520	84.8%	14,855	93%	13,815	84%	11,605	41%	4,758	13.9%	661	3.8%	52.9	2.0	670	25
72	17,313	84.8%	14,679	93%	13,652	84%	11,467	41%	4,702	13.9%	653	3.8%	55.5	2.1	662	25
73	17,085	84.8%	14,486	93%	13,472	84%	11,317	41%	4,640	13.9%	644	3.8%	58.1	2.2	654	25
74	16,835	84.8%	14,274	93%	13,275	84%	11,151	41%	4,572	13.9%	635	3.8%	60.8	2.3	644	24
75	16,561	85.8%	14,215	93%	13,220	84%	11,105	41%	4,553	13.9%	632	3.8%	35.9	1.4	634	24
76	16,260	85.8%	13,956	93%	12,979	84%	10,903	41%	4,470	13.9%	621	3.8%	37.4	1.4	622	24
77	15,929	85.8%	13,673	93%	12,716	84%	10,681	41%	4,379	13.9%	608	3.8%	38.9	1.5	610	23
78	15,567	85.8%	13,362	93%	12,427	84%	10,438	41%	4,280	13.9%	594	3.8%	40.3	1.5	596	23
79	15,171	85.8%	13,022	93%	12,110	84%	10,172	41%	4,171	13.9%	579	3.8%	41.6	1.6	580	22
80	14,737	85.7%	12,627	93%	11,743	84%	9,864	41%	4,044	13.9%	562	3.8%	28.2	1.1	855	33
81	14,263	85.7%	12,221	93%	11,366	84%	9,547	41%	3,914	13.9%	544	3.8%	28.9	1.1	828	32
82	13,747	85.7%	11,779	93%	10,955	84%	9,202	41%	3,773	13.9%	524	3.8%	29.5	1.1	798	30
83	13,186	85.7%	11,299	93%	10,508	84%	8,827	41%	3,619	13.9%	503	3.8%	30.0	1.1	765	29
84	12,579	85.7%	10,779	93%	10,024	84%	8,420	41%	3,452	13.9%	479	3.8%	30.3	1.2	730	28
Total	***1,242,083***		***992,443***		***922,972***		***775,296***		***317,872***		***44,149***		***3,016***	***109***	***51,996***	***1,832***

Table 13: Quality Adjusted Life Years Gained Through Brief Interventions

Males, between the Ages of 18 and 84

In a British Columbia Birth Cohort of 40,000

Age	Total Life Years	Annual GP Visits % (Table 11)	Annual GP Visits #	Screened at GP %	Screened at GP #	Sensitivity of Screen %	Sensitivity of Screen #	Accepting BI %	Accepting BI #	Reduction in Unhealthy Alcohol Use with BI %	Reduction in Unhealthy Alcohol Use with BI #	Benefit of Screening and BI	Total Life Years Lost (Table 7)	Life Years Gained via BI	Total QALYs (Table 9)	QALYs Gained via BI
18	19,870	53.0%	10,535	93%	9,797	84%	8,230	41%	3,374	13.9%	469	2.4%	42.0	1.0	1,570	37
19	19,858	53.0%	10,528	93%	9,791	84%	8,224	41%	3,372	13.9%	468	2.4%	49.3	1.2	1,569	37
20	19,843	45.8%	9,080	93%	8,445	84%	7,094	41%	2,908	13.9%	404	2.0%	116.1	2.4	1,568	32
21	19,826	45.8%	9,073	93%	8,437	84%	7,087	41%	2,906	13.9%	404	2.0%	130.0	2.6	1,567	32
22	19,807	45.8%	9,064	93%	8,429	84%	7,081	41%	2,903	13.9%	403	2.0%	142.0	2.9	1,565	32
23	19,786	45.8%	9,054	93%	8,420	84%	7,073	41%	2,900	13.9%	403	2.0%	152.2	3.1	1,563	32
24	19,763	45.8%	9,044	93%	8,411	84%	7,065	41%	2,897	13.9%	402	2.0%	157.9	3.2	1,562	32
25	19,739	52.4%	10,338	93%	9,614	84%	8,076	41%	3,311	13.9%	460	2.3%	148.5	3.5	1,560	36
26	19,714	52.4%	10,325	93%	9,602	84%	8,066	41%	3,307	13.9%	459	2.3%	152.0	3.5	1,558	36
27	19,689	52.4%	10,311	93%	9,589	84%	8,055	41%	3,303	13.9%	459	2.3%	154.2	3.6	1,556	36
28	19,662	52.4%	10,297	93%	9,576	84%	8,044	41%	3,298	13.9%	458	2.3%	156.2	3.6	1,554	36
29	19,635	52.4%	10,283	93%	9,563	84%	8,033	41%	3,294	13.9%	457	2.3%	158.0	3.7	1,552	36
30	19,607	51.7%	10,129	93%	9,420	84%	7,912	41%	3,244	13.9%	451	2.3%	141.3	3.2	1,431	33
31	19,579	51.7%	10,114	93%	9,406	84%	7,901	41%	3,239	13.9%	450	2.3%	141.7	3.3	1,429	33
32	19,550	51.7%	10,099	93%	9,392	84%	7,889	41%	3,235	13.9%	449	2.3%	142.0	3.3	1,427	33
33	19,520	51.7%	10,083	93%	9,378	84%	7,877	41%	3,230	13.9%	449	2.3%	143.1	3.3	1,425	33
34	19,489	51.7%	10,068	93%	9,363	84%	7,865	41%	3,225	13.9%	448	2.3%	144.1	3.3	1,422	33
35	19,458	63.1%	12,286	93%	11,426	84%	9,597	41%	3,935	13.9%	547	2.8%	130.9	3.7	1,420	40
36	19,425	63.1%	12,265	93%	11,407	84%	9,582	41%	3,928	13.9%	546	2.8%	132.3	3.7	1,418	40
37	19,392	63.1%	12,244	93%	11,387	84%	9,565	41%	3,922	13.9%	545	2.8%	134.4	3.8	1,415	40
38	19,357	63.1%	12,222	93%	11,366	84%	9,548	41%	3,915	13.9%	544	2.8%	136.2	3.8	1,413	40
39	19,321	63.1%	12,199	93%	11,345	84%	9,530	41%	3,907	13.9%	543	2.8%	138.6	3.9	1,410	40
40	19,283	62.8%	12,104	93%	11,256	84%	9,455	41%	3,877	13.9%	538	2.8%	136.0	3.8	1,467	41
41	19,245	62.8%	12,079	93%	11,234	84%	9,436	41%	3,869	13.9%	537	2.8%	137.9	3.9	1,464	41
42	19,204	62.8%	12,054	93%	11,210	84%	9,416	41%	3,861	13.9%	536	2.8%	140.9	3.9	1,461	41
43	19,162	62.8%	12,027	93%	11,185	84%	9,396	41%	3,852	13.9%	535	2.8%	144.4	4.0	1,457	41
44	19,117	62.8%	11,999	93%	11,159	84%	9,374	41%	3,843	13.9%	534	2.8%	147.5	4.1	1,454	41
45	19,071	68.5%	13,057	93%	12,143	84%	10,200	41%	4,182	13.9%	581	3.0%	144.5	4.4	1,134	35
46	19,022	68.5%	13,024	93%	12,112	84%	10,174	41%	4,171	13.9%	579	3.0%	148.6	4.5	1,131	34
47	18,970	68.5%	12,988	93%	12,079	84%	10,146	41%	4,160	13.9%	578	3.0%	153.0	4.7	1,128	34
48	18,915	68.5%	12,950	93%	12,044	84%	10,117	41%	4,148	13.9%	576	3.0%	158.1	4.8	1,125	34
49	18,857	68.5%	12,911	93%	12,007	84%	10,086	41%	4,135	13.9%	574	3.0%	163.8	5.0	1,122	34
50	18,795	65.6%	12,333	93%	11,470	84%	9,635	41%	3,950	13.9%	549	2.9%	159.1	4.6	1,164	34
51	18,729	65.6%	12,290	93%	11,430	84%	9,601	41%	3,936	13.9%	547	2.9%	165.0	4.8	1,160	34
52	18,659	65.6%	12,244	93%	11,387	84%	9,565	41%	3,922	13.9%	545	2.9%	171.2	5.0	1,156	34
53	18,583	65.6%	12,195	93%	11,341	84%	9,527	41%	3,906	13.9%	542	2.9%	177.8	5.2	1,151	34
54	18,503	65.6%	12,142	93%	11,292	84%	9,485	41%	3,889	13.9%	540	2.9%	184.6	5.4	1,146	33
55	18,417	72.8%	13,416	93%	12,477	84%	10,480	41%	4,297	13.9%	597	3.2%	161.8	5.2	1,141	37
56	18,325	72.8%	13,348	93%	12,414	84%	10,428	41%	4,275	13.9%	594	3.2%	168.1	5.4	1,135	37
57	18,226	72.8%	13,276	93%	12,347	84%	10,372	41%	4,252	13.9%	591	3.2%	174.5	5.7	1,129	37
58	18,120	72.8%	13,199	93%	12,275	84%	10,311	41%	4,228	13.9%	587	3.2%	181.5	5.9	1,122	36
59	18,006	72.8%	13,116	93%	12,198	84%	10,246	41%	4,201	13.9%	583	3.2%	188.6	6.1	1,115	36
60	17,884	82.5%	14,750	93%	13,718	84%	11,523	41%	4,724	13.9%	656	3.7%	150.0	5.5	961	35
61	17,752	82.5%	14,642	93%	13,617	84%	11,438	41%	4,690	13.9%	651	3.7%	155.8	5.7	954	35
62	17,610	82.5%	14,525	93%	13,508	84%	11,347	41%	4,652	13.9%	646	3.7%	162.0	5.9	946	35
63	17,458	82.5%	14,399	93%	13,391	84%	11,249	41%	4,612	13.9%	641	3.7%	168.0	6.2	938	34
64	17,293	82.5%	14,264	93%	13,265	84%	11,143	41%	4,568	13.9%	635	3.7%	174.4	6.4	929	34
65	17,116	84.7%	14,492	93%	13,478	84%	11,321	41%	4,642	13.9%	645	3.8%	132.9	5.0	919	35
66	16,925	84.7%	14,330	93%	13,327	84%	11,195	41%	4,590	13.9%	637	3.8%	137.7	5.2	909	34
67	16,719	84.7%	14,156	93%	13,165	84%	11,058	41%	4,534	13.9%	630	3.8%	142.5	5.4	898	34
68	16,496	84.7%	13,967	93%	12,990	84%	10,911	41%	4,474	13.9%	621	3.8%	147.4	5.6	886	33
69	16,256	84.7%	13,764	93%	12,801	84%	10,752	41%	4,409	13.9%	612	3.8%	152.2	5.7	873	33
70	15,997	85.9%	13,738	93%	12,776	84%	10,732	41%	4,400	13.9%	611	3.8%	104.7	4.0	583	22
71	15,718	85.9%	13,498	93%	12,553	84%	10,544	41%	4,323	13.9%	600	3.8%	107.8	4.1	572	22
72	15,416	85.9%	13,239	93%	12,312	84%	10,342	41%	4,240	13.9%	589	3.8%	110.9	4.2	561	21
73	15,092	85.9%	12,960	93%	12,053	84%	10,124	41%	4,151	13.9%	577	3.8%	113.8	4.3	550	21
74	14,742	85.9%	12,659	93%	11,773	84%	9,890	41%	4,055	13.9%	563	3.8%	116.4	4.4	537	21
75	14,365	90.4%	12,980	93%	12,071	84%	10,140	41%	4,157	13.9%	577	4.0%	69.3	2.8	523	21
76	13,960	90.4%	12,614	93%	11,731	84%	9,854	41%	4,040	13.9%	561	4.0%	70.6	2.8	508	20
77	13,526	90.4%	12,222	93%	11,366	84%	9,547	41%	3,914	13.9%	544	4.0%	71.6	2.9	493	20
78	13,061	90.4%	11,801	93%	10,975	84%	9,219	41%	3,780	13.9%	525	4.0%	72.4	2.9	476	19
79	12,563	90.4%	11,352	93%	10,557	84%	8,868	41%	3,636	13.9%	505	4.0%	72.9	2.9	458	18
80	12,033	86.7%	10,437	93%	9,706	84%	8,153	41%	3,343	13.9%	464	3.9%	43.8	1.7	621	24
81	11,469	86.7%	9,948	93%	9,251	84%	7,771	41%	3,186	13.9%	443	3.9%	43.6	1.7	592	23
82	10,872	86.7%	9,430	93%	8,770	84%	7,367	41%	3,020	13.9%	419	3.9%	43.2	1.7	561	22
83	10,242	86.7%	8,884	93%	8,262	84%	6,940	41%	2,845	13.9%	395	3.9%	42.6	1.6	529	20
84	9,582	86.7%	8,311	93%	7,729	84%	6,492	41%	2,662	13.9%	370	3.9%	41.6	1.6	495	19
Total	***1,177,243***		***799,751***		***743,769***		***624,766***		***256,154***		***35,577***		***8,798***	***266***	***74,587***	***2,161***

Potential Harms Associated with the Intervention

- Possible harms of screening for unhealthy alcohol use include stigma, anxiety, labeling, discrimination, privacy concerns, and interference with the patient-clinician relationship.[1574] The USPSTF notes that "more direct evidence is needed on the harms associated with screening and behavioral interventions."[1575]
- The USPSTF found no evidence of any unintended harmful effects associated with brief counselling interventions.[1576]

Summary of CPB

- Other assumptions used in assessing CPB are detailed in the Reference Document.

Based on these assumptions, the CPB associated with screening and behavioural counseling interventions to reduce unhealthy alcohol use in adults 18 years or older, including pregnant women, in a British Columbia birth cohort of 40,000 is 5,703 QALYs, 3,276 QALYs in females and 2,427 QALYs in males (Table 14, row *bg, bh, bi*). The CPB of 5,703 represents the gap between no coverage and the 'best in the world' screening coverage estimated at 93%. In addition, it assumes that 41% of individuals identified with unhealthy alcohol use with receive a brief intervention.

[1574] O'Connor E, Perdue L, Senger C et al. Screening and behavioral counseling interventions to reduce unhealthy alcohol use in adolescents and adults: Updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2018: 320(18); 1910-28.
[1575] US Preventive Services Task Force. Screening and Behavioral Counseling Interventions to Reduce Unhealthy Alcohol Use in Adolescents and Adults: US Preventive Services Task Force Recommendation Statement. JAMA. 2018: 320(18); 1899-1909.
[1576] O'Connor E, Perdue L, Senger C et al. Screening and behavioral counseling interventions to reduce unhealthy alcohol use in adolescents and adults: Updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2018: 320(18); 1910-28.

Table 14: CPB of Screening for Unhealthy Alcohol Use and Brief Intervention Ages 18 - 84 In a BC Birth Cohort of 40,000			
Row Label	**Variable**	**Base case**	**Data Source**
	Total Burden (QALYs) in Birth Cohort		
a	Life years lived between the ages of 18 and 84 - Females	1,242,083	Table 1
b	Life years lived between the ages of 18 and 84 - Males	1,177,243	Table 1
c	Proportion of life years with unhealthy alcohol use (low-binge) - Females	11.8%	Tables 1 & 2
d	Proportion of life years with unhealthy alcohol use (hazardous) - Females	7.0%	Tables 1 & 2
e	Proportion of life years with unhealthy alcohol use (harmful) - Females	2.7%	Tables 1 & 2
f	Proportion of life years with unhealthy alcohol use (low-binge) - Males	17.5%	Tables 1 & 2
g	Proportion of life years with unhealthy alcohol use (hazardous) - Males	7.2%	Tables 1 & 2
h	Proportion of life years with unhealthy alcohol use (harmful) - Males	6.4%	Tables 1 & 2
i	Life years with unhealthy alcohol use (low-binge) - Females	146,822	= a * c
j	Life years with unhealthy alcohol use (hazardous) - Females	86,762	= a * d
k	Life years with unhealthy alcohol use (harmful) - Females	33,249	= a * e
l	Life years with unhealthy alcohol use (low-binge) - Males	205,858	= b * f
m	Life years with unhealthy alcohol use (hazardous) - Males	85,240	= b * g
n	Life years with unhealthy alcohol use (harmful) - Males	75,363	= b * h
o	Life years lost attributable to unhealthy alcohol use - Females	3,016	Table 7
p	Life years lost attributable to unhealthy alcohol use - Males	8,798	Table 7
q	QoL reduction with unhealthy alcohol use - Low-binge	0.123	√
r	QoL reduction with unhealthy alcohol use - Hazardous	0.179	√
s	QoL reduction with unhealthy alcohol use - Harmful	0.304	√
t	QALYs lost with unhealthy alcohol use (low-binge) - Females	20,734	Table 9
u	QALYs lost with unhealthy alcohol use (hazardous) - Females	19,275	Table 9
v	QALYs lost with unhealthy alcohol use (harmful) - Females	11,987	Table 9
w	QALYs lost with unhealthy alcohol use - Total females	51,996	= t + u + v
x	QALYs lost with unhealthy alcohol use (low-binge) - Males	29,220	Table 9
y	QALYs lost with unhealthy alcohol use (hazardous) - Males	18,263	Table 9
z	QALYs lost with unhealthy alcohol use (harmful) - Males	27,105	Table 9
aa	QALYs lost with unhealthy alcohol use - Total males	74,587	= x + y + z
ab	Total QALYs lost - Females	55,013	= o + w
ac	Total QALYs lost - Males	83,386	= p + aa
ad	***Total QALYs lost in general population***	***138,398***	= ab + ac
	Total Burden of FASD in Children Born to Females in the Birth Cohort		
ae	Expected births to females in birth cohort	27,034	Table 5
af	Proportion with FASD	1.8%	√
ag	Proportion of FASD with FAS	19.0%	√
ah	Number of births with FASD	489	Table 8
ai	Number of births with FAS	93	Table 8
aj	Number of births with FASD, excluding FAS	397	Table 8
ak	Life years lost due to FAS	4,472	Table 8
al	Life years lost due to FASD, excluding FAS	6,939	Table 8
am	QALYs lost due to FAS	1,546	Table 10
an	QALYs lost due to FASD, excluding FAS	11,032	Table 10
ao	***Total QALYs lost, FASD***	***23,989***	= ak + al + am + an

Table 14 *(continued)* **: CPB of Screening for Unhealthy Alcohol Use and Brief** Ages 18 - 84 In a BC Birth Cohort of 40,000			
Row Label	**Variable**	**Base case**	**Data Source**
	Screening and Brief Intervention, General Population		
ap	Screening frequency (in years)	1	√
aq	Average proportion visiting primary care provider each year, both sexes	74.1%	Tables 12 & 13
ar	Proportion screened	93%	√
as	Screening Sensitivity	84%	√
at	Proportion of positive screens accepting treatment	41%	√
au	Reduction in unhealthy alcohol use in those receiving intervention	13.9%	√
av	Life-years lost, avoided, females	109	Table 12
aw	QALYs recovered (gained), females	1,832	Table 12
ax	Life-years lost, avoided, males	266	Table 13
ay	QALYs recovered (gained), males	2,161	Table 13
az	**Total QALYs gained, general population**	**4,368**	= av + aw + ax + ay
	Screening and Brief Intervention, Pregnant Women		
ba	Proportion screened, pregnant women	97%	√
bb	Screening Sensitivity	84%	√
bc	Proportion of positive screens accepting treatment	41%	√
bd	Reduction in unhealthy alcohol use in those receiving intervention	16.7%	√
be	Proportion of QALYs lost that could be recovered with screening and brief intervention	5.6%	= ba * bb * bc * bd
bf	**Total QALYs gained, FASD avoided**	**1,336**	= ao * be
	Clinically Preventable Burden (CPB)		
bg	QALYs gained - Females	3,276	= av + aw + bf
bh	QALYs gained - Males	2,427	= ax + ay
bi	**Total QALYs gained (CPB)**	**5,703**	= bg + bh

√ = Estimates from the literature

Sensitivity Analysis

We also modified several major assumptions and recalculated the CPB as follows:

- Reduced QoL impact. Assume that the QoL reduction for binge drinking changes from 0.123 to 0.082 (Table 14, row *q*), the QoL reduction for hazardous drinking changes from 0.179 to 0.121 (Table 14, row *r*), and the QoL reduction for harmful drinking changes from 0.304 to 0.204 (Table 14, row *s*): CPB = 4,390
- Increased QoL impact. Assume that the QoL reduction for binge drinking changes from 0.123 to 0.177 (Table 14, row *q*), the QoL reduction for hazardous drinking changes from 0.179 to 0.252 (Table 14, row *r*), and the QoL reduction for harmful drinking changes from 0.304 to 0.418 (Table 14, row *s*): **CPB = 7,337**
- Assume that the proportion of births with FASD increases from 1.81% to 2.93% (Table 14, row *af*): CPB = 6,530
- Assume that the screening sensitivity decreases from 84% to 67% (Table 14, row *as*): CPB = 4,549
- Assume that the screening sensitivity increases from 84% to 94% (Table 14, row *as*): CPB = 6,382

- Assume that the proportion benefitting from treatment in the general population is decreased from 13.9% to 8.7% (Table 14, row *au*) and is decreased from 16.7% to 8.0% in pregnant women (Table 14, row *bd*): **CPB = 3,376**
- Assume that the proportion benefitting from treatment in the general population is increased from 13.9% to 16.1% (Table 14, row *au*) and is increased from 16.7% to 23.3% in pregnant women (Table 14, row *bd*): CPB = 6,936
- Assume that the impacts of FASD are excluded (Table, row *bf*): CPB = 4,368

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with screening and behavioural counseling interventions to reduce unhealthy alcohol use in adults 18 years or older, including pregnant women, in a British Columbia birth cohort of 40,000.

In estimating CE, we made the following assumptions:

Cost of Screening

- For modelling purposes, we assumed that screening for unhealthy alcohol use would occur annually and modified this to once every 5 years in the sensitivity analysis (Table 23, row *a*). That is, in the base case, the 93% screening rate is applied to all individuals. In the sensitivity analysis, the 93% screening rate is applied to 1 in 5 individuals (20%) in each year.

- In Tables 15 and 16, we calculate the number of lifetime screens and behavioural interventions conducted for females and males respectively. There would be 922,972 lifetime screens conducted on females and 743,769 lifetime screens conducted on males in the cohort.
- In Table 17 we calculate the number of lifetime screens and behavioural interventions conducted for pregnant females. We assume that pregnant females are screened with each pregnancy and that these screens are in addition to the screens conducted on the general female population. There would be 26,223 screens of pregnant females.
- As noted earlier, the proportion of pregnant females with unhealthy alcohol use is difficult to determine. Evidence from 2005/06 suggest that 7.8% of BC females drank alcohol at some point during their pregnancies.[1577] Another source from 2007/08 suggests 7.2%.[1578] 2017/18 CCHS data suggests that 3.0% of women consumed alcohol after finding out they were pregnant.[1579] As noted earlier, self-report of alcohol consumption during pregnancy tends to be under-reported.

- For modelling purposes, we have assumed that the 2017/18 CCHS finding that 3.0% of BC females consume alcohol after becoming aware that they were pregnant is under-reported by a factor of 3. We therefore assume that 9.0% of pregnant females in BC consume some alcohol, and reduce this to 3.0% in the sensitivity analysis (Table 17).

[1577] Walker MJ, Al-Sahab B, Islam F et al. The epidemiology of alcohol utilization during pregnancy: an analysis of the Canadian Maternity Experiences Survey (MES). *BMC Pregnancy and Childbirth*. 2011; 11(1): 52.
[1578] Thanh NX and Jonsson E. Drinking alcohol during pregnancy: evidence from Canadian Community Health Survey 2007/2008. *Canadian Journal of Clinical Pharmacology*. 2010; 17(2): e302-7.
[1579] This analysis is based on the Statistics Canada's Canadian Community Health Survey 2017/18 Public Use Microdata File. All computations, use and interpretation is entirely that of H. Krueger & Associates Inc.

Table 15: Number Screened and Accepting Behavioural Intervention

Females, between the Ages of 18 and 84

In a British Columbia Birth Cohort of 40,000

Age	Total Life Years	Annual GP Visits % (Table 11)	Annual GP Visits #	Screening Frequency Years	Proportion Annually %	GP Screening Rate %	Screens Conducted #	Unhealthy Alcohol Use (UAU) % (Table 2)	Screens Conducted # (UAU)	Sensitivity of Screen %	Sensitivity of Screen # (UAU)	Accepting BI %	Accepting BI # (UAU)	Frequency of BI Years	Proportion Annually %	BI Conducted # (UAU)
18	19,891	65.0%	12,931	1	100%	93%	12,026	35%	4,209	84%	3,535	41%	1,449	3	33%	483
19	19,885	65.0%	12,927	1	100%	93%	12,022	35%	4,207	84%	3,534	41%	1,449	3	33%	483
20	19,878	66.0%	13,117	1	100%	93%	12,199	35%	4,269	84%	3,586	41%	1,470	3	33%	490
21	19,871	66.0%	13,113	1	100%	93%	12,195	35%	4,268	84%	3,585	41%	1,470	3	33%	490
22	19,863	66.0%	13,108	1	100%	93%	12,190	35%	4,266	84%	3,584	41%	1,469	3	33%	490
23	19,855	66.0%	13,102	1	100%	93%	12,185	35%	4,265	84%	3,582	41%	1,469	3	33%	490
24	19,847	66.0%	13,097	1	100%	93%	12,180	35%	4,263	84%	3,581	41%	1,468	3	33%	489
25	19,839	79.5%	15,767	1	100%	93%	14,664	35%	5,132	84%	4,311	41%	1,767	3	33%	589
26	19,830	79.5%	15,760	1	100%	93%	14,657	35%	5,130	84%	4,309	41%	1,767	3	33%	589
27	19,821	79.5%	15,753	1	100%	93%	14,650	35%	5,127	84%	4,307	41%	1,766	3	33%	589
28	19,811	79.5%	15,745	1	100%	93%	14,643	35%	5,125	84%	4,305	41%	1,765	3	33%	588
29	19,801	79.5%	15,737	1	100%	93%	14,636	35%	5,122	84%	4,303	41%	1,764	3	33%	588
30	19,790	81.7%	16,168	1	100%	93%	15,036	21%	3,109	84%	2,612	41%	1,071	3	33%	357
31	19,779	81.7%	16,159	1	100%	93%	15,028	21%	3,108	84%	2,610	41%	1,070	3	33%	357
32	19,767	81.7%	16,149	1	100%	93%	15,019	21%	3,106	84%	2,609	41%	1,070	3	33%	357
33	19,755	81.7%	16,139	1	100%	93%	15,010	21%	3,104	84%	2,607	41%	1,069	3	33%	356
34	19,742	81.7%	16,129	1	100%	93%	15,000	21%	3,102	84%	2,605	41%	1,068	3	33%	356
35	19,729	79.8%	15,751	1	100%	93%	14,648	21%	3,029	84%	2,544	41%	1,043	3	33%	348
36	19,715	79.8%	15,740	1	100%	93%	14,638	21%	3,027	84%	2,543	41%	1,042	3	33%	347
37	19,700	79.8%	15,728	1	100%	93%	14,627	21%	3,025	84%	2,541	41%	1,042	3	33%	347
38	19,685	79.8%	15,716	1	100%	93%	14,616	21%	3,022	84%	2,539	41%	1,041	3	33%	347
39	19,669	79.8%	15,703	1	100%	93%	14,604	21%	3,020	84%	2,537	41%	1,040	3	33%	347
40	19,652	76.4%	15,006	1	100%	93%	13,955	21%	2,886	84%	2,424	41%	994	3	33%	331
41	19,634	76.4%	14,992	1	100%	93%	13,942	21%	2,883	84%	2,422	41%	993	3	33%	331
42	19,615	76.4%	14,977	1	100%	93%	13,929	21%	2,880	84%	2,419	41%	992	3	33%	331
43	19,594	76.4%	14,961	1	100%	93%	13,914	21%	2,877	84%	2,417	41%	991	3	33%	330
44	19,572	76.4%	14,945	1	100%	93%	13,898	21%	2,874	84%	2,414	41%	990	3	33%	330
45	19,549	78.3%	15,300	1	100%	93%	14,229	20%	2,823	84%	2,371	41%	972	3	33%	324
46	19,524	78.3%	15,280	1	100%	93%	14,211	20%	2,819	84%	2,368	41%	971	3	33%	324
47	19,497	78.3%	15,259	1	100%	93%	14,191	20%	2,815	84%	2,365	41%	970	3	33%	323
48	19,469	78.3%	15,237	1	100%	93%	14,170	20%	2,811	84%	2,361	41%	968	3	33%	323
49	19,438	78.3%	15,213	1	100%	93%	14,148	20%	2,807	84%	2,358	41%	967	3	33%	322
50	19,405	81.5%	15,814	1	100%	93%	14,707	20%	2,917	84%	2,451	41%	1,005	3	33%	335
51	19,370	81.5%	15,785	1	100%	93%	14,680	20%	2,912	84%	2,446	41%	1,003	3	33%	334
52	19,332	81.5%	15,754	1	100%	93%	14,651	20%	2,906	84%	2,441	41%	1,001	3	33%	334
53	19,291	81.5%	15,721	1	100%	93%	14,620	20%	2,900	84%	2,436	41%	999	3	33%	333
54	19,247	81.5%	15,685	1	100%	93%	14,587	20%	2,894	84%	2,431	41%	997	3	33%	332
55	19,199	82.0%	15,735	1	100%	93%	14,633	20%	2,903	84%	2,438	41%	1,000	3	33%	333
56	19,148	82.0%	15,692	1	100%	93%	14,594	20%	2,895	84%	2,432	41%	997	3	33%	332
57	19,092	82.0%	15,647	1	100%	93%	14,552	20%	2,887	84%	2,425	41%	994	3	33%	331
58	19,032	82.0%	15,597	1	100%	93%	14,506	20%	2,877	84%	2,417	41%	991	3	33%	330
59	18,966	82.0%	15,544	1	100%	93%	14,456	20%	2,868	84%	2,409	41%	988	3	33%	329
60	18,895	80.9%	15,282	1	100%	93%	14,212	13%	1,893	84%	1,590	41%	652	3	33%	217
61	18,817	80.9%	15,219	1	100%	93%	14,154	13%	1,885	84%	1,584	41%	649	3	33%	216
62	18,733	80.9%	15,151	1	100%	93%	14,090	13%	1,877	84%	1,577	41%	646	3	33%	215
63	18,641	80.9%	15,077	1	100%	93%	14,021	13%	1,868	84%	1,569	41%	643	3	33%	214
64	18,541	80.9%	14,996	1	100%	93%	13,946	13%	1,858	84%	1,560	41%	640	3	33%	213
65	18,432	86.7%	15,986	1	100%	93%	14,867	13%	1,980	84%	1,664	41%	682	3	33%	227
66	18,312	86.7%	15,883	1	100%	93%	14,771	13%	1,968	84%	1,653	41%	678	3	33%	226
67	18,181	86.7%	15,769	1	100%	93%	14,665	13%	1,953	84%	1,641	41%	673	3	33%	224
68	18,038	86.7%	15,645	1	100%	93%	14,550	13%	1,938	84%	1,628	41%	667	3	33%	222
69	17,881	86.7%	15,509	1	100%	93%	14,423	13%	1,921	84%	1,614	41%	662	3	33%	221
70	17,709	84.8%	15,015	1	100%	93%	13,964	15%	2,149	84%	1,805	41%	740	3	33%	247
71	17,520	84.8%	14,855	1	100%	93%	13,815	15%	2,126	84%	1,786	41%	732	3	33%	244
72	17,313	84.8%	14,679	1	100%	93%	13,652	15%	2,101	84%	1,765	41%	724	3	33%	241
73	17,085	84.8%	14,486	1	100%	93%	13,472	15%	2,073	84%	1,742	41%	714	3	33%	238
74	16,835	84.8%	14,274	1	100%	93%	13,275	15%	2,043	84%	1,716	41%	704	3	33%	235
75	16,561	85.8%	14,215	1	100%	93%	13,220	15%	2,034	84%	1,709	41%	701	3	33%	234
76	16,260	85.8%	13,956	1	100%	93%	12,979	15%	1,997	84%	1,678	41%	688	3	33%	229
77	15,929	85.8%	13,673	1	100%	93%	12,716	15%	1,957	84%	1,644	41%	674	3	33%	225
78	15,567	85.8%	13,362	1	100%	93%	12,427	15%	1,912	84%	1,606	41%	659	3	33%	220
79	15,171	85.8%	13,022	1	100%	93%	12,110	15%	1,864	84%	1,566	41%	642	3	33%	214
80	14,737	85.7%	12,627	1	100%	93%	11,743	22%	2,542	84%	2,136	41%	876	3	33%	292
81	14,263	85.7%	12,221	1	100%	93%	11,366	22%	2,461	84%	2,067	41%	847	3	33%	282
82	13,747	85.7%	11,779	1	100%	93%	10,955	22%	2,372	84%	1,992	41%	817	3	33%	272
83	13,186	85.7%	11,299	1	100%	93%	10,508	22%	2,275	84%	1,911	41%	784	3	33%	261
84	12,579	85.7%	10,779	1	100%	93%	10,024	22%	2,170	84%	1,823	41%	747	3	33%	249
Total	***1,242,083***		***992,443***				***922,972***		***194,687***		***163,537***		***67,050***			***22,350***

Table 16: Number Screened and Accepting Behavioural Intervention

Males, between the Ages of 18 and 84

In a British Columbia Birth Cohort of 40,000

Age	Total Life Years	Annual GP Visits % (Table 11)	Annual GP Visits #	Screening Frequency Years	Proportion Annually %	GP Screening Rate %	Screens Conducted #	Unhealthy Alcohol Use (UAU) % (Table 2)	Screens Conducted # (UAU)	Sensitivity of Screen %	Sensitivity of Screen # (UAU)	Accepting BI %	Accepting BI # (UAU)	Frequency of BI Years	Proportion Annually %	BI Conducted # (UAU)
18	19,870	53.0%	10,535	1	100%	93%	9,797	45%	4,390	84%	3,687	41%	1,512	3	33%	504
19	19,858	53.0%	10,528	1	100%	93%	9,791	45%	4,387	84%	3,685	41%	1,511	3	33%	504
20	19,843	45.8%	9,080	1	100%	93%	8,445	45%	3,784	84%	3,178	41%	1,303	3	33%	434
21	19,826	45.8%	9,073	1	100%	93%	8,437	45%	3,780	84%	3,175	41%	1,302	3	33%	434
22	19,807	45.8%	9,064	1	100%	93%	8,429	45%	3,777	84%	3,172	41%	1,301	3	33%	434
23	19,786	45.8%	9,054	1	100%	93%	8,420	45%	3,773	84%	3,169	41%	1,299	3	33%	433
24	19,763	45.8%	9,044	1	100%	93%	8,411	45%	3,768	84%	3,165	41%	1,298	3	33%	433
25	19,739	52.4%	10,338	1	100%	93%	9,614	45%	4,307	84%	3,618	41%	1,483	3	33%	494
26	19,714	52.4%	10,325	1	100%	93%	9,602	45%	4,302	84%	3,614	41%	1,482	3	33%	494
27	19,689	52.4%	10,311	1	100%	93%	9,589	45%	4,296	84%	3,609	41%	1,480	3	33%	493
28	19,662	52.4%	10,297	1	100%	93%	9,576	45%	4,291	84%	3,604	41%	1,478	3	33%	493
29	19,635	52.4%	10,283	1	100%	93%	9,563	45%	4,285	84%	3,599	41%	1,476	3	33%	492
30	19,607	51.7%	10,129	1	100%	93%	9,420	37%	3,531	84%	2,966	41%	1,216	3	33%	405
31	19,579	51.7%	10,114	1	100%	93%	9,406	37%	3,526	84%	2,962	41%	1,214	3	33%	405
32	19,550	51.7%	10,099	1	100%	93%	9,392	37%	3,521	84%	2,957	41%	1,212	3	33%	404
33	19,520	51.7%	10,083	1	100%	93%	9,378	37%	3,515	84%	2,953	41%	1,211	3	33%	404
34	19,489	51.7%	10,068	1	100%	93%	9,363	37%	3,510	84%	2,948	41%	1,209	3	33%	403
35	19,458	63.1%	12,286	1	100%	93%	11,426	37%	4,283	84%	3,598	41%	1,475	3	33%	492
36	19,425	63.1%	12,265	1	100%	93%	11,407	37%	4,276	84%	3,592	41%	1,473	3	33%	491
37	19,392	63.1%	12,244	1	100%	93%	11,387	37%	4,268	84%	3,585	41%	1,470	3	33%	490
38	19,357	63.1%	12,222	1	100%	93%	11,366	37%	4,261	84%	3,579	41%	1,467	3	33%	489
39	19,321	63.1%	12,199	1	100%	93%	11,345	37%	4,253	84%	3,572	41%	1,465	3	33%	488
40	19,283	62.8%	12,104	1	100%	93%	11,256	37%	4,220	84%	3,544	41%	1,453	3	33%	484
41	19,245	62.8%	12,079	1	100%	93%	11,234	37%	4,211	84%	3,537	41%	1,450	3	33%	483
42	19,204	62.8%	12,054	1	100%	93%	11,210	37%	4,202	84%	3,530	41%	1,447	3	33%	482
43	19,162	62.8%	12,027	1	100%	93%	11,185	37%	4,193	84%	3,522	41%	1,444	3	33%	481
44	19,117	62.8%	11,999	1	100%	93%	11,159	37%	4,183	84%	3,514	41%	1,441	3	33%	480
45	19,071	68.5%	13,057	1	100%	93%	12,143	29%	3,559	84%	2,989	41%	1,226	3	33%	409
46	19,022	68.5%	13,024	1	100%	93%	12,112	29%	3,549	84%	2,982	41%	1,222	3	33%	407
47	18,970	68.5%	12,988	1	100%	93%	12,079	29%	3,540	84%	2,973	41%	1,219	3	33%	406
48	18,915	68.5%	12,950	1	100%	93%	12,044	29%	3,530	84%	2,965	41%	1,216	3	33%	405
49	18,857	68.5%	12,911	1	100%	93%	12,007	29%	3,519	84%	2,956	41%	1,212	3	33%	404
50	18,795	65.6%	12,333	1	100%	93%	11,470	29%	3,361	84%	2,824	41%	1,158	3	33%	386
51	18,729	65.6%	12,290	1	100%	93%	11,430	29%	3,350	84%	2,814	41%	1,154	3	33%	385
52	18,659	65.6%	12,244	1	100%	93%	11,387	29%	3,337	84%	2,803	41%	1,149	3	33%	383
53	18,583	65.6%	12,195	1	100%	93%	11,341	29%	3,324	84%	2,792	41%	1,145	3	33%	382
54	18,503	65.6%	12,142	1	100%	93%	11,292	29%	3,309	84%	2,780	41%	1,140	3	33%	380
55	18,417	72.8%	13,416	1	100%	93%	12,477	29%	3,656	84%	3,071	41%	1,259	3	33%	420
56	18,325	72.8%	13,348	1	100%	93%	12,414	29%	3,638	84%	3,056	41%	1,253	3	33%	418
57	18,226	72.8%	13,276	1	100%	93%	12,347	29%	3,618	84%	3,039	41%	1,246	3	33%	415
58	18,120	72.8%	13,199	1	100%	93%	12,275	29%	3,597	84%	3,022	41%	1,239	3	33%	413
59	18,006	72.8%	13,116	1	100%	93%	12,198	29%	3,575	84%	3,003	41%	1,231	3	33%	410
60	17,884	82.5%	14,750	1	100%	93%	13,718	23%	3,212	84%	2,698	41%	1,106	3	33%	369
61	17,752	82.5%	14,642	1	100%	93%	13,617	23%	3,188	84%	2,678	41%	1,098	3	33%	366
62	17,610	82.5%	14,525	1	100%	93%	13,508	23%	3,162	84%	2,656	41%	1,089	3	33%	363
63	17,458	82.5%	14,399	1	100%	93%	13,391	23%	3,135	84%	2,633	41%	1,080	3	33%	360
64	17,293	82.5%	14,264	1	100%	93%	13,265	23%	3,105	84%	2,609	41%	1,070	3	33%	357
65	17,116	84.7%	14,492	1	100%	93%	13,478	23%	3,155	84%	2,650	41%	1,087	3	33%	362
66	16,925	84.7%	14,330	1	100%	93%	13,327	23%	3,120	84%	2,621	41%	1,075	3	33%	358
67	16,719	84.7%	14,156	1	100%	93%	13,165	23%	3,082	84%	2,589	41%	1,061	3	33%	354
68	16,496	84.7%	13,967	1	100%	93%	12,990	23%	3,041	84%	2,554	41%	1,047	3	33%	349
69	16,256	84.7%	13,764	1	100%	93%	12,801	23%	2,997	84%	2,517	41%	1,032	3	33%	344
70	15,997	85.9%	13,738	1	100%	93%	12,776	14%	1,800	84%	1,512	41%	620	3	33%	207
71	15,718	85.9%	13,498	1	100%	93%	12,553	14%	1,768	84%	1,486	41%	609	3	33%	203
72	15,416	85.9%	13,239	1	100%	93%	12,312	14%	1,735	84%	1,457	41%	597	3	33%	199
73	15,092	85.9%	12,960	1	100%	93%	12,053	14%	1,698	84%	1,426	41%	585	3	33%	195
74	14,742	85.9%	12,659	1	100%	93%	11,773	14%	1,659	84%	1,393	41%	571	3	33%	190
75	14,365	90.4%	12,980	1	100%	93%	12,071	14%	1,701	84%	1,429	41%	586	3	33%	195
76	13,960	90.4%	12,614	1	100%	93%	11,731	14%	1,653	84%	1,388	41%	569	3	33%	190
77	13,526	90.4%	12,222	1	100%	93%	11,366	14%	1,601	84%	1,345	41%	551	3	33%	184
78	13,061	90.4%	11,801	1	100%	93%	10,975	14%	1,546	84%	1,299	41%	532	3	33%	177
79	12,563	90.4%	11,352	1	100%	93%	10,557	14%	1,487	84%	1,249	41%	512	3	33%	171
80	12,033	86.7%	10,437	1	100%	93%	9,706	16%	1,593	84%	1,338	41%	549	3	33%	183
81	11,469	86.7%	9,948	1	100%	93%	9,251	16%	1,519	84%	1,276	41%	523	3	33%	174
82	10,872	86.7%	9,430	1	100%	93%	8,770	16%	1,440	84%	1,209	41%	496	3	33%	165
83	10,242	86.7%	8,884	1	100%	93%	8,262	16%	1,356	84%	1,139	41%	467	3	33%	156
84	9,582	86.7%	8,311	1	100%	93%	7,729	16%	1,269	84%	1,066	41%	437	3	33%	146
Total	***1,177,243***		***799,751***				***743,769***		***216,573***		***181,922***		***74,588***			***24,863***

Table 17: Number Screened and Accepting Behavioural Intervention

Females Giving Birth, between the Ages of 18 and 49

In a British Columbia Birth Cohort of 40,000

Age	Expected Birthing Mothers (Table 8)	GP Screening Rate %	Screens Conducted #	Any Alcohol Use (AAU) %	Screens Conducted # (AAU)	Sensitivity of Screen %	Sensitivity of Screen # (AAU)	Accepting BI %	Accepting BI # (AAU)	Frequency of BI Years	Proportion Annually %	BI Conducted # (AAU)
18	136	97%	132	9.0%	12	84%	10	41%	4	3	33%	1
19	136	97%	132	9.0%	12	84%	10	41%	4	3	33%	1
20	591	97%	573	9.0%	52	84%	43	41%	18	3	33%	6
21	591	97%	573	9.0%	52	84%	43	41%	18	3	33%	6
22	591	97%	573	9.0%	52	84%	43	41%	18	3	33%	6
23	591	97%	573	9.0%	52	84%	43	41%	18	3	33%	6
24	590	97%	573	9.0%	52	84%	43	41%	18	3	33%	6
25	1,421	97%	1,379	9.0%	124	84%	104	41%	43	3	33%	14
26	1,421	97%	1,378	9.0%	124	84%	104	41%	43	3	33%	14
27	1,420	97%	1,377	9.0%	124	84%	104	41%	43	3	33%	14
28	1,419	97%	1,377	9.0%	124	84%	104	41%	43	3	33%	14
29	1,418	97%	1,376	9.0%	124	84%	104	41%	43	3	33%	14
30	1,970	97%	1,911	9.0%	172	84%	144	41%	59	3	33%	20
31	1,969	97%	1,909	9.0%	172	84%	144	41%	59	3	33%	20
32	1,967	97%	1,908	9.0%	172	84%	144	41%	59	3	33%	20
33	1,966	97%	1,907	9.0%	172	84%	144	41%	59	3	33%	20
34	1,965	97%	1,906	9.0%	172	84%	144	41%	59	3	33%	20
35	1,126	97%	1,092	9.0%	98	84%	83	41%	34	3	33%	11
36	1,125	97%	1,091	9.0%	98	84%	82	41%	34	3	33%	11
37	1,124	97%	1,090	9.0%	98	84%	82	41%	34	3	33%	11
38	1,123	97%	1,090	9.0%	98	84%	82	41%	34	3	33%	11
39	1,122	97%	1,089	9.0%	98	84%	82	41%	34	3	33%	11
40	235	97%	228	9.0%	21	84%	17	41%	7	3	33%	2
41	235	97%	228	9.0%	21	84%	17	41%	7	3	33%	2
42	235	97%	228	9.0%	21	84%	17	41%	7	3	33%	2
43	235	97%	228	9.0%	20	84%	17	41%	7	3	33%	2
44	234	97%	227	9.0%	20	84%	17	41%	7	3	33%	2
45	15	97%	15	9.0%	1	84%	1	41%	0	3	33%	0
46	15	97%	15	9.0%	1	84%	1	41%	0	3	33%	0
47	15	97%	15	9.0%	1	84%	1	41%	0	3	33%	0
48	15	97%	15	9.0%	1	84%	1	41%	0	3	33%	0
49	15	97%	15	9.0%	1	84%	1	41%	0	3	33%	0
Total	***27,034***		***26,223***		***2,360***		***1,982***		***813***			***271***

- For modelling purposes, we assumed that 2 minutes of a 10 minute primary care provider appointment (20%) is used for the quick screen (Table 23, row *e*). If patients screen positive, we assume a more in-depth screening test is applied and assume that this test takes the remainder of the 10 minute appointment (i.e. 80%).

- We assume that the false positives identified during the short screen are either correctly identified as healthy alcohol users or do not participate in treatment after the second (more in-depth) screen.

- For modelling purposes, we assumed that a brief intervention would be required every three years (ranging this from two to four years in the sensitivity analysis) to maintain the benefits associated with the brief intervention (Table 23, row *ae*). We model this by assuming that 33% (1 in 3) receive a brief intervention in any given year (Tables 15, 16 and 17).

- We assume that the benefits of the behavioural intervention are ongoing for each individual that received benefits, regardless of whether the screening takes place every year or once every five years.

- For modelling purposes, we assumed that 3 10-minute sessions would be required, for a total contact time of 30 minutes per brief intervention (Table 23, row *ai*). For costing purposes, we assumed that all of the brief interventions would take place in a primary care provider's office (Table 23, row *aj*).

- Patient time costs resulting from receiving, as well as travelling to and from, a service are valued based on the average hourly wage rate in BC in 2022 ($31.49[1580]) plus 18% benefits for an average cost per hour of $37.16. In the absence of specific data on the amount of time required, we assume two hours per service (see Reference Document).
- The estimated cost of a visit to a GP of $35.97 is based on the average cost of an office visit between the ages of 2 and 79 (see Reference Document).

Costs Avoided Due to a Reduction in Unhealthy Alcohol Use

- In addition to a reduced life expectancy and quality of life, alcohol use is also associated with higher *annual medical care costs* (e.g., hospitalization, physician, drug, etc.) than no alcohol use. In BC, any alcohol use is associated with an annual economic burden of $1,462 million in 2015. Of this amount, $487.4 million is for direct medical care costs (the remaining is for indirect costs associated with premature mortality and short and long-term disability).[1581]
- The Canadian Institute for Substance Use Research (CISUR) and the Canadian Centre on Substance Use and Addiction (CCSUA) estimated the annual costs of alcohol use in Canada to be $14,641.1 million in 2014. Of this amount, $4,230.2 million (29%) was for healthcare costs, $5,916.4 million (40%) for indirect costs, $3,154.2 million (22%) for criminal justice costs and $1,340.3 million (9%) for 'other' costs (primarily fire and motor vehicle damage).[1582]
- The CISUR and CCSUA analysis also estimated the annual costs of alcohol use in BC to be $1,936 million in 2014. Of this amount, $673 million (35%) was for

[1580] BC Stats. *Earning & Employment Trends – August 2022*. Available at https://www2.gov.bc.ca/assets/gov/data/statistics/people-population-community/income/earnings_and_employment_trends_data_tables.pdf. Accessed September 2022.
[1581] H. Krueger & Associates Inc. *The Economic Burden of Risk Factors in British Columbia: Excess Weight, Tobacco Smoking, Alcohol Use, Physical Inactivity and Low Fruit and Vegetable Consumption.* 2018. Vancouver, B.C.: Provincial Health Services Authority, Population and Public Health Program.
[1582] Canadian Substance Use Costs and Harms Scientific Working Group. *Canadian substance use costs and harms (2007 – 2014)*. 2018. Prepared by the Canadian Institute for Substance Use Research and the Canadian Centre on Substance Use and Addiction. Ottawa, Ontario.

healthcare costs, $744 million (38%) for indirect costs, $349 million (18%) for criminal justice costs and $169 million (9%) for 'other' costs.[1583]

- The economic burden attributable to alcohol use increases with the amount consumed. Low alcohol use (less than 3 drinks per day for males and less than 1.5 drinks per day for females) is associated with excess annual medical care costs per female of $36 and per male of $77 (in 2013 CAD). Hazardous alcohol use (3 to 4.5 drinks per day for males and 1.5 to 3 drinks per day for females) is associated with excess annual medical care costs per female of $279 and per male of $488. Harmful alcohol use (>4.5 drinks per day for males and >3 drinks per day for females) is associated with excess annual medical care costs per female of $1,153 and per male of $1,235.[1584]
- We increased the above annual economic burden attributable to alcohol use by sex and consumption level by 38% to take into account higher estimate of healthcare costs for BC in the CISUR / CCSUA analysis ($673 million) compared with the previous BC analysis ($487.4 million).
- In addition to direct medical care costs, alcohol use is associated with criminal justice costs and 'other' costs, primarily fire and motor vehicle damage. In BC, the CISUR / CCSUA analysis indicates that the criminal justice costs are equivalent to 51% of the direct medical care costs while other costs are equivalent to 25% of the direct medical care costs.[1585]
- The adjusted excess annual medical care costs (direct costs), criminal justice costs and other costs (both calculated as a proportion of direct medical care costs) are shown in Table 18 below, inflated to 2022 CAD.

Table 18: Summary of Annual Cost of Unhealthy Alcohol Use
British Columbia, 2022 CAD

	Direct Healthcare Costs		Criminal Justice Costs		'Other' Costs		**Total Costs**	
	Female	Male	Female	Male	Female	Male	**Female**	**Male**
Low Alcohol Use	$57	$122	$29	$62	$14	$31	**$101**	**$215**
Hazardous Alcohol Use	$443	$774	$226	$395	$111	$194	**$779**	**$1,362**
Harmful Alcohol Use	$1,829	$1,959	$933	$999	$457	$490	**$3,219**	**$3,448**

Sources: Canadian Substance Use Costs and Harms Scientific Working Group (2018) and Krueger et al. (2017)

- Table 2 shows the proportion of the total population in the low-binge, hazardous and harmful drinking categories by age and sex. Tables 15 and 16 show the number of individuals in the general population accepting a brief intervention (BI). Combining this information with the annual cost information in Table 18, we can calculate the cost avoided as a result of brief interventions that work. The results are shown in Tables 19 and 20.

[1583] Canadian Substance Use Costs and Harms Scientific Working Group. *Canadian substance use costs and harms in the provinces and territories (2007 – 2014)*. 2018. Prepared by the Canadian Institute for Substance Use Research and the Canadian Centre on Substance Use and Addiction. Ottawa, Ontario.
[1584] Krueger H, Koot J, Andres E. The economic benefits of fruit and vegetable consumption in Canada. *Canadian Journal of Public Health*. 2017; 108(2): e152-61.
[1585] Canadian Substance Use Costs and Harms Scientific Working Group. *Canadian substance use costs and harms in the provinces and territories (2007 – 2014)*. 2018. Prepared by the Canadian Institute for Substance Use Research and the Canadian Centre on Substance Use and Addiction. Ottawa, Ontario.

- For example, an estimated 1,449 18 year-old females with unhealthy alcohol use would accept a brief intervention. Of these, 75% are in the low-binge category (26.1% [18 year-old females in low-binge category]/ 35.0% [18 year-old females in any unhealthy alcohol use category]). Of these, 150 (13.9%) would cease unhealthy alcohol use at the low-binge level which has an excess annual cost of $101 (see Table 18). This results in total cost avoided of $15,109 for low-binge 18 year-old females who have ceased unhealthy alcohol use (see Table 19).

Table 19: Costs Avoided Due to Reduction in Unhealthy Alcohol Use

Females, between the Ages of 18 and 84

In a British Columbia Birth Cohort of 40,000

	Accepting BI	Proportion of those Accepting BI			Reduction in Unhealthy Alcohol Use with Brief Intervention (BI)				TOTAL Costs Avoided Annually per Individual			Costs Avoided			
Age	# with UAU (Table 15)	% Low-Binge (Table 2)	% Hazardous (Table 2)	% Harmful (Table 2)	%	Low-Binge #	Hazardous #	Harmful #	Low-Binge $	Hazardous $	Harmful $	Low-Binge $	Hazardous $	Harmful $	**Total $**
18	1,449	75%	15%	11%	13.9%	150	29	22	$101	$779	$3,219	$15,109	$22,752	$70,101	**$107,962**
19	1,449	75%	15%	11%	13.9%	150	29	22	$101	$779	$3,219	$15,104	$22,745	$70,078	**$107,927**
20	1,470	75%	15%	11%	13.9%	153	30	22	$101	$779	$3,219	$15,327	$23,080	$71,112	**$109,520**
21	1,470	75%	15%	11%	13.9%	152	30	22	$101	$779	$3,219	$15,322	$23,072	$71,086	**$109,480**
22	1,469	75%	15%	11%	13.9%	152	30	22	$101	$779	$3,219	$15,316	$23,063	$71,060	**$109,439**
23	1,469	75%	15%	11%	13.9%	152	30	22	$101	$779	$3,219	$15,310	$23,054	$71,031	**$109,395**
24	1,468	75%	15%	11%	13.9%	152	30	22	$101	$779	$3,219	$15,303	$23,045	$71,002	**$109,350**
25	1,767	75%	15%	11%	13.9%	183	36	27	$101	$779	$3,219	$18,424	$27,743	$85,479	**$131,646**
26	1,767	75%	15%	11%	13.9%	183	36	27	$101	$779	$3,219	$18,416	$27,731	$85,441	**$131,587**
27	1,766	75%	15%	11%	13.9%	183	36	27	$101	$779	$3,219	$18,407	$27,718	$85,401	**$131,526**
28	1,765	75%	15%	11%	13.9%	183	36	27	$101	$779	$3,219	$18,398	$27,705	$85,360	**$131,463**
29	1,764	75%	15%	11%	13.9%	183	36	27	$101	$779	$3,219	$18,389	$27,690	$85,316	**$131,395**
30	1,071	63%	31%	6%	13.9%	93	46	9	$101	$779	$3,219	$9,372	$36,139	$29,644	**$75,155**
31	1,070	63%	31%	6%	13.9%	93	46	9	$101	$779	$3,219	$9,367	$36,119	$29,628	**$75,113**
32	1,070	63%	31%	6%	13.9%	93	46	9	$101	$779	$3,219	$9,361	$36,097	$29,610	**$75,068**
33	1,069	63%	31%	6%	13.9%	93	46	9	$101	$779	$3,219	$9,356	$36,075	$29,592	**$75,022**
34	1,068	63%	31%	6%	13.9%	93	46	9	$101	$779	$3,219	$9,349	$36,051	$29,572	**$74,973**
35	1,043	63%	31%	6%	13.9%	91	45	9	$101	$779	$3,219	$9,130	$35,206	$28,879	**$73,215**
36	1,042	63%	31%	6%	13.9%	91	45	9	$101	$779	$3,219	$9,124	$35,181	$28,858	**$73,163**
37	1,042	63%	31%	6%	13.9%	91	45	9	$101	$779	$3,219	$9,117	$35,155	$28,837	**$73,109**
38	1,041	63%	31%	6%	13.9%	91	45	9	$101	$779	$3,219	$9,110	$35,128	$28,815	**$73,053**
39	1,040	63%	31%	6%	13.9%	91	45	9	$101	$779	$3,219	$9,103	$35,099	$28,791	**$72,993**
40	994	63%	31%	6%	13.9%	87	43	9	$101	$779	$3,219	$8,698	$33,540	$27,513	**$69,751**
41	993	63%	31%	6%	13.9%	86	43	9	$101	$779	$3,219	$8,690	$33,510	$27,487	**$69,687**
42	992	63%	31%	6%	13.9%	86	43	9	$101	$779	$3,219	$8,682	$33,476	$27,460	**$69,618**
43	991	63%	31%	6%	13.9%	86	43	9	$101	$779	$3,219	$8,673	$33,442	$27,432	**$69,546**
44	990	63%	31%	6%	13.9%	86	43	9	$101	$779	$3,219	$8,663	$33,404	$27,401	**$69,468**
45	972	59%	30%	11%	13.9%	79	41	16	$101	$779	$3,219	$7,939	$31,548	$49,978	**$89,464**
46	971	59%	30%	11%	13.9%	79	40	16	$101	$779	$3,219	$7,928	$31,508	$49,914	**$89,350**
47	970	59%	30%	11%	13.9%	79	40	15	$101	$779	$3,219	$7,918	$31,465	$49,845	**$89,227**
48	968	59%	30%	11%	13.9%	79	40	15	$101	$779	$3,219	$7,906	$31,419	$49,772	**$89,097**
49	967	59%	30%	11%	13.9%	79	40	15	$101	$779	$3,219	$7,893	$31,369	$49,694	**$88,957**
50	1,005	59%	30%	11%	13.9%	82	42	16	$101	$779	$3,219	$8,205	$32,608	$51,657	**$92,471**
51	1,003	59%	30%	11%	13.9%	81	42	16	$101	$779	$3,219	$8,190	$32,549	$51,563	**$92,302**
52	1,001	59%	30%	11%	13.9%	81	42	16	$101	$779	$3,219	$8,174	$32,485	$51,462	**$92,121**
53	999	59%	30%	11%	13.9%	81	42	16	$101	$779	$3,219	$8,157	$32,417	$51,353	**$91,927**
54	997	59%	30%	11%	13.9%	81	42	16	$101	$779	$3,219	$8,138	$32,342	$51,235	**$91,716**
55	1,000	59%	30%	11%	13.9%	81	42	16	$101	$779	$3,219	$8,164	$32,445	$51,398	**$92,007**
56	997	59%	30%	11%	13.9%	81	42	16	$101	$779	$3,219	$8,142	$32,358	$51,260	**$91,760**
57	994	59%	30%	11%	13.9%	81	41	16	$101	$779	$3,219	$8,119	$32,264	$51,111	**$91,493**
58	991	59%	30%	11%	13.9%	81	41	16	$101	$779	$3,219	$8,093	$32,162	$50,949	**$91,204**
59	988	59%	30%	11%	13.9%	80	41	16	$101	$779	$3,219	$8,065	$32,051	$50,774	**$90,889**
60	652	30%	55%	15%	13.9%	27	50	14	$101	$779	$3,219	$2,719	$38,945	$43,467	**$85,131**
61	649	30%	55%	15%	13.9%	27	50	13	$101	$779	$3,219	$2,707	$38,786	$43,289	**$84,782**
62	646	30%	55%	15%	13.9%	27	50	13	$101	$779	$3,219	$2,695	$38,612	$43,095	**$84,403**
63	643	30%	55%	15%	13.9%	27	49	13	$101	$779	$3,219	$2,682	$38,423	$42,884	**$83,989**
64	640	30%	55%	15%	13.9%	27	49	13	$101	$779	$3,219	$2,668	$38,216	$42,654	**$83,538**
65	682	30%	55%	15%	13.9%	28	52	14	$101	$779	$3,219	$2,844	$40,741	$45,472	**$89,057**
66	678	30%	55%	15%	13.9%	28	52	14	$101	$779	$3,219	$2,825	$40,477	$45,176	**$88,479**
67	673	30%	55%	15%	13.9%	28	52	14	$101	$779	$3,219	$2,805	$40,188	$44,854	**$87,847**
68	667	30%	55%	15%	13.9%	28	51	14	$101	$779	$3,219	$2,783	$39,871	$44,500	**$87,154**
69	662	30%	55%	15%	13.9%	27	51	14	$101	$779	$3,219	$2,759	$39,524	$44,113	**$86,395**
70	740	15%	71%	14%	13.9%	15	73	14	$101	$779	$3,219	$1,547	$56,804	$46,595	**$104,946**
71	732	15%	71%	14%	13.9%	15	72	14	$101	$779	$3,219	$1,531	$56,198	$46,098	**$103,827**
72	724	15%	71%	14%	13.9%	15	71	14	$101	$779	$3,219	$1,512	$55,533	$45,553	**$102,599**
73	714	15%	71%	14%	13.9%	15	70	14	$101	$779	$3,219	$1,493	$54,803	$44,954	**$101,250**
74	704	15%	71%	14%	13.9%	15	69	14	$101	$779	$3,219	$1,471	$54,001	$44,296	**$99,768**
75	701	15%	71%	14%	13.9%	15	69	14	$101	$779	$3,219	$1,465	$53,776	$44,112	**$99,353**
76	688	15%	71%	14%	13.9%	14	68	13	$101	$779	$3,219	$1,438	$52,798	$43,310	**$97,546**
77	674	15%	71%	14%	13.9%	14	66	13	$101	$779	$3,219	$1,409	$51,726	$42,430	**$95,565**
78	659	15%	71%	14%	13.9%	14	65	13	$101	$779	$3,219	$1,377	$50,550	$41,465	**$93,392**
79	642	15%	71%	14%	13.9%	13	63	13	$101	$779	$3,219	$1,342	$49,262	$40,409	**$91,013**
80	876	10%	79%	11%	13.9%	12	96	13	$101	$779	$3,219	$1,239	$74,914	$42,207	**$118,360**
81	847	10%	79%	11%	13.9%	12	93	13	$101	$779	$3,219	$1,199	$72,506	$40,850	**$114,555**
82	817	10%	79%	11%	13.9%	11	90	12	$101	$779	$3,219	$1,156	$69,883	$39,373	**$110,411**
83	784	10%	79%	11%	13.9%	11	86	12	$101	$779	$3,219	$1,109	$67,033	$37,767	**$105,908**
84	747	10%	79%	11%	13.9%	11	82	11	$101	$779	$3,219	$1,058	$63,947	$36,028	**$101,033**
Total	***67,050***											***$503,481***	***$2,581,527***	***$3,188,900***	***$6,273,909***

Table 20: Costs Avoided Due to Reduction in Unhealthy Alcohol Use

Males, between the Ages of 18 and 84

In a British Columbia Birth Cohort of 40,000

	Accepting BI	Proportion of those Accepting BI			Reduction in Unhealthy Alcohol Use with Brief Intervention (BI)				TOTAL Costs Avoided Annually per Individual			Costs Avoided			
Age	# with UAU (Table 16)	% Low-Binge (Table 2)	% Hazardous (Table 2)	% Harmful (Table 2)	%	Low-Binge #	Hazardous #	Harmful #	Low-Binge $	Hazardous $	Harmful $	Low-Binge $	Hazardous $	Harmful $	**Total $**
18	1,512	68%	16%	16%	13.9%	143	33	34	$215	$1,362	$3,448	$30,738	$44,709	$117,784	**$193,232**
19	1,511	68%	16%	16%	13.9%	143	33	34	$215	$1,362	$3,448	$30,719	$44,681	$117,710	**$193,109**
20	1,303	68%	16%	16%	13.9%	123	28	29	$215	$1,362	$3,448	$26,495	$38,537	$101,524	**$166,556**
21	1,302	68%	16%	16%	13.9%	123	28	29	$215	$1,362	$3,448	$26,472	$38,504	$101,437	**$166,413**
22	1,301	68%	16%	16%	13.9%	123	28	29	$215	$1,362	$3,448	$26,446	$38,467	$101,339	**$166,252**
23	1,299	68%	16%	16%	13.9%	123	28	29	$215	$1,362	$3,448	$26,418	$38,426	$101,231	**$166,075**
24	1,298	68%	16%	16%	13.9%	123	28	29	$215	$1,362	$3,448	$26,388	$38,382	$101,116	**$165,886**
25	1,483	68%	16%	16%	13.9%	140	32	34	$215	$1,362	$3,448	$30,163	$43,873	$115,581	**$189,616**
26	1,482	68%	16%	16%	13.9%	140	32	33	$215	$1,362	$3,448	$30,125	$43,818	$115,436	**$189,378**
27	1,480	68%	16%	16%	13.9%	140	32	33	$215	$1,362	$3,448	$30,086	$43,761	$115,286	**$189,132**
28	1,478	68%	16%	16%	13.9%	140	32	33	$215	$1,362	$3,448	$30,046	$43,702	$115,131	**$188,879**
29	1,476	68%	16%	16%	13.9%	140	32	33	$215	$1,362	$3,448	$30,004	$43,642	$114,972	**$188,617**
30	1,216	57%	22%	21%	13.9%	97	37	35	$215	$1,362	$3,448	$20,748	$50,249	$122,396	**$193,393**
31	1,214	57%	22%	21%	13.9%	96	37	35	$215	$1,362	$3,448	$20,718	$50,176	$122,217	**$193,111**
32	1,212	57%	22%	21%	13.9%	96	37	35	$215	$1,362	$3,448	$20,687	$50,101	$122,036	**$192,825**
33	1,211	57%	22%	21%	13.9%	96	37	35	$215	$1,362	$3,448	$20,656	$50,025	$121,850	**$192,531**
34	1,209	57%	22%	21%	13.9%	96	37	35	$215	$1,362	$3,448	$20,623	$49,947	$121,659	**$192,229**
35	1,475	57%	22%	21%	13.9%	117	45	43	$215	$1,362	$3,448	$25,167	$60,950	$148,461	**$234,578**
36	1,473	57%	22%	21%	13.9%	117	45	43	$215	$1,362	$3,448	$25,125	$60,849	$148,214	**$234,188**
37	1,470	57%	22%	21%	13.9%	117	45	43	$215	$1,362	$3,448	$25,081	$60,744	$147,958	**$233,783**
38	1,467	57%	22%	21%	13.9%	116	45	43	$215	$1,362	$3,448	$25,036	$60,634	$147,692	**$233,363**
39	1,465	57%	22%	21%	13.9%	116	44	43	$215	$1,362	$3,448	$24,990	$60,521	$147,416	**$232,927**
40	1,453	57%	22%	21%	13.9%	115	44	42	$215	$1,362	$3,448	$24,794	$60,048	$146,263	**$231,105**
41	1,450	57%	22%	21%	13.9%	115	44	42	$215	$1,362	$3,448	$24,744	$59,927	$145,969	**$230,640**
42	1,447	57%	22%	21%	13.9%	115	44	42	$215	$1,362	$3,448	$24,692	$59,801	$145,661	**$230,154**
43	1,444	57%	22%	21%	13.9%	115	44	42	$215	$1,362	$3,448	$24,637	$59,669	$145,339	**$229,645**
44	1,441	57%	22%	21%	13.9%	114	44	42	$215	$1,362	$3,448	$24,580	$59,530	$145,003	**$229,113**
45	1,226	56%	23%	21%	13.9%	96	39	35	$215	$1,362	$3,448	$20,667	$52,779	$121,864	**$195,310**
46	1,222	56%	23%	21%	13.9%	96	39	35	$215	$1,362	$3,448	$20,614	$52,643	$121,551	**$194,808**
47	1,219	56%	23%	21%	13.9%	96	39	35	$215	$1,362	$3,448	$20,557	$52,500	$121,218	**$194,275**
48	1,216	56%	23%	21%	13.9%	95	38	35	$215	$1,362	$3,448	$20,498	$52,348	$120,868	**$193,714**
49	1,212	56%	23%	21%	13.9%	95	38	35	$215	$1,362	$3,448	$20,435	$52,187	$120,496	**$193,118**
50	1,158	56%	23%	21%	13.9%	91	37	33	$215	$1,362	$3,448	$19,521	$49,854	$115,109	**$184,484**
51	1,154	56%	23%	21%	13.9%	90	36	33	$215	$1,362	$3,448	$19,453	$49,679	$114,705	**$183,836**
52	1,149	56%	23%	21%	13.9%	90	36	33	$215	$1,362	$3,448	$19,380	$49,492	$114,275	**$183,147**
53	1,145	56%	23%	21%	13.9%	90	36	33	$215	$1,362	$3,448	$19,302	$49,293	$113,815	**$182,409**
54	1,140	56%	23%	21%	13.9%	89	36	33	$215	$1,362	$3,448	$19,218	$49,080	$113,322	**$181,620**
55	1,259	56%	23%	21%	13.9%	99	40	36	$215	$1,362	$3,448	$21,234	$54,228	$125,209	**$200,671**
56	1,253	56%	23%	21%	13.9%	98	40	36	$215	$1,362	$3,448	$21,128	$53,957	$124,582	**$199,667**
57	1,246	56%	23%	21%	13.9%	98	39	36	$215	$1,362	$3,448	$21,014	$53,666	$123,911	**$198,590**
58	1,239	56%	23%	21%	13.9%	97	39	36	$215	$1,362	$3,448	$20,892	$53,354	$123,190	**$197,435**
59	1,231	56%	23%	21%	13.9%	97	39	36	$215	$1,362	$3,448	$20,760	$53,018	$122,415	**$196,193**
60	1,106	45%	32%	24%	13.9%	69	49	36	$215	$1,362	$3,448	$14,811	$66,093	$124,838	**$205,742**
61	1,098	45%	32%	24%	13.9%	68	48	36	$215	$1,362	$3,448	$14,702	$65,607	$123,919	**$204,228**
62	1,089	45%	32%	24%	13.9%	68	48	36	$215	$1,362	$3,448	$14,585	$65,083	$122,929	**$202,597**
63	1,080	45%	32%	24%	13.9%	67	47	35	$215	$1,362	$3,448	$14,458	$64,519	$121,864	**$200,841**
64	1,070	45%	32%	24%	13.9%	67	47	35	$215	$1,362	$3,448	$14,322	$63,911	$120,716	**$198,950**
65	1,087	45%	32%	24%	13.9%	68	48	36	$215	$1,362	$3,448	$14,552	$64,935	$122,650	**$202,137**
66	1,075	45%	32%	24%	13.9%	67	47	35	$215	$1,362	$3,448	$14,389	$64,211	$121,281	**$199,881**
67	1,061	45%	32%	24%	13.9%	66	47	35	$215	$1,362	$3,448	$14,214	$63,428	$119,804	**$197,446**
68	1,047	45%	32%	24%	13.9%	65	46	34	$215	$1,362	$3,448	$14,025	$62,584	$118,209	**$194,817**
69	1,032	45%	32%	24%	13.9%	64	45	34	$215	$1,362	$3,448	$13,821	$61,673	$116,489	**$191,983**
70	620	32%	41%	28%	13.9%	27	35	24	$215	$1,362	$3,448	$5,867	$47,805	$81,771	**$135,442**
71	609	32%	41%	28%	13.9%	27	34	23	$215	$1,362	$3,448	$5,764	$46,970	$80,343	**$133,077**
72	597	32%	41%	28%	13.9%	26	34	23	$215	$1,362	$3,448	$5,654	$46,069	$78,802	**$130,525**
73	585	32%	41%	28%	13.9%	26	33	22	$215	$1,362	$3,448	$5,534	$45,098	$77,142	**$127,775**
74	571	32%	41%	28%	13.9%	25	32	22	$215	$1,362	$3,448	$5,406	$44,052	$75,353	**$124,812**
75	586	32%	41%	28%	13.9%	26	33	22	$215	$1,362	$3,448	$5,543	$45,167	$77,260	**$127,971**
76	569	32%	41%	28%	13.9%	25	32	22	$215	$1,362	$3,448	$5,387	$43,895	$75,083	**$124,365**
77	551	32%	41%	28%	13.9%	24	31	21	$215	$1,362	$3,448	$5,219	$42,529	$72,747	**$120,495**
78	532	32%	41%	28%	13.9%	23	30	20	$215	$1,362	$3,448	$5,040	$41,065	$70,244	**$116,349**
79	512	32%	41%	28%	13.9%	23	29	20	$215	$1,362	$3,448	$4,848	$39,502	$67,569	**$111,918**
80	549	6%	59%	35%	13.9%	5	45	27	$215	$1,362	$3,448	$1,005	$61,150	$91,886	**$154,041**
81	523	6%	59%	35%	13.9%	4	43	25	$215	$1,362	$3,448	$958	$58,285	$87,581	**$146,824**
82	496	6%	59%	35%	13.9%	4	41	24	$215	$1,362	$3,448	$908	$55,251	$83,022	**$139,181**
83	467	6%	59%	35%	13.9%	4	38	23	$215	$1,362	$3,448	$856	$52,051	$78,212	**$131,119**
84	437	6%	59%	35%	13.9%	4	36	21	$215	$1,362	$3,448	$800	$48,693	$73,168	**$122,662**
Total	***74,588***											***$1,203,715***	***$3,491,373***	***$7,576,095***	***$12,271,183***

- The estimated average annual direct costs per individual with FASD is detailed in Table 21. From a societal perspective, annual costs total $18,780 in 2007. Of this amount, $4,785 (25%) are patient out-of-pocket costs.[1586] Inflated to 2022, the equivalent costs are $23,959 and $7,077.

Table 21: Estimated Average Annual Cost of FASD per Case
Canada, 2007

Component	Societal Cost ($)	Ministry of Health/Social Services Cost ($)	Patient Cost ($)
Direct Costs: Medical			
Hospitalization	$1,445	$1,445	N/A
Emergency Room/Clinic Visits	$661	$661	N/A
	$2,106	**$2,106**	
Visits to Health Professionals			
Family Doctor	$301	$301	N/A
Orthopedic Surgery	$68	$68	N/A
Urologist	$46	$46	N/A
Allergist	$6	$6	N/A
Pediatrician	$242	$242	N/A
Psychiatrist	$892	$892	N/A
Occupational Therapist	$444	$352	$92
Physiotherapist	$91	$91	$0
Speech Therapist	$59	$28	$30
Psychologist	$737	$122	$615
	$2,886	**$2,148**	**$738**
Medical Devices	$416	$282	$134
Medication Dispensing Fees	$56	$48	$9
Prescription Medications	$800	$592	$208
Non-Prescription Medication	$218	N/A	$218
Diagnostic Tests	$148	$148	N/A
	$1,638	**$1,070**	**$569**
Total	**$6,630**	**$5,324**	**$1,306**
Direct Costs: Education			
Home Schooling	$199	$199	N/A
Special Schooling	$3,238	$3,238	N/A
Residential Program	$1,600	$1,000	$600
Post-Secondary Education - Tutor	$64	N/A	$64
Job Education	$160	$160	N/A
Total	**$5,260**	**$4,596**	**$664**
Direct Costs: Social Services			
Respite Care	$152	$152	N/A
Foster Care	$2,000	$2,000	N/A
Institutionalization	$1,655	$1,655	N/A
ODSP	$143	$143	N/A
Legal Aid	$125	$125	N/A
Total	**$4,076**	**$4,076**	
Out-of-Pocket			
Transportation Per Visit	$152	N/A	$152
Parking	$162	N/A	$162
Externalizing Behaviours	$2,500	N/A	$2,500
Total	**$2,814**	**N/A**	**$2,814**
Total Direct Costs	**$18,780**	**$13,995**	**$4,785**

Source: Stade B, Ali A, Bennett D et al. The burden of prenatal exposure to alcohol: revised measurement of cost. Canadian Journal of Clinical Pharmacology. 2009; 16(1): e91-102

[1586] Stade B, Ali A, Bennett D et al. The burden of prenatal exposure to alcohol: revised measurement of cost. *Canadian Journal of Clinical Pharmacology*. 2009; 16(1): e91-e102.

- Stade and colleagues provide additional information on costs by severity of FASD, with adjusted annual costs of $10,009 for mild (n = 122), $17,345 for moderate (n = 84) and $31,235 for severe (n = 44) FASD.[1587] Stade and colleagues included individuals up to age 53 in their study and presented adjusted annual costs by age group.
- To calculate the lifetime costs of an individual living with FASD (see Table 22), we took the age-specific breakdown from Stade et al. and made the following adjustments:
    - assumed that "severe FASD" was equivalent to FAS and that mild and moderate FASD cases would be proportionally distributed in our FASD without FAS population
    - calculated that the annual cost of FAS ("severe FASD") would be 1.93 times the average annual cost of FASD and that the combination of mild and moderate FASD would be 0.80 times the average annual cost of FASD
    - assumed that the annual cost from 54 - 65 years of age was equivalent to the average of the 36 – 45 and 46 – 53 year age groups reported by Stade et al.
    - inflated the 2007 CAD costs to 2022 CAD costs

Table 22: Lifetime Cost of FAS / FASD
Canada, 2022

	Annual Cost (2007 CAD)				Severity Adjustment		Annual Cost (2022 CAD)		Years	Lifetime Cost per Individual	
Age Range	Mean	95% CI		Inflation	FASD	FAS	FASD	FAS	#	FASD[1]	FAS[2]
0 - 2	$30,222	$26,302	$38,222	1.28	0.80	1.93	$30,924	$74,296	3	$92,771	$222,887
3 - 6	$26,544	$23,666	$30,328	1.28	0.80	1.93	$27,160	$65,254	4	$108,641	$261,016
7 - 12	$28,666	$25,446	$32,832	1.28	0.80	1.93	$29,332	$70,471	6	$175,990	$422,823
13 - 17	$20,201	$16,997	$24,885	1.28	0.80	1.93	$20,670	$49,661	5	$103,350	$248,304
18 - 21	$16,544	$14,888	$18,234	1.28	0.80	1.93	$16,928	$40,671	4	$67,713	$162,683
22 - 25	$16,232	$14,666	$18,002	1.28	0.80	1.93	$16,609	$39,904	4	$66,436	$159,615
26 - 35	$15,998	$14,021	$18,112	1.28	0.80	1.93	$16,369	$39,328	10	$163,695	$353,956
36 - 45	$14,689	$12,888	$16,681	1.28	0.80	1.93	$15,030	$36,110	10	$150,301	
46 - 53	$14,810	$12,664	$16,988	1.28	0.80	1.93	$15,154	$36,408	8	$121,231	
54 - 65	$14,750	n/a	n/a	1.28	0.80	1.93	$15,092	$36,259	12	$181,104	
										$1,231,232	**$1,831,283**

Source: Stade et al. (2009). Adjustments by H. Krueger & Associates Inc.
[1] From birth to 65 years old.
[2] From birth to 34 years old.

- The lifetime cost of FASD without FAS is $1,231,232 per individual (Table 23, row *be*). The lifetime cost of FAS is $1,831,283 per individual (Table 23, row *bf*).

[1587] Stade B, Ali A, Bennett D et al. The burden of prenatal exposure to alcohol: revised measurement of cost. *Canadian Journal of Clinical Pharmacology*. 2009; 16(1): e91-e102.

Summary of CE

- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the CE associated with screening and behavioural counseling interventions to reduce unhealthy alcohol use in adults 18 years or older, including pregnant women, in a British Columbia birth cohort of 40,000 is $10,575 (Table 23, row *bx*). The CE of $10,575 represents the gap between no coverage and the 'best in the world' screening coverage estimated at 93%. In addition, it assumes that 41% of individuals identified with unhealthy alcohol use would receive a brief intervention.

Table 23: CE of Screening for Unhealthy Alcohol Use and Brief Intervention
Ages 18 - 84
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
	Cost of Screening		
a	Screening frequency (in years)	1	√
b	Lifetime short screens conducted, females	922,972	Table 15
c	Lifetime short screens conducted, males	743,769	Table 16
d	Lifetime short screens conducted, pregnant females	26,223	Table 17
e	Proportion of office visit required for short screen	20.0%	√
f	Cost of 10-minute office visit	$35.97	Ref. Doc.
g	Patient time costs / office visit	$74.32	Ref. Doc.
h	Lifetime cost of short screens	$37,343,381	= (b + c + d) * e * (f + g)
i	Lifetime short screens, females with unhealthy alcohol use	194,687	Table 15
j	Lifetime short screens, males with unhealthy alcohol use	216,573	Table 16
k	Lifetime short screens, pregnant females with unhealthy alcohol use	2,360	Table 17
l	Screening sensitivity	84%	√
m	Lifetime short screen true positives, female	163,537	= i * l
n	Lifetime short screen true positives, male	181,922	= j * l
o	Lifetime short screen true positives, pregnant females	1,982	= k * l
p	Lifetime short screens, females ***without*** unhealthy alcohol use	728,285	= b - i
q	Lifetime short screens, males ***without*** unhealthy alcohol use	527,195	= c - j
r	Lifetime short screens, pregnant females ***without*** unhealthy alcohol use	23,863	= d - k
s	Screening specificity	74.0%	√
t	Lifetime short screen false positives, female	189,354	= (1 - s) * p
u	Lifetime short screen false positives, male	137,071	= (1 - s) * q
v	Lifetime short screen false positives, pregnant females	6,204	= (1 - s) * r
w	Lifetime in-depth screens delivered, female	352,891	= m + t
x	Lifetime in-depth screens delivered, male	318,992	= n + u
y	Lifetime in-depth screens delivered, pregnant females	8,187	= o + v
z	Proportion of office visit required for in-depth screen	80.0%	√
aa	Cost of 10-minute office visit	$35.97	Ref. Doc.
ab	Patient time costs / office visit	$74.32	Ref. Doc.
ac	Lifetime cost of in-depth screen	$60,003,968	= (w + x + y) * z * (aa + ab)
ad	**Total cost of lifetime screening**	**$97,347,349**	= h + ac
	Cost of Brief Intervention		
ae	Frequency of brief intervention, years	3	√
af	Lifetime number of brief interventions, female	22,350	Table 15
ag	Lifetime number of brief interventions, male	24,863	Table 16
ah	Lifetime number of brief interventions, pregnant females	271	Table 17
ai	Number of 10-minute sessions, per brief intervention	3	√
aj	Proportion of office visit required for short screen	100.0%	√
ak	Cost of 10-minute office visit	$35.97	Ref. Doc.
al	Patient time costs / office visit	$74.32	Ref. Doc.
am	**Lifetime cost of office-based interventions**	**$15,710,914**	= (af + ag + ah) * ai * aj * (ak + al)
an	**Total lifetime cost of screening and brief interventions, cohort**	**$113,058,263**	= ad + am

Table 23 (continued)**: CE of Screening for Unhealthy Alcohol Use and Brief Intervention** Ages 18 - 84 In a BC Birth Cohort of 40,000			
	Costs Avoided due to Brief Intervention - General Population		
ao	Cost avoided, low-binge drinking, female	$503,481	Table 19
ap	Cost avoided, hazardous drinking, female	$2,581,527	Table 19
aq	Cost avoided, harmful drinking, female	$3,188,900	Table 19
ar	Cost avoided, total, female	$6,273,909	= ao + ap + aq
as	Cost avoided, low-binge drinking, male	$1,203,715	Table 20
at	Cost avoided, hazardous drinking, male	$3,491,373	Table 20
au	Cost avoided, harmful drinking, male	$7,576,095	Table 20
av	Cost avoided, total, male	$12,271,183	= as + at + au
aw	**Total cost avoided, general population**	**$18,545,092**	= ar + av
	Costs Avoided due to Brief Intervention - FASD		
ax	Number of births with FASD	489	Table 8
ay	Number of births with FASD, excluding FAS	397	Table 8
az	Number of births with FAS	93	Table 8
ba	Proportion of FASD births avoided through brief intervention	5.6%	Table 14, row be
bb	Number of births with FASD avoided, excluding FAS	22	= ay * ba
bc	Number of births with FAS avoided	5	= az * ba
bd	Proportion of FASD costs that are patient costs	25%	√
be	Lifetime cost, FASD excluding FAS	$1,231,232	Table 22
bf	Lifetime cost, FAS	$1,831,283	Table 22
bg	Lifetime patient cost, FASD excluding FAS	$313,684	bd * be
bh	Lifetime health care and social services cost, FASD excluding FAS	$917,548	= be - bg
bi	Cost avoided, patient cost, FASD excluding FAS	$6,925,502	= bb * bg
bj	Cost avoided, health care and social services, FASD excluding FAS	$20,257,609	= bb * bh
bk	**Total cost avoided, FASD excluding FAS**	**$27,183,110**	= bi + bj
bl	Lifetime patient cost, FAS	$466,560	= bd * bf
bm	Lifetime health care and social services cost, FAS	$1,364,723	= bf * bl
bn	Cost avoided, patient cost, FAS	$2,410,101	= bc * bl
bo	Cost avoided, health care and social services, FAS	$7,049,726	= bc * bm
bp	**Total cost avoided, FAS**	**$9,459,828**	= bn + bo
bq	**Total cost avoided, all FASD**	**$36,642,938**	= bk + bp
br	**Lifetime cost avoided, brief intervention**	**$55,188,030**	= aw + bq
	Net Cost of Screening and Brief Intervention		
bs	Net Cost of Screening and Brief Intervention	$57,870,233	= an - br
bt	QALYs saved	5,703	Table 14
bu	CE ($/QALY Saved)	$10,147	= bs / bt
bv	Net Cost of Brief Intervention, 1.5% Discount	$39,900,057	Calculated
bw	QALYs saved, 1.5% Discount	3,773	Calculated
bx	**CE ($/QALY Saved), 1.5% Discount**	**$10,575**	= bv / bw

√ = Estimates from the literature

Sensitivity Analysis

We also modified several major assumptions and recalculated the CE as follows:

- Assume that screening frequency is changed from one time each year to one time every five (5) years (Table 23, row *a*): CE = **$3**
- Reduced QoL impact. Assume that the QoL reduction for binge drinking changes from 0.123 to 0.082 (Table 14, row *q*), the QoL reduction for hazardous drinking changes from 0.179 to 0.121 (Table 14, row *r*), and the QoL reduction for harmful drinking changes from 0.304 to 0.204 (Table 14, row *s*): CE = $13,733
- Increased QoL impact. Assume that the QoL reduction for binge drinking changes from 0.123 to 0.177 (Table 14, row *q*), the QoL reduction for hazardous drinking changes from 0.179 to 0.252 (Table 14, row *r*), and the QoL reduction for harmful drinking changes from 0.304 to 0.418 (Table 14, row *s*): CE = $8,220
- Assume that the proportion of births with FASD increases from 1.81% to 2.93% (Table 14, row *af*): CE = $6,091

- Assume that the number of pregnant women with any alcohol use decreases from 9.0% to 3.0% (Table 17): CE = $10,554
- Assume that the screening sensitivity decreases from 84% to 67% (Table 14, row *as*): CE = $13,397
- Assume that the screening sensitivity increases from 84% to 94% (Table 14, row *as*): CE = $9,392
- Assume that the screening specificity decreases from 74% to 46% (Table 23, row *s*): CE = $15,771
- Assume that the screening sensitivity increases from 74% to 88% (Table 23, row *s*): CE = $7,977
- Assume that the frequency of the brief intervention changes from once every 3 years to once every 2 years (Table 23, row *ae*): CE = $12,002
- Assume that the frequency of the brief intervention changes from once every 3 years to once every 4 years (Table 23, row *ae*): CE = $9,862
- Assume that the proportion benefitting from treatment in the general population is decreased from 13.9% to 8.7% (Table 14, row *au*) and is decreased from 16.7% to 8.0% in pregnant women (Table 14, row *bd*): CE = **$25,002**
- Assume that the proportion benefitting from treatment in the general population is increased from 13.9% to 16.1% (Table 14, row *au*) and is increased from 16.7% to 23.3% in pregnant women (Table 14, row *bd*): CE = $6,386
- Assume that the impacts of FASD are excluded (Table, row *bf*): CE = $21,550

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with behavioural counselling for the prevention of alcohol misuse is estimated to be 3,773 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $10,575 per QALY (see Table 24).

Table 24: Screening for Unhealthy Alcohol Use and Brief Intervention in a Birth Cohort of 40,000

Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume No Current Service			
1.5% Discount Rate	**3,773**	**2,229**	**4,854**
3% Discount Rate	2,696	1,590	3,469
0% Discount Rate	5,703	3,376	7,337
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$10,575**	**$3**	**$25,002**
3% Discount Rate	$10,939	$650	$25,111
0% Discount Rate	$10,147	Cost-saving	$24,842
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	Cost-saving	Cost-saving	$3,909
3% Discount Rate	Cost-saving	Cost-saving	$4,176
0% Discount Rate	Cost-saving	Cost-saving	$2,616

Screening and Interventions to Reduce Unhealthy Drug Use

United States Preventive Services Task Force Recommendations (2020)[1588]

An estimated 12% of adults 18 years or older and 8% of adolescents aged 12 to 17 years report unhealthy use of prescription or illegal drugs in the US.

The USPSTF recommends screening by asking questions about unhealthy drug use in adults age 18 years or older. Screening should be implemented when services for accurate diagnosis, effective treatment, and appropriate care can be offered or referred. (Screening refers to asking questions about unhealthy drug use, not testing biological specimens.) (B recommendation)

The USPSTF concludes that the current evidence is insufficient to assess the balance of benefits and harms of screening for unhealthy drug use in adolescents. (I statement)

Best in the World

- In the US, paediatricians' self-reported rates of screening adolescents for routine unhealthy drug use vary from less than 50% to 86%, although few physicians report using a validated screening tool, and most rely on clinical impressions.[1589]
- In the survey in which 86% of paediatricians self-reported rates of screening adolescents for routine unhealthy drug use, 46.5% reported using a validated screening tool.[1590]
- Based on the US National Survey on Drug Use and Health (noninstitutionalized individuals aged 12 years and older), the percentage of individuals with ≥1 health care visit who reported screening by a health care provider ("During the past 12 months, did any doctor or other health care professional ask, in person or on a form, if you use marijuana or other illegal drugs?") increased from 48.5% in 2013 to 54.3% in 2015.[1591]
- There were 21,505 individuals in the 2015-17 US National Survey on Drug Use and Health who were 18 years or older, had at least one health care visit during the past 12 months **and** who reported any past-year drug use. Of these individuals, 34.5% (7,042) reported no drug use screening or discussion, 44.5% (9,703) reported screening only and 21.0% (4,760) reported drug use discussions with their providers.[1592]

[1588] US Preventive Services Task Force. Screening for Unhealthy Drug Use: US Preventive Services Task Force Recommendation Statement. *JAMA*. 2020; 323(22): 2301-2309.
[1589] Levy S, Williams J; Committee on Substance Use and Prevention. Substance use screening, brief intervention, and referral to treatment. *Pediatrics*. 2016; 138(1): e20161211.
[1590] Harris S, Herr-Zaya K, Weinstein Z et al. Results of a statewide survey of adolescent substance use screening rates and practices in primary care. *Substance Abuse*. 2012; 33: 321-6.
[1591] Scialli, A & Terplan, M. Rates of and factors associated with patient-reported illicit drug use screening by health care professionals in the United States from 2013 to 2015. *Journal of Addiction Medicine*. 2020; 14(1): 63-68.
[1592] Mauro P, Samples H, Klein K et al. Discussing drug use with health care providers is associated with perceived need and receipt of drug treatment among adults in the United States: We need to talk. *Medical Care*. 2020; 58(7): 617-624.

- For modelling purposes, we assume that the ***best in the world*** screening rate is 54.3% of those who have had a health care visit in the past year, based on results from the 2015 US National Survey on Drug Use and Health.[1593]

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with screening and brief behavioural interventions to reduce unhealthy drug use in adults 18 to 69 years of age in a British Columbia birth cohort of 40,000.

In estimating CPB, we made the following assumptions:

Defining and Estimating the Population at Risk

- Unhealthy drug use is defined by the USPSTF as "the use of illegal drugs and the nonmedical use of prescription psychoactive medications (i.e., use of medications for reasons, for duration, in amounts, or with frequency other than prescribed or use by persons other than the prescribed individual)."[1594] Unhealthy drug use does not include tobacco or alcohol use.
- In the United States in 2018/2019, an estimated 12.73% of the adult population (**ages 18 and older**) had unhealthy drug use in the **past month** (Table 1).[1595] The majority of this usage was for marijuana (11.17% of the adult population). In the **past year**, 3.69% of the US adult population misused pain relievers, 2.16% used cocaine, 0.76% used methamphetamines and 0.31% used heroin at least once (Table 1).
- The proportion of the US adult population with unhealthy drug use in the **past month** other than marijuana was estimated at 3.41% (Table 1).

Table 1: Unhealthy Drug Use in the Past Month / Year
United States, 2018 and 2019
By Age Group and Drug Category

		18-25			26+			18+		
Drug Category	**Time Frame**	**Estimate**	95% CI		Estimate	95% CI		**Estimate**	95% CI	
Marijuana	Past Month	**22.54%**	21.90%	23.19%	**9.39%**	9.08%	9.70%	**11.17%**	10.88%	11.47%
Marijuana	Past Year	**35.09%**	34.33%	35.85%	**14.27%**	13.88%	14.67%	**17.10%**	16.72%	17.47%
Pain Reliever Misuse	Past Year	**5.33%**	5.03%	5.65%	**3.43%**	3.26%	3.61%	**3.69%**	3.53%	3.85%
Cocaine	Past Year	**5.54%**	5.19%	5.92%	**1.63%**	1.52%	1.75%	**2.16%**	2.05%	2.28%
Methamphetamine	Past Year	**0.81%**	0.70%	0.94%	**0.75%**	0.67%	0.83%	**0.76%**	0.69%	0.83%
Heroin	Past Year	**0.36%**	0.28%	0.45%	**0.30%**	0.25%	0.37%	**0.31%**	0.26%	0.37%
All Unhealthy Drug Use	Past Month	**24.40%**	23.74%	25.07%	**10.90%**	10.57%	11.24%	**12.73%**	12.42%	13.05%
All Unhealthy Drug Use excluding	Past Month	**6.07%**	5.73%	6.43%	**2.99%**	2.82%	3.16%	**3.41%**	3.25%	3.57%

Note: *Unhealthy Drug Use includes the misuse of prescription psychotherapeutics or the use of marijuana, cocaine (including crack), heroin, hallucinogens, inhalants, or methamphetamine. Misuse of prescription psychotherapeutics is defined as use in any way not directed by a doctor, including use without a prescription of one's own; use in greater amounts, more often, or longer than told; or use in any other way not directed by a doctor. Prescription psychotherapeutics do not include over-the-counter drugs.*

[1593] Scialli, A & Terplan, M. Rates of and factors associated with patient-reported illicit drug use screening by health care professionals in the United States from 2013 to 2015. *Journal of Addiction Medicine*. 2020; 14(1): 63-68.

[1594] US Preventive Services Task Force. Screening for Unhealthy Drug Use: US Preventive Services Task Force Recommendation Statement. *JAMA*. 2020; 323(22): 2301-2309.

[1595] Substance Abuse and Mental Health Services Administration (SAMHSA), Center for Behavioral Health Statistics and Quality. *2018-2019 National Survey on Drug Use and Health: Model-Based Prevalence Estimates*. Available online at https://www.samhsa.gov/data/report/2018-2019-nsduh-state-prevalence-estimates. Accessed August 2021.

- Based on responses in the 2015/16 Canadian Community Health Survey, Bragazzi et al estimated the **past year** unhealthy drug use (including cannabis) in Canada to be 10.4% (95% CI 10.1% - 10.8%) in the **population ages 12 and older**.[1596] The results for BC were 12.6% (95% CI 11.7% - 13.5%). The past year unhealthy drug use by females in Canada was 7.4% (95% CI 7.1% - 7.8%) and for males was 13.6% (95% CI 13.0 – 14.1%). The past year unhealthy drug use by age group in Canada was as follows:
    - 12 to 19 – 10.1% (95% CI 9.2% - 11.0%)
    - 20 to 29 – 23.5% (95% CI 22.1% - 24.8%)
    - 30 to 39 – 15.9% (95% CI 15.0% - 16.9%)
    - 40 to 49 – 8.0% (95% CI 7.4% - 8.7%)
    - 50 to 59 – 7.3% (95% CI 6.8% - 8.0%)
    - 60 to 69 – 4.1% (95% CI 3.7% - 4.6%)
    - ≥ 70 – 1.0% (95% CI 0.8% - 1.3%)
- Based on data from the 2017 Canadian Tobacco, Alcohol and Drugs Survey (CTADS), 15.2% of Canadians **ages 15 and older** had unhealthy drug use, **including cannabis** (see Table 2).[1597] **Excluding cannabis**, 3.3% of Canadians ages 15 and older reported using cocaine/crack, speed/methamphetamine/crystal meth, ecstasy, hallucinogens and/or heroin. A further 1.2% reported the unhealthy use of pharmaceuticals, although these individuals may also have had other unhealthy drug use.
- The proportion of Canadians ages 15 and older with unhealthy drug use (**excluding cannabis**) is higher in males (4.9%) than females (1.8%). The proportion of male Canadians ages 15 and older with unhealthy drug use (**including cannabis**) is 71% higher than in females (19.3% vs 11.3%) (Table 2).

Table 2: Unhealthy Drug Use in the Past Year
Canada, 2017
By Age Group and Drug Category

	15-19			20-24			25+			15 and older			15+ Female			15+ Male		
Drug Category	Estimate	95% CI		Estimate	95% CI		Estimate	95% CI		**Estimate**	95% CI		**Estimate**	95% CI		**Estimate**	95% CI	
Including Cannabis*	19.9%	17.8%	21.9%	34.9%	31.9%	37.9%	13.0%	11.1%	14.9%	**15.2%**	13.6%	16.9%	**11.3%**	9.5%	13.1%	**19.3%**	16.6%	22.0%
Excluding Cannabis**	4.1%	3.1%	5.1%	10.3%	8.3%	12.3%	2.6%	1.5%	3.8%	**3.3%**	2.4%	4.3%	**1.8%**	1.1%	2.4%	**4.9%**	3.1%	6.8%
Pharmaceuticals***	2.1%	1.4%	2.7%	3.6%	2.3%	4.9%	#			**1.2%**	0.6%	1.7%	#			**1.1%**	0.7%	1.5%

** Cannabis, cocaine/crack, speed/methamphetamine/crystal meth, ecstasy, hallucinogens, heroin.*

*** Cocaine/crack, speed/methamphetamine/crystal meth, ecstasy, hallucinogens, heroin.*

****Unhealthy use of pharmaceuticals including pain relievers, stimulants and sedatives. Unhealthy use includes drugs used for reasons other than for prescribed therapeutic purposes including use for the experience, for the feeling they caused, to get high, to feel better (improve mood) or to cope with stress or problems. Those with unhealthy use of pharmaceuticals may also have unhealthy use of other drugs.*

 # Not reported due to high sampling variability.

- The 2017 CTADS sample size is insufficient to provide detailed information for BC.[1598] Of note, however, is that past year use of **cannabis**, cocaine/crack, speed/methamphetamine/crystal meth, ecstasy, hallucinogens and/or heroin in the BC population ages 15 and older is estimated at 24.4%, 9.2 percentage points higher than

[1596] Bragazzi N, Beamish D, Kong J et al. Illicit drug use in Canada and implications for suicidal behaviours, and household food insecurity: Findings from a large, nationally representative survey. *International Journal of Environmental Research and Public Health.* 2021; 18: 6425.
[1597] Statistics Canada. *Canadian Tobacco, Alcohol and Drugs Survey (CTADS): 2017 detailed tables*. Available online at https://www.canada.ca/en/health-canada/services/canadian-tobacco-alcohol-drugs-survey/2017-summary/2017-detailed-tables.html#t13. Accessed August 2021.
[1598] Ibid.

the Canadian average of 15.2% (or +60.5%). The province with the second highest rate is Nova Scotia at 19.0%.

- Bragazzi et al estimated the past year unhealthy drug use (including cannabis) in the population ages 12 and older in BC at 12.6% (95% CI of 11.7% to 13.5%), 2.2 percentage points higher than the Canadian average of 10.4% (or +21.2%).[1599]
- The systematic review and meta-analysis by Leung et al calculated that 22% (95% CI of 20% - 24%) of individuals who used cannabis in the past month/year had a cannabis use disorder.[1600] See footnote for a definition of cannabis use disorder.[1601]

For modelling purposes, we estimated the prevalence of unhealthy drug use in British Columbians ages 18 and older as follows:

- Start with the 3.3% of Canadians ages 15 and older who reported using cocaine/crack, speed/methamphetamine/crystal meth, ecstasy, hallucinogens and/or heroin in 2017.[1602]
- Increase this by 0.5% to take into account unhealthy use of pharmaceuticals by those who may not have used any of the above drugs and the fact that 15, 16 and 17 year-olds are included in the 3.3%.

[1599] Bragazzi N, Beamish D, Kong J et al. Illicit drug use in Canada and implications for suicidal behaviours, and household food insecurity: Findings from a large, nationally representative survey. *International Journal of Environmental Research and Public Health.* 2021; 18: 6425.

[1600] Leung J, Chan G, Hides L et al. What is the prevalence and risk of cannabis use disorders among people who use cannabis? A systematic review and meta-analysis. *Addictive Behaviors*. 2020; 109: 106479.

[1601] Patel J and Marwaha R. *Cannabis Use Disorder*. StatPearls Publishing, 2021. Available online at https://www.ncbi.nlm.nih.gov/books/NBK538131/. Accessed August 2021.

"Cannabis abuse and dependence were combined in the DSM-5 into a single entity capturing the behavioral disorder that can occur with chronic cannabis use and named Cannabis Use Disorder; it is defined as:

A problematic pattern of cannabis use leading to clinically significant impairment or distress, as manifested by at least two of the following, occurring within a 12-month period:

- Cannabis is often taken in larger amounts or over a longer period than was intended.
- There is a persistent desire or unsuccessful efforts to cut down or control cannabis use.
- A great deal of time is spent in activities necessary to obtain cannabis, use cannabis, or recover from its effects.
- Craving, or a strong desire or urge to use cannabis.
- Recurrent cannabis use results in failure to fulfill role obligations at work, school, or home.
- Continued cannabis use despite having persistent or recurrent social or interpersonal problems caused or exacerbated by the effects of cannabis.
- Important social, occupational, or recreational activities are given up or reduced because of cannabis use.
- Recurrent cannabis use in situations in which it is physically hazardous.
- Cannabis use continues despite knowledge of having a persistent or recurrent physical or psychological problem that is likely to have been caused or exacerbated by cannabis.
- Tolerance, as defined by either: (1) a need for markedly increased cannabis to achieve intoxication or desired effect or (2) a markedly diminished effect with continued use of the same amount of the substance.
- Withdrawal, as manifested by either (1) the characteristic withdrawal syndrome for cannabis or (2) cannabis is taken to relieve or avoid withdrawal symptoms."

[1602] Statistics Canada. *Canadian Tobacco, Alcohol and Drugs Survey (CTADS): 2017 detailed tables*. Available online at https://www.canada.ca/en/health-canada/services/canadian-tobacco-alcohol-drugs-survey/2017-summary/2017-detailed-tables.html#t13. Accessed August 2021.

- Adjust the resulting 3.8% upward by 40.8% (the midpoint of 21.2%[1603] and 60.5%[1604]) to take into account the higher than average unhealthy drug use in BC compared with other Canadian provinces. The result is an estimated prevalence for unhealthy drug use (excluding cannabis) in BC of 5.35%.
- To estimate the prevalence of cannabis use disorder, we started with the 23.8%[1605] of British Columbians ages 15 and older with unhealthy drug use (including cannabis) and reduced this by the 5.35% estimated above for 18.45% of the BC population who used cannabis (but no other unhealthy drug use) in the past year. Of the 18.45%, we assumed that 22%[1606] had a cannabis use disorder, or 4.06% of BC adults.
- **In summary, we estimated that 5.35% of the BC adult population had unhealthy drug use (excluding cannabis) and a further 4.06% had cannabis use disorder.**
- We proportionally distributed unhealthy drug use (excluding cannabis) and cannabis use disorder by sex based on evidence from the 2017 CTADS.[1607]
- We proportionally distributed unhealthy drug use by age group using the evidence from the 2015/16 CCHS.[1608]

- By comparison, a review of the first 7 screening, brief intervention, and referral to treatment (SBIRT) programs funded by the US Substance Abuse and Mental Health Services Administration (SAMHSA) found a mean positive screening rate for unhealthy drug use in the past 30 days of 9.4%, ranging from 7.0% in a health centre to 17.9% in an emergency department.[1609] This positive screening rate for unhealthy drug use of 9.4% compares favourably with our estimate of a prevalence of 9.41% unhealthy drug use in BC adults.
- By another comparison, the USPSTF estimated that 12% of adults 18 years or older report unhealthy drug use in the US[1610] while SAMHSA's estimate is 12.73% (Table 1).[1611] **Both of these estimates, however, include all adults who use cannabis, while our estimate for BC of 9.41% only includes those with cannabis use disorder** (or 22% of those who use cannabis)**.**

[1603] Bragazzi N, Beamish D, Kong J et al. Illicit drug use in Canada and implications for suicidal behaviours, and household food insecurity: Findings from a large, nationally representative survey. *International Journal of Environmental Research and Public Health.* 2021; 18: 6425.
[1604] Statistics Canada. *Canadian Tobacco, Alcohol and Drugs Survey (CTADS): 2017 detailed tables*. Available online at https://www.canada.ca/en/health-canada/services/canadian-tobacco-alcohol-drugs-survey/2017-summary/2017-detailed-tables.html#t13. Accessed August 2021.
[1605] Ibid.
[1606] Leung J, Chan G, Hides L et al. What is the prevalence and risk of cannabis use disorders among people who use cannabis? A systematic review and meta-analysis. *Addictive Behaviors*. 2020; 109: 106479.
[1607] Statistics Canada. *Canadian Tobacco, Alcohol and Drugs Survey (CTADS): 2017 detailed tables*. Available online at https://www.canada.ca/en/health-canada/services/canadian-tobacco-alcohol-drugs-survey/2017-summary/2017-detailed-tables.html#t13. Accessed August 2021.
[1608] Bragazzi N, Beamish D, Kong J et al. Illicit drug use in Canada and implications for suicidal behaviours, and household food insecurity: Findings from a large, nationally representative survey. *International Journal of Environmental Research and Public Health.* 2021; 18: 6425.
[1609] Bray J, Mallonee E, Dowd W et al. Program- and service-level costs of seven screening, brief intervention, and referral to treatment programs. *Substance Abuse and Rehabilitation*. 2014; 5: 63-73.
[1610] US Preventive Services Task Force. Screening for Unhealthy Drug Use: US Preventive Services Task Force Recommendation Statement. *JAMA*. 2020; 323(22): 2301-2309.
[1611] Substance Abuse and Mental Health Services Administration (SAMHSA), Center for Behavioral Health Statistics and Quality. *2018-2019 National Survey on Drug Use and Health: Model-Based Prevalence Estimates*. Available online at https://www.samhsa.gov/data/report/2018-2019-nsduh-state-prevalence-estimates. Accessed August 2021.

Calculating Life Years Lived with Unhealthy Drug Use

- Based on the above assumptions of the prevalence and distribution (by age and sex) of unhealthy drug use in BC, we calculated the number of life years lived with unhealthy drug use between the ages of 18 and 59/69/79 in a BC birth cohort of 40,000. Of the 1,986,226 life years lived between the ages of 18 and 69 in a BC birth cohort of 40,000, an estimated 121,403 (6.11%) would be years lived with unhealthy drug use (excluding cannabis use disorder) and a further 92,065 (4.64%) would be life years lived with cannabis use disorder (Table 3).

- For the base model, we assumed that screening would stop at age 69 and modified this to age 59 and 79 in the sensitivity analysis.

Table 3: Life Years Lived with Unhealthy Drug Use

Between the Ages of 18 and 59/69/79

In a British Columbia Birth Cohort of 40,000

	Female					*Male*					*Total Population*				
		Unhealthy Drug Use		Cannabis Use			Unhealthy Drug Use		Cannabis Use			Unhealthy Drug Use		Cannabis Use	
	Total Life	(excluding Cannabis)		Disorder		**Total Life**	(excluding Cannabis)		Disorder		**Total Life**	(excluding Cannabis)		Disorder	
Age	**Years**	%	#	%	#	**Years**	%	#	%	#	**Years**	%	#	%	#
18	19,891	2.79%	554	2.77%	551	19,870	7.59%	1,508	5.10%	1,013	39,761	5.19%	2,063	3.93%	1,564
19	19,885	2.79%	554	2.77%	551	19,858	7.59%	1,508	5.10%	1,012	39,742	5.19%	2,062	3.93%	1,563
20	19,878	6.48%	1,288	6.44%	1,281	19,843	17.67%	3,506	11.87%	2,354	39,721	12.07%	4,794	9.15%	3,635
21	19,871	6.48%	1,287	6.44%	1,280	19,826	17.67%	3,504	11.87%	2,353	39,696	12.07%	4,791	9.15%	3,633
22	19,863	6.48%	1,286	6.44%	1,279	19,807	17.68%	3,502	11.87%	2,351	39,670	12.07%	4,788	9.15%	3,631
23	19,855	6.47%	1,285	6.44%	1,279	19,786	17.68%	3,499	11.88%	2,350	39,641	12.07%	4,784	9.15%	3,628
24	19,847	6.47%	1,284	6.44%	1,278	19,763	17.69%	3,496	11.88%	2,348	39,610	12.07%	4,781	9.15%	3,625
25	19,839	6.47%	1,283	6.43%	1,276	19,739	17.70%	3,493	11.88%	2,346	39,578	12.07%	4,777	9.15%	3,622
26	19,830	6.47%	1,282	6.43%	1,275	19,714	17.71%	3,491	11.89%	2,344	39,544	12.07%	4,773	9.15%	3,619
27	19,821	6.46%	1,281	6.43%	1,274	19,689	17.71%	3,487	11.89%	2,342	39,509	12.07%	4,769	9.15%	3,616
28	19,811	6.46%	1,280	6.43%	1,273	19,662	17.72%	3,484	11.90%	2,340	39,473	12.07%	4,764	9.15%	3,613
29	19,801	6.46%	1,279	6.42%	1,272	19,635	17.73%	3,481	11.90%	2,338	39,436	12.07%	4,760	9.15%	3,609
30	19,790	4.37%	864	4.34%	860	19,607	12.00%	2,353	8.06%	1,580	39,398	8.17%	3,217	6.19%	2,440
31	19,779	4.37%	863	4.34%	859	19,579	12.01%	2,351	8.06%	1,578	39,358	8.17%	3,214	6.19%	2,437
32	19,767	4.36%	863	4.34%	858	19,550	12.01%	2,348	8.07%	1,577	39,317	8.17%	3,211	6.19%	2,435
33	19,755	4.36%	862	4.34%	857	19,520	12.02%	2,346	8.07%	1,575	39,275	8.17%	3,207	6.19%	2,432
34	19,742	4.36%	861	4.34%	856	19,489	12.02%	2,343	8.07%	1,573	39,232	8.17%	3,204	6.19%	2,429
35	19,729	4.36%	860	4.33%	855	19,458	12.03%	2,340	8.08%	1,572	39,187	8.17%	3,200	6.19%	2,427
36	19,715	4.36%	859	4.33%	854	19,425	12.03%	2,338	8.08%	1,570	39,140	8.17%	3,196	6.19%	2,424
37	19,700	4.35%	858	4.33%	853	19,392	12.04%	2,335	8.08%	1,568	39,092	8.17%	3,192	6.19%	2,421
38	19,685	4.35%	857	4.33%	852	19,357	12.05%	2,332	8.09%	1,566	39,042	8.17%	3,188	6.19%	2,418
39	19,669	4.35%	855	4.33%	851	19,321	12.05%	2,329	8.09%	1,564	38,990	8.17%	3,184	6.19%	2,415
40	19,652	2.19%	430	2.18%	427	19,283	6.07%	1,170	4.07%	786	38,936	4.11%	1,600	3.12%	1,213
41	19,634	2.19%	429	2.17%	427	19,245	6.07%	1,168	4.08%	785	38,879	4.11%	1,597	3.12%	1,211
42	19,615	2.18%	428	2.17%	426	19,204	6.07%	1,166	4.08%	783	38,819	4.11%	1,595	3.12%	1,210
43	19,594	2.18%	428	2.17%	426	19,162	6.08%	1,165	4.08%	782	38,756	4.11%	1,592	3.12%	1,208
44	19,572	2.18%	427	2.17%	425	19,117	6.08%	1,163	4.08%	781	38,690	4.11%	1,590	3.12%	1,205
45	19,549	2.18%	426	2.17%	424	19,071	6.09%	1,160	4.09%	779	38,620	4.11%	1,587	3.12%	1,203
46	19,524	2.18%	425	2.17%	423	19,022	6.09%	1,158	4.09%	778	38,546	4.11%	1,584	3.12%	1,201
47	19,497	2.18%	425	2.17%	422	18,970	6.09%	1,156	4.09%	776	38,467	4.11%	1,580	3.12%	1,199
48	19,469	2.18%	424	2.16%	421	18,915	6.10%	1,153	4.09%	775	38,384	4.11%	1,577	3.12%	1,196
49	19,438	2.17%	423	2.16%	420	18,857	6.10%	1,151	4.10%	773	38,295	4.11%	1,573	3.12%	1,193
50	19,405	1.98%	385	1.97%	383	18,795	5.57%	1,047	3.74%	703	38,200	3.75%	1,432	2.84%	1,086
51	19,370	1.98%	384	1.97%	382	18,729	5.58%	1,045	3.75%	702	38,099	3.75%	1,428	2.84%	1,083
52	19,332	1.98%	383	1.97%	381	18,659	5.58%	1,042	3.75%	700	37,990	3.75%	1,424	2.84%	1,080
53	19,291	1.98%	381	1.97%	379	18,583	5.59%	1,038	3.75%	697	37,874	3.75%	1,420	2.84%	1,077
54	19,247	1.98%	380	1.97%	378	18,503	5.59%	1,035	3.76%	695	37,750	3.75%	1,415	2.84%	1,073
55	19,199	1.97%	379	1.96%	377	18,417	5.60%	1,031	3.76%	693	37,616	3.75%	1,410	2.84%	1,069
56	19,148	1.97%	377	1.96%	375	18,325	5.61%	1,027	3.77%	690	37,472	3.75%	1,405	2.84%	1,065
57	19,092	1.97%	376	1.96%	374	18,226	5.61%	1,023	3.77%	687	37,318	3.75%	1,399	2.84%	1,061
58	19,032	1.97%	374	1.96%	372	18,120	5.62%	1,019	3.78%	684	37,152	3.75%	1,393	2.84%	1,056
59	18,966	1.96%	372	1.95%	370	18,006	5.63%	1,014	3.78%	681	36,972	3.75%	1,386	2.84%	1,051
Total to Age 59	**823,150**	**3.72%**	**30,602**	**3.70%**	**30,439**	**807,096**	**10.32%**	**83,305**	**6.93%**	**55,941**	**1,630,246**	**6.99%**	**113,907**	**5.30%**	**86,380**
60	18,895	1.10%	208	1.10%	207	17,884	3.17%	566	2.13%	380	36,778	2.11%	774	1.60%	587
61	18,817	1.10%	207	1.09%	206	17,752	3.17%	563	2.13%	378	36,569	2.11%	770	1.60%	584
62	18,733	1.10%	206	1.09%	205	17,610	3.18%	560	2.13%	376	36,343	2.11%	765	1.60%	580
63	18,641	1.10%	204	1.09%	203	17,458	3.18%	556	2.14%	373	36,099	2.11%	760	1.60%	576
64	18,541	1.09%	203	1.09%	202	17,293	3.19%	552	2.14%	371	35,834	2.11%	755	1.60%	572
65	18,432	1.09%	201	1.09%	200	17,116	3.20%	547	2.15%	368	35,548	2.11%	749	1.60%	568
66	18,312	1.09%	199	1.08%	198	16,925	3.21%	543	2.15%	364	35,237	2.11%	742	1.60%	563
67	18,181	1.09%	197	1.08%	196	16,719	3.21%	537	2.16%	361	34,900	2.11%	735	1.60%	557
68	18,038	1.08%	195	1.08%	194	16,496	3.22%	532	2.16%	357	34,534	2.11%	727	1.60%	551
69	17,881	1.08%	193	1.07%	192	16,256	3.23%	526	2.17%	353	34,137	2.11%	719	1.60%	545
Total to Age 69	**1,007,621**	**3.24%**	**32,616**	**3.22%**	**32,442**	**978,605**	**9.07%**	**88,787**	**6.09%**	**59,623**	**1,986,226**	**6.11%**	**121,403**	**4.64%**	**92,065**
70	17,709	0.26%	47	0.26%	46	15,997	0.79%	127	0.53%	85	33,706	0.51%	173	0.39%	131
71	17,520	0.26%	46	0.26%	46	15,718	0.79%	125	0.53%	84	33,238	0.51%	171	0.39%	129
72	17,313	0.26%	45	0.26%	45	15,416	0.80%	123	0.54%	83	32,729	0.51%	168	0.39%	127
73	17,085	0.26%	44	0.26%	44	15,092	0.80%	121	0.54%	81	32,177	0.51%	165	0.39%	125
74	16,835	0.26%	44	0.26%	43	14,742	0.80%	119	0.54%	80	31,577	0.51%	162	0.39%	123
75	16,561	0.26%	43	0.26%	42	14,365	0.81%	116	0.54%	78	30,926	0.51%	159	0.39%	120
76	16,260	0.26%	42	0.26%	41	13,960	0.81%	114	0.55%	76	30,220	0.51%	155	0.39%	118
77	15,929	0.26%	41	0.25%	40	13,526	0.82%	111	0.55%	74	29,455	0.51%	151	0.39%	115
78	15,567	0.25%	40	0.25%	39	13,061	0.82%	108	0.55%	72	28,628	0.51%	147	0.39%	111
79	15,171	0.25%	38	0.25%	38	12,563	0.83%	104	0.56%	70	27,734	0.51%	142	0.39%	108
Total to Age 79	***1,173,570***	***2.82%***	***33,044***	***2.80%***	***32,868***	***1,123,045***	***8.01%***	***89,953***	***5.38%***	***60,406***	***2,296,615***	***5.36%***	***122,997***	***4.06%***	***93,273***

Estimating the Quality of Life Reduction

- Disability weights assigned by the Global Burden of Diseases (GBD) study for unhealthy drug use are as follows:[1612]
    - **Mild opioid dependence** ("uses heroin or methadone daily and has difficulty controlling the habit. When not using, the person functions normally") – **0.335** with a 95% CI of 0.221 to 0.473.
    - **Severe opioid dependence** ("uses heroin daily and has difficulty controlling the habit. When the effects wear off, the person feels severe nausea, agitation, vomiting and fever. The person has a lot of difficulty in daily activities") – **0.697** with a 95% CI of 0.510 to 0.843.
    - **Mild cocaine dependence** ("uses cocaine at least once a week and has some difficulty controlling the habit. When not using, the person functions normally") – **0.116** with a 95% CI of 0.074 to 0.165.
    - **Severe cocaine dependence** ("uses cocaine and has difficulty controlling the habit. The person sometimes has mood swings, anxiety, paranoia, hallucinations and sleep problems, and has some difficulty in daily activities") – **0.479** with a 95% CI of 0.324 to 0.634.
    - **Mild amphetamine dependence** ("uses stimulants at least once a week and has some difficulty controlling the habit. When not using, the person functions normally") – **0.079** with a 95% CI of 0.051 to 0.114.
    - **Severe amphetamine dependence** ("uses stimulants and has difficulty controlling the habit. The person sometimes has depression, hallucinations and mood swings, and has difficulty in daily activities") – **0.486** with a 95% CI of 0.329 to 0.637.
    - **Mild cannabis dependence** ("uses marijuana at least once a week and has some difficulty controlling the habit. When not using, the person functions normally") – **0.039** with a 95% CI of 0.024 to 0.060.
    - **Severe cannabis dependence** ("uses marijuana daily and has difficulty controlling the habit. The person sometimes has mood swings, anxiety and hallucinations, and has some difficulty in daily activities") – **0.266** with a 95% CI of 0.178 to 0.364.
- In estimating the QoL reduction associated with unhealthy drug use (excluding cannabis), we assumed a distribution in the population with unhealthy drug use of 59% opioid use, 28% cocaine use and 13% amphetamine use, based on estimates calculated by the GBD for high income North America (Canada and the US).[1613,1614]
- In a study including 201 untreated opioid drug users in Vancouver, Fischer and colleagues found that 6.1% received legal paid work income, 25.4% had permanent housing, 53.3% rated their health as fair or poor and 74.1% were under judicial

[1612] Institute for Health Metrics and Evaluation. GBD 2016 sequelae, health states, health state lay descriptions, and disability weights. Available online at http://ghdx.healthdata.org/record/global-burden-disease-study-2016-gbd-2016-disability-weights. Accessed August 2021.
[1613] GBD 2016 Alcohol and Drug Use Collaborators. The global burden of disease attributable to alcohol and drug use in 195 countries and territories, 1990–2016: A systematic analysis for the Global Burden of Disease Study 2016. *Lancet Psychiatry*. 2018; 5: 987-1012.
[1614] Peacock A, Leung J, Larney S et al. Global statistics on alcohol, tobacco and illicit drug use: 2017 status report. *Addiction*. 2018; 113: 1905-26.

restraint.[1615] In a further study using this same data, Monga et al found that 64.3% of untreated opioid drug users in Vancouver were in the group of injection drug users of heroin exhibiting the highest levels of HIV and Hepatitis C infections.[1616]

- Based on data from the US National Epidemiologic Survey on Alcohol and Related Conditions – III, Grant and colleagues found that between 34% (lifetime prevalence) and 49% (12-month prevalence) of those with a drug use disorder were in the 'mild' category (3 or less of the 11 criteria used in the DSM-V to diagnose a substance use disorder).[1617]
- Data from SAMHSA indicates that of those who had used cocaine at any time during the past year, 37% used cocaine during the past month. Similarly, of those who had used amphetamine at any time during the past year, 32% used amphetamine during the past month.[1618]
- Based on this information, we calculated disability weights for unhealthy drug use assuming that 34% of those with opioid and cannabis use disorder (CUD) would be in the 'mild' category and 66% would be in the 'severe' category. For cocaine and amphetamine use we assumed the severe use would be 37% and 32% respectively (after SAMHSA). Life years lived with unhealthy drug use (excluding CUD) are associated with an average disability weight of 0.436. Life years lived with CUD are associated with an average disability weight of 0.189 (Table 4).

Table 4: Disability Weights Associated with Unhealthy Drug Use

	User Proportion		% of Users			Disability Weight		
	Mild	Severe	Mild	Severe	Total	Mild	Severe	Total
Opioid Use	34%	66%	20.1%	38.9%	59.0%	0.335	0.697	0.574
Cocaine Use	63%	37%	17.6%	10.4%	28.0%	0.116	0.479	0.250
Amphetamine Use	68%	32%	8.8%	4.2%	13.0%	0.079	0.486	0.209
Sub-total			**46.5%**	**53.5%**	**100.0%**	**0.240**	**0.609**	**0.436**
Cannabis Use Disorder	34%	66%	34.0%	66.0%	100.0%	0.039	0.266	**0.189**

- We then multiplied the life years lived with unhealthy drug use (Table 3) by the appropriate disability weight (Table 4). For example, in our birth cohort of 40,000, an estimated 554 18-year old females would have unhealthy drug use (excluding CUD) while a further 551 18-year old females would have CUD (Table 5). Calculating QALYs lost for 18-year old females meant multiplying the 554 first by 0.914 (the average QoL of an 18-year old, see the *Reference Document* for details) and then by 0.436 (the disability weight for unhealthy drug use [excluding CUD]) for a calculated 221 QALYs lost. This is followed by multiplying the 553 by 0.914 and then by 0.191 for a calculated 95 QALYs lost, for a total of 316 QALYs lost (Table 5). This process is repeated for each age year and sex.

[1615] Fischer B, Rehm J, Brissette S et al. Illicit opioid use in Canada: Comparing social, health, and drug use characteristics of untreated users in five cities (OPICAN study). *Journal of Urban Health*. 2005; 82: 250 – 66.
[1616] Monga N, Rehm J, Fischer B et al. Using latent class analysis (LCA) to analyze patterns of drug use in a population of illegal opioid users. *Drug and Alcohol Dependence*. 2007; 88: 1–8.
[1617] Grant B, Saha T, Ruan W et al. Epidemiology of DSM-5 Drug Use Disorder: Results from the National Epidemiologic Survey on Alcohol and Related Conditions–III. *JAMA Psychiatry*. 2016; 73(1): 39-47.
[1618] Substance Abuse and Mental Health Services Administration (SAMHSA), Center for Behavioral Health Statistics and Quality. *Results from the 2020 National Survey on Drug Use and Health: Detailed Tables*. Table 1.1A. Available online at https://www.samhsa.gov/data/report/2020-nsduh-detailed-tables. Accessed December 2021.

- In total, unhealthy drug use in a BC birth cohort of 40,000 is expected to result in 62,692 QALYs lost between the ages of 18 and 69, 18,140 (28.9%) in females and 44,551 (71.1%) in males (Table 5).
- While the prevalence of unhealthy drug use is lower in women than men, unhealthy drug use is increasing more rapidly among women than men.[1619,1620] Substance use among women generally begins later in life, with consumption increasing more rapidly, 'telescoping' the time between initiation, a substance use disorder (SUD) and potential entry into treatment.[1621]
- Relative to men, women in SUD treatment consistently report more severe functional impairment in domains such as employment, social/family, medical and psychiatric functioning, as well as a poorer overall quality of life.[1622] This impairment is intensified by contextual factors such as exposure to intimate partner violence, trauma, homelessness and social expectations (e.g. as caretakers).[1623]
- Women are also more sensitive to the long-term effects of alcohol and drugs than men, resulting in a greater susceptibility to alcohol- and drug-related diseases and organ damage. Women with unhealthy drug use also have physiological consequences, health issues, and medical needs related to gynecology.[1624]

[1619] McHugh R, Votaw V, Sugarman D et al. Sex and gender differences in substance use disorders. *Clinical Psychology Review*. 2018; 66: 12-23.
[1620] Erol A, Karpyak V. Sex and gender-related differences in alcohol use and its consequences: Contemporary knowledge and future research considerations. *Drug and Alcohol Dependence*. 2015; 156: 1-13.
[1621] Fonseca F, Robles-Martinez M, Tirado-Munoz J et al. A gender perspective on addictive disorders. *Current Addiction Reports*. 2021; 8: 89-99.
[1622] McHugh R, Votaw V, Sugarman D et al. Sex and gender differences in substance use disorders. *Clinical Psychology Review*. 2018; 66: 12-23.
[1623] Meyer J, Isaacs K, El-Shahawy O et al. Research on women with substance use disorders: Reviewing progress and developing a research and implementation roadmap. *Drug and Alcohol Dependence*. 2019; 197: 158-63.
[1624] Center for Substance Abuse Treatment. *Substance Abuse Treatment: Addressing the Specific Needs of Women*. Treatment Improvement Protocol (TIP) Series 51. HHS Publication No. (SMA) 09-4426. Rockville, MD: Substance Abuse and Mental Health Services Administration, 2009.

Table 5: QALYs Lost Living with Unhealthy Drug Use

Between the Ages of 18 and 59/69/79

In a British Columbia Birth Cohort of 40,000

	Female				*Male*				*Total*
		Years Lived with				Years Lived with			
Age	Mean QoL*	Unhealthy Drug Use Excl CUD	CUD	QALYs Lost	Mean QoL*	Unhealthy Drug Excl CUD	CUD	QALYs Lost	QALYs Lost
18	0.914	554	551	316	0.914	1,508	1,013	776	1,092
19	0.914	554	551	316	0.914	1,508	1,012	775	1,091
20	0.914	1,288	1,281	734	0.914	3,506	2,354	1,803	2,537
21	0.914	1,287	1,280	734	0.914	3,504	2,353	1,802	2,536
22	0.914	1,286	1,279	733	0.914	3,502	2,351	1,801	2,534
23	0.914	1,285	1,279	733	0.914	3,499	2,350	1,800	2,532
24	0.914	1,284	1,278	732	0.914	3,496	2,348	1,798	2,530
25	0.914	1,283	1,276	732	0.914	3,493	2,346	1,797	2,528
26	0.914	1,282	1,275	731	0.914	3,491	2,344	1,795	2,526
27	0.914	1,281	1,274	730	0.914	3,487	2,342	1,794	2,524
28	0.914	1,280	1,273	730	0.914	3,484	2,340	1,792	2,522
29	0.914	1,279	1,272	729	0.914	3,481	2,338	1,790	2,519
30	0.890	864	860	480	0.890	2,353	1,580	1,178	1,658
31	0.890	863	859	479	0.890	2,351	1,578	1,177	1,656
32	0.890	863	858	479	0.890	2,348	1,577	1,176	1,655
33	0.890	862	857	478	0.890	2,346	1,575	1,175	1,653
34	0.890	861	856	478	0.890	2,343	1,573	1,173	1,651
35	0.890	860	855	477	0.890	2,340	1,572	1,172	1,649
36	0.890	859	854	477	0.890	2,338	1,570	1,171	1,647
37	0.890	858	853	476	0.890	2,335	1,568	1,169	1,645
38	0.890	857	852	475	0.890	2,332	1,566	1,168	1,643
39	0.890	855	851	475	0.890	2,329	1,564	1,166	1,641
40	0.854	430	427	229	0.854	1,170	786	562	791
41	0.854	429	427	229	0.854	1,168	785	561	790
42	0.854	428	426	228	0.854	1,166	783	561	789
43	0.854	428	426	228	0.854	1,165	782	560	787
44	0.854	427	425	227	0.854	1,163	781	559	786
45	0.854	426	424	227	0.854	1,160	779	558	785
46	0.854	425	423	227	0.854	1,158	778	557	783
47	0.854	425	422	226	0.854	1,156	776	555	782
48	0.854	424	421	226	0.854	1,153	775	554	780
49	0.854	423	420	225	0.854	1,151	773	553	778
50	0.820	385	383	197	0.820	1,047	703	483	680
51	0.820	384	382	196	0.820	1,045	702	482	678
52	0.820	383	381	196	0.820	1,042	700	481	676
53	0.820	381	379	195	0.820	1,038	697	479	674
54	0.820	380	378	194	0.820	1,035	695	478	672
55	0.820	379	377	194	0.820	1,031	693	476	670
56	0.820	377	375	193	0.820	1,027	690	474	667
57	0.820	376	374	192	0.820	1,023	687	472	664
58	0.820	374	372	191	0.820	1,019	684	470	661
59	0.820	372	370	190	0.820	1,014	681	468	658
Total to Age 59		**30,602**	**30,439**	**16,935**		**83,305**	**55,941**	**41,590**	**58,525**
60	0.799	208	207	104	0.799	566	380	255	358
61	0.799	207	206	103	0.799	563	378	253	356
62	0.799	206	205	102	0.799	560	376	252	354
63	0.799	204	203	102	0.799	556	373	250	352
64	0.799	203	202	101	0.799	552	371	248	349
65	0.799	201	200	100	0.799	547	368	246	346
66	0.799	199	198	99	0.799	543	364	244	343
67	0.799	197	196	98	0.799	537	361	242	340
68	0.799	195	194	97	0.799	532	357	239	336
69	0.799	193	192	96	0.799	526	353	236	333
Total to Age 69		**32,616**	**32,442**	**17,938**		**88,787**	**59,623**	**44,055**	**61,993**
70	0.757	47	46	22	0.757	127	85	54	76
71	0.757	46	46	22	0.757	125	84	53	75
72	0.757	45	45	21	0.757	123	83	52	74
73	0.757	44	44	21	0.757	121	81	51	72
74	0.757	44	43	21	0.757	119	80	51	71
75	0.757	43	42	20	0.757	116	78	49	70
76	0.757	42	41	20	0.757	114	76	48	68
77	0.757	41	40	19	0.757	111	74	47	66
78	0.757	40	39	19	0.757	108	72	46	64
79	0.757	38	38	18	0.757	104	70	44	62
Total to Age 79		***33,044***	***32,868***	***18,140***		***89,953***	***60,406***	***44,551***	***62,692***

**** See Reference document "Calculating Changes in Quality of Life". CUD=cannabis use disorder***

- In addition to a reduction in QoL associated with living with unhealthy drug use, unhealthy drug use contributes to life years lost.
- Deaths due to unhealthy drug use[1625] in BC increased from 295 in 2011 to 2,232 in 2021 (an increase of 657%) (Table 6).[1626]

Table 6: Unhealthy Drug Use Deaths by Age Group
British Columbia, 2011 - 2021

	Calendar Year											% of Total
Age Group	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2019-21
<19	4	5	6	3	5	12	25	18	13	18	29	1.2%
19-29	75	61	94	83	117	204	273	300	170	309	326	16.2%
30-39	75	61	77	101	137	261	400	396	274	415	539	24.7%
40-49	77	67	74	85	130	233	355	348	216	409	487	22.3%
50-59	54	56	62	73	110	230	314	363	214	405	558	23.6%
60-69	10	19	21	24	29	50	121	127	91	195	263	11.0%
70-79	0	1	0	0	1	3	7	8	4	16	30	1.0%
Total	**295**	**270**	**334**	**369**	**529**	**993**	**1,495**	**1,560**	**982**	**1,767**	**2,232**	**100%**

- Between 2019 and 2021, 70.6% of deaths were in adults ages 30-59 (Table 6). The top drugs involved among unhealthy drug use deaths between 2019 and 2021 include illicit fentanyl and its analogues (85.1% of deaths), cocaine (46.2%), methamphetamine/amphetamine (41.6%), other opioids (23.2%) and ethyl alcohol (26.9%).[1627]
- Table 7 provides data on the rate / 100,000 population for unhealthy drug use deaths by month for the 12 months between February 2021 and January 2022 in BC by age and sex.[1628] The death rate in males (5.70 / 100,000) is 3.7 times as high as the death rate in females (1.55 / 100,000) (Table 7).

[1625] The unhealthy drug use category includes street drugs (controlled and illegal drugs: heroin, cocaine, MDMA, methamphetamine, illicit fentanyl etc.), medications not prescribed to the decedent but obtained/purchased on the street, from unknown means or where origin of drug not known, or combinations of the above with prescribed medications.
[1626] BC Coroners Service, *Illicit Drug Toxicity Deaths in BC; January 1, 2011 – January 31, 2022*. Available online at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/deaths/coroners-service/statistical/illicit-drug.pdf. Accessed March 2022.
[1627] Ibid.
[1628] BC Centre for Disease Control. *Overdose Response Indicator Report*. December 2021. Available online at http://www.bccdc.ca/health-professionals/data-reports/overdose-response-indicators. Accessed March 2022.

Table 7: Unhealthy Drug Use Deaths in British Columbia

Rate per 100,000 Population by Age and Sex

February 2021 to January 2022

		Month and Year												Mean
		2021											2022	Feb '21 -
Sex	***Age***	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Jan '22
Female	0-18	-	0.45	0.67	-	0.22	0.90	0.22	-	.	0.45	0.22	-	0.28
	19-39	2.56	2.02	2.42	1.88	2.42	1.75	2.15	2.69	2.69	3.77	2.42	2.27	2.42
	40-59	2.56	2.70	1.71	2.42	2.13	2.99	2.42	2.13	3.42	3.27	3.27	1.70	2.56
	60+	0.54	0.54	0.54	0.27	-	0.41	0.54	0.41	0.68	0.27	0.54	0.92	0.47
	All	1.56	1.52	1.41	1.26	1.29	1.56	1.45	1.45	1.87	2.09	1.75	1.35	1.55
Male	0-18	0.64	-	0.21	0.64	0.43	0.21	0.21	0.21	0.21	-	0.21	-	0.25
	19-39	5.42	7.10	6.20	6.59	5.29	7.36	8.14	5.29	6.97	7.75	10.33	6.78	6.94
	40-59	8.98	8.38	11.67	10.18	10.03	11.52	10.18	8.83	11.22	11.22	10.33	14.35	10.57
	60+	4.12	3.36	3.05	2.44	3.81	3.05	3.66	2.14	3.20	3.20	3.36	2.96	3.20
	All	5.14	5.18	5.73	5.38	5.26	6.04	6.08	4.48	5.88	6.08	6.70	6.50	5.70
All	0-18	0.33	0.22	0.44	0.33	0.33	0.55	0.22	0.11	0.11	0.22	0.22	-	0.26
	19-39	4.02	4.61	4.35	4.28	3.89	4.61	5.21	4.02	4.88	5.80	6.46	4.57	4.73
	40-59	5.69	5.47	6.56	6.20	5.98	7.15	6.20	5.40	7.22	7.15	6.71	7.89	6.47
	60+	2.23	1.87	1.72	1.29	1.80	1.65	2.01	1.22	1.87	1.65	1.87	1.88	1.76
	All	3.33	3.33	3.54	3.29	3.25	3.77	3.73	2.95	3.85	4.06	4.20	3.89	3.60

- Applying the unhealthy drug use death rate / 100,000 population from Table 7 to our BC birth cohort of 40,000 indicates that we would expect to see approximately 100 deaths (22 in females and 78 in males) due to unhealthy drug use between the ages of 18 to 69 resulting in 3,966 life years lost (974 in females and 2,992 in males [Table 8]).

Table 8: Life Years Lost Due to Unhealthy Drug Use Deaths

Between the Ages of 18 and 59/69/79

In a British Columbia Birth Cohort of 40,000

	Female					*Male*					*Total Population*	
Age	**Total Life Years**	Death Rate / 100,000	Estimated Deaths	Life Years Lost / Death	Life Years Lost	**Total Life Years**	Death Rate / 100,000	Estimated Deaths	Life Years Lost / Death	Life Years Lost	Estimated Deaths	Life Years Lost
18	19,891	0.28	0.06	67.4	3.8	19,870	0.25	0.05	62.4	3.1	0.1	7
19	19,885	2.42	0.48	66.4	31.9	19,858	6.94	1.38	61.4	84.6	1.9	117
20	19,878	2.42	0.48	65.4	31.5	19,843	6.94	1.38	60.5	83.2	1.9	115
21	19,871	2.42	0.48	64.4	31.0	19,826	6.94	1.37	59.5	81.8	1.9	113
22	19,863	2.42	0.48	63.5	30.5	19,807	6.94	1.37	58.6	80.5	1.9	111
23	19,855	2.42	0.48	62.5	30.0	19,786	6.94	1.37	57.7	79.1	1.9	109
24	19,847	2.42	0.48	61.5	29.5	19,763	6.94	1.37	56.7	77.7	1.9	107
25	19,839	2.42	0.48	60.5	29.1	19,739	6.94	1.37	55.8	76.3	1.8	105
26	19,830	2.42	0.48	59.6	28.6	19,714	6.94	1.37	54.8	75.0	1.8	104
27	19,821	2.42	0.48	58.6	28.1	19,689	6.94	1.37	53.9	73.6	1.8	102
28	19,811	2.42	0.48	57.6	27.6	19,662	6.94	1.36	53.0	72.2	1.8	100
29	19,801	2.42	0.48	56.6	27.1	19,635	6.94	1.36	52.1	70.9	1.8	98
30	19,790	2.42	0.48	55.7	26.7	19,607	6.94	1.36	51.1	69.5	1.8	96
31	19,779	2.42	0.48	54.7	26.2	19,579	6.94	1.36	50.2	68.2	1.8	94
32	19,767	2.42	0.48	53.7	25.7	19,550	6.94	1.36	49.3	66.8	1.8	92
33	19,755	2.42	0.48	52.8	25.2	19,520	6.94	1.35	48.4	65.5	1.8	91
34	19,742	2.42	0.48	51.8	24.7	19,489	6.94	1.35	47.4	64.1	1.8	89
35	19,729	2.42	0.48	50.8	24.3	19,458	6.94	1.35	46.5	62.7	1.8	87
36	19,715	2.42	0.48	49.9	23.8	19,425	6.94	1.35	45.6	61.4	1.8	85
37	19,700	2.42	0.48	48.9	23.3	19,392	6.94	1.34	44.7	60.0	1.8	83
38	19,685	2.42	0.48	47.9	22.8	19,357	6.94	1.34	43.7	58.7	1.8	82
39	19,669	2.42	0.48	47.0	22.4	19,321	6.94	1.34	42.8	57.3	1.8	80
40	19,652	2.56	0.50	46.0	23.1	19,283	10.57	2.04	41.9	85.4	2.5	109
41	19,634	2.56	0.50	45.1	22.6	19,245	10.57	2.03	41.0	83.4	2.5	106
42	19,615	2.56	0.50	44.1	22.1	19,204	10.57	2.03	40.1	81.3	2.5	103
43	19,594	2.56	0.50	43.1	21.6	19,162	10.57	2.03	39.1	79.3	2.5	101
44	19,572	2.56	0.50	42.2	21.1	19,117	10.57	2.02	38.2	77.3	2.5	98
45	19,549	2.56	0.50	41.2	20.6	19,071	10.57	2.02	37.3	75.2	2.5	96
46	19,524	2.56	0.50	40.3	20.1	19,022	10.57	2.01	36.4	73.2	2.5	93
47	19,497	2.56	0.50	39.3	19.6	18,970	10.57	2.01	35.5	71.2	2.5	91
48	19,469	2.56	0.50	38.4	19.1	18,915	10.57	2.00	34.6	69.2	2.5	88
49	19,438	2.56	0.50	37.4	18.6	18,857	10.57	1.99	33.7	67.2	2.5	86
50	19,405	2.56	0.50	36.5	18.1	18,795	10.57	1.99	32.8	65.2	2.5	83
51	19,370	2.56	0.50	35.6	17.6	18,729	10.57	1.98	31.9	63.2	2.5	81
52	19,332	2.56	0.49	34.6	17.1	18,659	10.57	1.97	31.0	61.2	2.5	78
53	19,291	2.56	0.49	33.7	16.6	18,583	10.57	1.97	30.2	59.2	2.5	76
54	19,247	2.56	0.49	32.8	16.2	18,503	10.57	1.96	29.3	57.3	2.4	73
55	19,199	2.56	0.49	31.9	15.7	18,417	10.57	1.95	28.4	55.3	2.4	71
56	19,148	2.56	0.49	30.9	15.2	18,325	10.57	1.94	27.5	53.4	2.4	69
57	19,092	2.56	0.49	30.0	14.7	18,226	10.57	1.93	26.7	51.4	2.4	66
58	19,032	2.56	0.49	29.1	14.2	18,120	10.57	1.92	25.8	49.5	2.4	64
59	18,966	2.56	0.49	28.2	13.7	18,006	10.57	1.90	25.0	47.6	2.4	61
Total to Age 59	**823,150**	**2.43**	**20**	**47.0**	**942**	**807,096**	**8.46**	**68**	**41.3**	**2,818**	**88**	**3,760**
60	18,895	0.47	0.09	27.3	2.4	17,884	3.20	0.57	24.1	13.8	0.7	16
61	18,817	0.47	0.09	26.4	2.3	17,752	3.20	0.57	23.3	13.2	0.7	16
62	18,733	0.47	0.09	25.5	2.3	17,610	3.20	0.56	22.5	12.7	0.7	15
63	18,641	0.47	0.09	24.6	2.2	17,458	3.20	0.56	21.7	12.1	0.6	14
64	18,541	0.47	0.09	23.8	2.1	17,293	3.20	0.55	20.9	11.5	0.6	14
65	18,432	0.47	0.09	22.9	2.0	17,116	3.20	0.55	20.1	11.0	0.6	13
66	18,312	0.47	0.09	22.0	1.9	16,925	3.20	0.54	19.3	10.4	0.6	12
67	18,181	0.47	0.09	21.2	1.8	16,719	3.20	0.53	18.5	9.9	0.6	12
68	18,038	0.47	0.09	20.3	1.7	16,496	3.20	0.53	17.7	9.3	0.6	11
69	17,881	0.47	0.08	19.5	1.6	16,256	3.20	0.52	17.0	8.8	0.6	10
Total to Age 69	**1,007,621**	**2.08**	**21**	**46.0**	**962**	**978,605**	**7.54**	**74**	**39.7**	**2,931**	**95**	**3,893**
70	17,709	0.47	0.08	18.7	1.6	15,997	3.20	0.51	16.2	8.3	0.6	10
71	17,520	0.47	0.08	17.9	1.5	15,718	3.20	0.50	15.5	7.8	0.6	9
72	17,313	0.47	0.08	17.1	1.4	15,416	3.20	0.49	14.8	7.3	0.6	9
73	17,085	0.47	0.08	16.3	1.3	15,092	3.20	0.48	14.1	6.8	0.6	8
74	16,835	0.47	0.08	15.5	1.2	14,742	3.20	0.47	13.4	6.3	0.6	8
75	16,561	0.47	0.08	14.7	1.2	14,365	3.20	0.46	12.7	5.8	0.5	7
76	16,260	0.47	0.08	14.0	1.1	13,960	3.20	0.45	12.0	5.4	0.5	6
77	15,929	0.47	0.08	13.2	1.0	13,526	3.20	0.43	11.4	4.9	0.5	6
78	15,567	0.47	0.07	12.5	0.9	13,061	3.20	0.42	10.8	4.5	0.5	5
79	15,171	0.47	0.07	11.8	0.8	12,563	3.20	0.40	10.1	4.1	0.5	5
Total to Age 79	***1,173,570***	***1.55***	***22***	***44.9***	***974***	***1,123,045***	***5.31***	***78***	***38.2***	***2,992***	***100***	***3,966***

- We noted previously that our model would use the best in the world screening rate of 54.3% *of those who have had a health care visit in the past year*. Not all of the population ages 18 and older will have an annual health care visit.
- The Canadian Community Health Survey includes questions related to access to primary care providers (PCP). Table 9 presents weighted data for BC in 2015/16[1629] on the proportion of those surveyed who had consulted with a general practitioner or family doctor in the last 12 months. On average, 73.7% of the BC population ages 18 and older visited a PCP in the past 12 months (79.9% of females and 67.2% of males). The proportion also varies by age, with a higher proportion of the population seeing a PCP with increasing age.

Table 9: Consultations with General Practitioner or Family Doctor in Last 12 Months

British Columbia, by Sex and Age Group

Age Group	Female %	Male %	Total %
18 - 19	65.0%	53.0%	59.1%
20 - 24	66.0%	45.8%	54.8%
25 - 29	79.5%	52.4%	66.6%
30 - 34	81.7%	51.7%	67.0%
35 - 39	79.8%	63.1%	71.7%
40 - 44	76.4%	62.8%	69.9%
45 - 49	78.3%	68.5%	73.2%
50 - 54	81.5%	65.6%	73.4%
55 - 59	82.0%	72.8%	77.5%
60 - 64	80.9%	82.5%	81.6%
65 - 69	86.7%	84.7%	85.7%
70 - 74	84.8%	85.9%	85.3%
75 - 79	85.8%	90.4%	88.0%
80+	85.7%	86.7%	86.1%
	79.9%	67.2%	73.7%

Source: Canadian Community Health Survey 2015/16 Public Use Microdata File (PUMF). All data interpretation by H. Krueger & Associates Inc.

[1629] The question regarding consultations with care providers in the last 12 months was not included in the 2017/18 CCHS survey. However, the age- and sex-specific rates of individuals who reported they had a primary care provider were similar between the 2015/16 survey and the 2017/18 survey.

Effectiveness of the Intervention – Screening

- The USPSTF evidence review found that a number of screening instruments, including single-item drug frequency questions, the Substance Use Brief Screen, the Tobacco, Alcohol, Prescription Medication, and Other Substance Use tool and the Drug Abuse Screening Test (10 items) all had a sensitivity of greater than 0.80 and a specificity of greater than 0.85 for identifying unhealthy drug use. "Based on the range in test accuracy estimates and a prevalence of drug use among adults of 11%, the positive predictive value (PPV) of screening instruments is approximately 40%."[1630] That is, 40% of patients who screen positive for unhealthy drug use actually have unhealthy drug use (i.e. 60% of positive screens are false positive results).
- The PPV of 40% is based on the use of a single screening tool. If we apply the USPSTF sensitivity of 0.80 and specificity of 0.85 to a population with an expected unhealthy drug use prevalence of 9.41% (as in BC), then we get a PPV of 35.7%. The modelled screening approach, however, uses a brief screen followed by a more detailed screen for those who test positive on the brief screen.
- Tiet et al assessed a two-item screening tool for unhealthy drug use in a primary care population, "How many days in the past 12 months have you used drugs other than alcohol?" followed by ""How many days in the past 12 months have you used drugs more than you meant to?" When compared with the results of the Inventory of Drug Use Consequences (InDUC), this two-item tool had a sensitivity of 90.1% and a specificity of 92.4%.[1631] If we use this sensitivity and specificity with a prevalence of 9.41%, we get a PPV of 55.1%.
- Smith et al assessed the more detailed 10-item Drug Abuse Screening Test (DAST-10) and found it to have a sensitivity of 80.0% and a specificity of 93.9%.[1632] If we assume this screening test would be used for all those who initially screened positive on the brief two-item screening tool, we get an overall PPV of 94.2% (i.e. a false positive rate of 5.8%)
- For modelling purposes, we assume that the overall sensitivity of the brief screen followed by a detail screen is 72.1% (0.721 = 0.901 * 0.80). We further assume that 94.2% of patients with both a brief and a more detailed positive screen for unhealthy drug use are true positives and 5.8% are false positives.
- Whatever screening tests are ultimately chosen for use in BC, the screening (and intervention) process must be trauma-informed. Many individuals with unhealthy drug use have experienced trauma. Trauma-informed care has been defined as care "that is grounded in an understanding of and responsiveness to the impact of trauma, that emphasizes physical, psychological, and emotional safety for both providers and survivors, and that creates opportunities for survivors to rebuild a sense of control and empowerment…. It also involves vigilance in anticipating and avoiding

[1630] Patnode C, Perdue L, Rushkin M et al. Screening for Unhealthy Drug Use: Updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2020: 323(22); 2310-2328.
[1631] Tiet Q, Leyva Y, Moos R et al. Screen of drug use: Diagnostic accuracy of a new brief tool for primary care. *JAMA Internal Medicine*. 2015:175(8); 1371-7.
[1632] Smith P, Schmidt S, Allensworth-Davies D et al. A single-question screening test for drug use in primary care. *Archives of Internal Medicine*. 2010:170(13);1155-60

institutional processes and individual practices that are likely to retraumatize individuals who already have histories of trauma…"[1633]

- Pregnant women and women with children face specific challenges when it comes to screening and treatment. Foremost among these barriers is the stigmatization of women who use substances during pregnancy and/or while parenting and a child welfare policy that makes it difficult for substance-using mothers to disclose that they need help, for fear of losing custody of their children.[1634,1635] Specific screening tests may be considered when screening for unhealthy drug use during pregnancy.[1636]

Screening Frequency / Outcomes

- "There is little evidence about … the optimal interval for screening in adults older than 18 years."[1637]
- In their model assessing the costs and revenues associated with SBIRT for both alcohol and unhealthy drug use, Cowell et al assumed that one full screen would be required for every 3.14 pre-screens and that an average of 30.8% of full screens would lead to a brief intervention (ranging from 24.2% to 37.3%) and 8.1% of full screens would lead to a referral for treatment (ranging from 6.4% to 9.8%).[1638]
- In a cohort of 16,419 primary care patients eligible for unhealthy drug use screening studied by Hargraves et al, 5,581 received a pre-screen, 7,303 received a full screen (the 10 item Drug Abuse Screening Test or DAST-10) of which 1,335 scored positive on the full screen and 442 received a brief intervention (33.1% of positive screens). 172 were referred on for further treatment.[1639] Of all patients screened, 34.0% received a pre-screen only and 66.0% received a full-screen. Of those who received a full screen, 18.3% scored positive, 6.1% received a brief intervention and 2.4% were referred on for further treatment.
- D'Onoforio and Degutis report on the integration of an SBIRT-style program in an urban emergency department. They found that 3,530 of the screened patients had unhealthy drug use in the previous twelve months. Of the patients with unhealthy drug use, 2,315 (65.5%) received a brief intervention.[1640]

[1633] Center for Substance Abuse Treatment. *Trauma-informed Care in Behavioral Health Services*. Treatment Improvement Protocol (TIP) Series 57. HHS Publication No. (SMA) 13-4801. Rockville, MD: Substance Abuse and Mental Health Services Administration, 2014.
[1634] Dawson A, Jackson D, Cleary M. Mothering on the margins: Homeless women with an SUD and complex mental health co-morbidities. *Issues in Mental Health Nursing*. 2013; 34: 288-93.
[1635] Schamp J, van Havere T, Simonis S et al. Women's views on barriers and facilitators for seeking alcohol and drug treatment in Belgium. *Nordic Studies on Alcohol and Drugs*. 2021; 38(2): 175-89.
[1636] Chang G. Maternal substance use: Consequences, identification, and interventions. *Alcohol Research*. 2020; 40(2):
[1637] US Preventive Services Task Force. Screening for Unhealthy Drug Use: US Preventive Services Task Force Recommendation Statement. *JAMA*. 2020: 323(22); 2301-9.
[1638] Cowell A, Dowd W, Mills M et al. Sustaining SBIRT in the wild: Simulating revenues and cost for Screening, Brief Intervention and Referral to Treatment programs. *Addiction*. 2017: 112 (Suppl. 2); 101-9.
[1639] Hargraves D, White C, Frederick R et al. Implementing SBIRT (screening, brief intervention and referral to treatment) in primary care: Lessons learned from a multi-practice evaluation portfolio. *Public Health Reviews.* 2017: 38(31).
[1640] D'Onofrio G and Degutis LC. Integrating Project ASSERT: a screening, intervention, and referral to treatment program for unhealthy alcohol and drug use into an urban emergency department. *Academic Emergency Medicine*. 2010; 17(8): 903-11.

- There are key differences in the SBIRT interventions modelled by Cowell et al[1641] and those identified by Hargraves et al.[1642] This difference may be due to dissimilarities in SBIRT intervention rates for unhealthy alcohol versus unhealthy drug use. In the same study by Hargraves et al, in the cohort of 22,360 primary care patients eligible for unhealthy alcohol use screening, 12,697 received a pre-screen, 7,361 received a full screen of which 1,840 scored positive on the full screen and 1,009 received a brief intervention. 209 were referred on for further treatment. That is, 13.7% of full screens would lead to a brief intervention (more than double the 6.1% for unhealthy drug use screening) and 2.8% of full screens would lead to a referral for treatment.

- For modelling purposes, we assume that 54.3% of individuals who visit a GP or family physician in a given year would receive a brief screen (as noted previously). Of those screened, 15.4% would have a positive screen (both true and false positive) and would thus require a more detailed screen. Of those receiving a positive result on the detailed screen, 33.1% would receive a brief intervention.[1643] We use the emergency department number of 65.5%[1644] receiving a brief intervention as the upper bound in our sensitivity analysis.

Effectiveness of the Intervention – Brief Intervention

- Are pharmacotherapy and/or psychosocial interventions effective at reducing unhealthy drug use in populations whose unhealthy drug use was identified through primary care-based screening with questions about drug use or drug-related risks (*screen-detected populations*)? Evidence from studies of persons seeking or referred for treatment for substance use (*treatment-seeking populations*) might also be useful for informing assessments regarding screening in primary care settings.[1645]

- "Many drug use disorders are chronic, relapsing conditions, and many persons who start treatment do not complete treatment. Therefore, treatment must often be repeated to stabilize current drug use, reduce relapse, and achieve abstinence or other treatment goals."[1646]

- "Most brief interventions consisted of a single, personalized counselling session with in-person or computer-based feedback, with or without a telephone or in-person booster session."[1647]

- For example, in the study by Bernstein et al[1648] a trained peer interventionist initiated a motivational interview which involved the following steps: establishing rapport,

[1641] Cowell A, Dowd W, Mills M et al. Sustaining SBIRT in the wild: Simulating revenues and cost for Screening, Brief Intervention and Referral to Treatment programs. *Addiction*. 2017: 112 (Suppl. 2); 101-9.
[1642] Hargraves D, White C, Frederick R et al. Implementing SBIRT (screening, brief intervention and referral to treatment) in primary care: Lessons learned from a multi-practice evaluation portfolio. *Public Health Reviews*. 2017: 38(31).
[1643] Ibid.
[1644] D'Onofrio G and Degutis LC. Integrating Project ASSERT: a screening, intervention, and referral to treatment program for unhealthy alcohol and drug use into an urban emergency department. *Academic Emergency Medicine*. 2010; 17(8): 903-11.
[1645] Chou R, Dana T, Blazina I et al. *Interventions for Drug Use—Supplemental Report: A Systematic Review for the U.S. Preventive Services Task Force*. Evidence Synthesis No. 187. AHRQ Publication No. 19-05255-EF-2. Rockville, MD: Agency for Healthcare Research and Quality; 2020.
[1646] US Preventive Services Task Force. Screening for Unhealthy Drug Use: US Preventive Services Task Force Recommendation Statement. *JAMA*. 2020: 323(22); 2301-2309.
[1647] Ibid.
[1648] Bernstein J, Bernstein E, Tassiopoulos K et al. Brief motivational intervention at the clinic visit reduces cocaine and heroin use. *Drug and Alcohol Dependence*. 2005: 77; 49-59.

asking permission to discuss drugs, exploring the pros and cons of drug use, eliciting the gap between real and desired quality of life, and assessing readiness to change on a ruler scaled from 1 (not ready) to 10 (ready). The peer interventionist negotiated an action plan based on examples of the enrollee's past successes in making behavior change. Finally, a handout is given to the patient by the interventionist stating that "based on your screening responses, you would benefit from help with your drug use." This form included a list of treatment options including detox, AA/NA, acupuncture, residential treatment facilities, and harm reduction information about safe sex and needle exchange. This part of the intervention averages 20 min (range 10–45 min), and is completed during the course of clinical care for the problem that initiated the clinic visit, while the patient is waiting for the doctor or for lab results or medications. In a subsequent 5 - 10 minute "booster" call, which occurs ten days later, the original interventionist reviews the action plan and negotiates alternative referrals if necessary.

- In the study by Bogenschutz et al[1649] participants were provided with an in-person manual-guided brief intervention based on motivational interviewing principles, including feedback based on screening information and the development of a change plan, while in the emergency department waiting to be seen. The BI lasted an average of 30 minutes and was provided by members of the study staff cross trained as research assistants conducting screening and assessments for the study as well as providing the intervention. In addition to the initial brief intervention, all participants who could be reached received 2 telephone "booster" sessions in which the interventionist checked to see whether they had engaged in treatment, reviewed and reinforced change plans, and sought a commitment from them. Each of these booster calls were approximately 20 minutes long.
- In the study by Ondersma et al[1650] females participated in a single 20-minute postpartum computer-based intervention session. No keyboarding was required; all answers were provided by choosing responses from a list or by touching a visual analogue scale. The overall intervention was broken down into components broadly focusing on (a) eliciting the participant's thoughts about change and their perceived advantages of doing so, if any; (b) reviewing feedback regarding how the participant's drug use compares to that of others, and of possible benefits of changing; and (c) optional goal-setting, including a menu of change options.
- Brief interventions are associated with an increased likelihood of abstinence at 3-4 months (RR of 1.46, 95% CI of 1.11 to 2.09) and at 6-12 months (RR of 1.22, 95% CI of 1.08 to 1.42) compared with controls receiving usual care. The effect size of psychosocial interventions is bigger in treatment-seeking populations (RR of 2.08, 95% CI of 1.51 to 3.07) than in screen-detected populations (RR of 1.28, 95% CI of 0.97 to 1.84).[1651]
- For all psychosocial interventions with a follow-up at 6 – 12 months, the absolute risk difference (ARD) for abstinence is 6% (CI of 2% to 10%). That is, 6% more individuals will be abstinent in the treatment group compared to the control group. The ARD of 6% is based on 14 studies referenced by the USPSTF. In 9 of these

[1649] Bogenschutz M, Donovan D, Adinoff B et al. Design of NIDA CTN Protocol 0047: Screening, motivational assessment, referral, and treatment in emergency departments (SMART-ED). *American Journal of Drug and Alcohol Abuse*. 2011: 37(5); 417 - 25.
[1650] Ondersma S, Svikis D, Thacker L et al. Computer-delivered screening and brief intervention (e-SBI) for postpartum drug use: A randomized trial. *Journal of Substance Abuse Treatment*. 2014: 46(1); doi:10.1016/j.jsat.2013.07.013.
[1651] Patnode C, Perdue L, Rushkin M et al. Screening for Unhealthy Drug Use: Updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2020: 323(22); 2310-2328.

studies (representing 85% of the pooled participants), the psychosocial intervention included just one session, with the remaining five studies including 2, 2, 3, 4 and up to 6 sessions.[1652]

- For modelling purposes, we assumed that a brief intervention would be associated with a 6% increase in abstinence. We use 2% to 10% in our sensitivity analysis. To maintain this benefit, we assumed that screening and a brief intervention would need to occur annually. We modified this second assumption for screening and a brief intervention to once every 3 and 5 years in the sensitivity analysis.

- Tables 10 and 11 show the QALYs gained associated with screening and brief behavioural interventions to reduce unhealthy drug use in females (113 QALYs) and males (212 QALYs) between the ages of 18 and 69 in a British Columbia birth cohort of 40,000.

- For each sex we started by displaying the total life years for each age, then the estimated number of those life years lived with unhealthy drug use (from Table 5). We multiplied the life years lived with unhealthy drug use by the proportion of that age group that sees a general practitioner (GP) each year, and then multiplied by the proportion of those seeing their GP who would be screened in depth. This number is then multiplied by the sensitivity of the screening instrument(s), to determine how many of those screened with unhealthy drug use received a positive result. We multiply the number receiving a positive result by the proportion who receive a brief intervention, and multiply that number by the proportion of those receiving a brief intervention who remain abstinent at 12 months. This results in a number for each age and sex of the number of life years lived with unhealthy drug use that could be avoided with a brief intervention. Each year lived with unhealthy drug use is associated with a reduced quality of life and the possibility of a premature death. These consequences of unhealthy drug use would be avoided by those who benefit from a brief intervention.

- For example, for 20-year-old females, 2,569 life years are lived with unhealthy drug use (from Table 5). About 66% of 20-year-old females see a GP in a given year, resulting in 1,695 life years that could be impacted due to GP screening. Primary screens are given to 54.3% of those visiting a GP, so 921 life years can be potentially impacted by a brief intervention. The sensitivity of the first screen (90.4%), correctly identifies 832 life years to advance to the in-depth screen. The in-depth screen sensitivity (80%) correctly identifies 666 life years to offer a brief intervention. The brief intervention is offered to and accepted by 33.1% (or 220) of the 666 20-year-olds identified and 6% of these 220 would cease unhealthy drug use, or 13.2. The 13.2 who ceased unhealthy drug use that year would gain 3.80 QALYs due to not living with unhealthy drug use and 0.16 QALYs due to a reduced risk of a death due to unhealthy drug use. The total QALYs gained in 20-year-old females is thus 3.94.

[1652] Chou R, Dana T, Blazina I, et al. *Interventions for Unhealthy Drug Use—Supplemental Report: A Systematic Review for the U.S. Preventive Services Task Force*. Evidence Synthesis, No. 187. 2020. Rockville (MD): Agency for Healthcare Research and Quality.

Table 10: QALYs Gained Through Brief Interventions (BI) for Unhealthy Drug Use (UDU)

Females, between the Ages of 18 and 59/69/79

In a British Columbia Birth Cohort of 40,000

Age	Total Life Years	# with UDU (Table 5)	Annual GP Visits % (Table 9)	Annual GP Visits #	Basic Screen at GP %	Basic Screen at GP #	Positive Basic Screen Sensitivity	Positive Basic Screen #	Positive Detailed Screen Sensitivity	Positive Detailed Screen #	Offered & Accepting BI %	Offered & Accepting BI #	Benefitting from a BI %	Benefitting from a BI #	QALYs Gained Living With UDU	QALYs Gained Death Avoided	Total QALYs Gained
18	19,891	1,105	65.0%	719	54.3%	390	90.4%	353	80.0%	282	33.1%	93	6.0%	5.6	1.602	0.019	1.62
19	19,885	1,105	65.0%	718	54.3%	390	90.4%	353	80.0%	282	33.1%	93	6.0%	5.6	1.601	0.162	1.76
20	19,878	2,569	66.0%	1,695	54.3%	921	90.4%	832	80.0%	666	33.1%	220	6.0%	13.2	3.779	0.162	3.94
21	19,871	2,567	66.0%	1,694	54.3%	920	90.4%	832	80.0%	665	33.1%	220	6.0%	13.2	3.776	0.159	3.94
22	19,863	2,566	66.0%	1,693	54.3%	919	90.4%	831	80.0%	665	33.1%	220	6.0%	13.2	3.774	0.157	3.93
23	19,855	2,564	66.0%	1,692	54.3%	919	90.4%	831	80.0%	664	33.1%	220	6.0%	13.2	3.771	0.154	3.93
24	19,847	2,562	66.0%	1,691	54.3%	918	90.4%	830	80.0%	664	33.1%	220	6.0%	13.2	3.768	0.152	3.92
25	19,839	2,560	79.5%	2,034	54.3%	1,105	90.4%	999	80.0%	799	33.1%	264	6.0%	15.9	4.535	0.180	4.71
26	19,830	2,558	79.5%	2,033	54.3%	1,104	90.4%	998	80.0%	798	33.1%	264	6.0%	15.9	4.531	0.177	4.71
27	19,821	2,555	79.5%	2,031	54.3%	1,103	90.4%	997	80.0%	798	33.1%	264	6.0%	15.8	4.527	0.174	4.70
28	19,811	2,553	79.5%	2,029	54.3%	1,102	90.4%	996	80.0%	797	33.1%	264	6.0%	15.8	4.523	0.171	4.69
29	19,801	2,551	79.5%	2,027	54.3%	1,101	90.4%	995	80.0%	796	33.1%	264	6.0%	15.8	4.518	0.168	4.69
30	19,790	1,724	81.7%	1,409	54.3%	765	90.4%	691	80.0%	553	33.1%	183	6.0%	11.0	3.057	0.170	3.23
31	19,779	1,722	81.7%	1,407	54.3%	764	90.4%	691	80.0%	553	33.1%	183	6.0%	11.0	3.054	0.167	3.22
32	19,767	1,721	81.7%	1,406	54.3%	763	90.4%	690	80.0%	552	33.1%	183	6.0%	11.0	3.051	0.164	3.21
33	19,755	1,719	81.7%	1,404	54.3%	762	90.4%	689	80.0%	551	33.1%	183	6.0%	11.0	3.048	0.161	3.21
34	19,742	1,717	81.7%	1,403	54.3%	762	90.4%	688	80.0%	551	33.1%	182	6.0%	10.9	3.044	0.158	3.20
35	19,729	1,715	79.8%	1,369	54.3%	743	90.4%	672	80.0%	538	33.1%	178	6.0%	10.7	2.971	0.151	3.12
36	19,715	1,713	79.8%	1,367	54.3%	743	90.4%	671	80.0%	537	33.1%	178	6.0%	10.7	2.968	0.148	3.12
37	19,700	1,711	79.8%	1,366	54.3%	742	90.4%	670	80.0%	536	33.1%	178	6.0%	10.7	2.964	0.145	3.11
38	19,685	1,709	79.8%	1,364	54.3%	741	90.4%	670	80.0%	536	33.1%	177	6.0%	10.6	2.960	0.142	3.10
39	19,669	1,706	79.8%	1,362	54.3%	740	90.4%	669	80.0%	535	33.1%	177	6.0%	10.6	2.956	0.139	3.10
40	19,652	857	76.4%	655	54.3%	355	90.4%	321	80.0%	257	33.1%	85	6.0%	5.1	1.363	0.138	1.50
41	19,634	856	76.4%	654	54.3%	355	90.4%	321	80.0%	257	33.1%	85	6.0%	5.1	1.361	0.135	1.50
42	19,615	855	76.4%	653	54.3%	354	90.4%	320	80.0%	256	33.1%	85	6.0%	5.1	1.359	0.132	1.49
43	19,594	853	76.4%	652	54.3%	354	90.4%	320	80.0%	256	33.1%	85	6.0%	5.1	1.357	0.129	1.49
44	19,572	852	76.4%	650	54.3%	353	90.4%	319	80.0%	255	33.1%	85	6.0%	5.1	1.355	0.126	1.48
45	19,549	850	78.3%	665	54.3%	361	90.4%	327	80.0%	261	33.1%	87	6.0%	5.2	1.386	0.126	1.51
46	19,524	849	78.3%	664	54.3%	361	90.4%	326	80.0%	261	33.1%	86	6.0%	5.2	1.383	0.123	1.51
47	19,497	847	78.3%	663	54.3%	360	90.4%	325	80.0%	260	33.1%	86	6.0%	5.2	1.380	0.120	1.50
48	19,469	845	78.3%	661	54.3%	359	90.4%	325	80.0%	260	33.1%	86	6.0%	5.2	1.377	0.117	1.49
49	19,438	843	78.3%	660	54.3%	358	90.4%	324	80.0%	259	33.1%	86	6.0%	5.1	1.374	0.114	1.49
50	19,405	767	81.5%	625	54.3%	340	90.4%	307	80.0%	246	33.1%	81	6.0%	4.9	1.251	0.115	1.37
51	19,370	765	81.5%	624	54.3%	339	90.4%	306	80.0%	245	33.1%	81	6.0%	4.9	1.247	0.112	1.36
52	19,332	763	81.5%	622	54.3%	338	90.4%	305	80.0%	244	33.1%	81	6.0%	4.9	1.244	0.109	1.35
53	19,291	761	81.5%	620	54.3%	337	90.4%	304	80.0%	244	33.1%	81	6.0%	4.8	1.240	0.106	1.35
54	19,247	758	81.5%	618	54.3%	336	90.4%	303	80.0%	243	33.1%	80	6.0%	4.8	1.236	0.103	1.34
55	19,199	756	82.0%	619	54.3%	336	90.4%	304	80.0%	243	33.1%	81	6.0%	4.8	1.239	0.100	1.34
56	19,148	753	82.0%	617	54.3%	335	90.4%	303	80.0%	242	33.1%	80	6.0%	4.8	1.234	0.097	1.33
57	19,092	750	82.0%	614	54.3%	334	90.4%	302	80.0%	241	33.1%	80	6.0%	4.8	1.229	0.094	1.32
58	19,032	746	82.0%	612	54.3%	332	90.4%	300	80.0%	240	33.1%	80	6.0%	4.8	1.223	0.091	1.31
59	18,966	743	82.0%	609	54.3%	331	90.4%	299	80.0%	239	33.1%	79	6.0%	4.7	1.217	0.088	1.30
Total to Age 59	**823,150**	**61,041**	**76.5%**	**46,670**	**54.3%**	**25,342**		**22,909**		**18,327**	**33.1%**	**6,066**	**6.0%**	**364**	***100.8***	***5.7***	***106.5***
60	18,895	415	80.9%	336	54.3%	182	90.4%	165	80.0%	132	33.1%	44	6.0%	2.6	0.654	0.015	0.67
61	18,817	413	80.9%	334	54.3%	181	90.4%	164	80.0%	131	33.1%	43	6.0%	2.6	0.650	0.015	0.67
62	18,733	410	80.9%	332	54.3%	180	90.4%	163	80.0%	130	33.1%	43	6.0%	2.6	0.646	0.014	0.66
63	18,641	407	80.9%	329	54.3%	179	90.4%	162	80.0%	129	33.1%	43	6.0%	2.6	0.642	0.014	0.66
64	18,541	404	80.9%	327	54.3%	178	90.4%	161	80.0%	128	33.1%	43	6.0%	2.6	0.637	0.013	0.65
65	18,432	401	86.7%	348	54.3%	189	90.4%	171	80.0%	137	33.1%	45	6.0%	2.7	0.678	0.013	0.69
66	18,312	398	86.7%	345	54.3%	187	90.4%	169	80.0%	135	33.1%	45	6.0%	2.7	0.672	0.013	0.68
67	18,181	394	86.7%	342	54.3%	185	90.4%	168	80.0%	134	33.1%	44	6.0%	2.7	0.666	0.012	0.68
68	18,038	390	86.7%	338	54.3%	184	90.4%	166	80.0%	133	33.1%	44	6.0%	2.6	0.659	0.012	0.67
69	17,881	385	86.7%	334	54.3%	181	90.4%	164	80.0%	131	33.1%	43	6.0%	2.6	0.651	0.011	0.66
Total to Age 69	**1,007,621**	**65,057**	**76.9%**	**50,034**	**54.3%**	**27,169**		**24,560**		**19,648**	**33.1%**	**6,504**	**6.0%**	**390**	***107.4***	***5.8***	***113.2***
70	17,709	93	84.8%	79	54.3%	43	90.4%	39	80.0%	31	33.1%	10	6.0%	0.6	0.145	0.010	0.16
71	17,520	91	84.8%	78	54.3%	42	90.4%	38	80.0%	30	33.1%	10	6.0%	0.6	0.143	0.010	0.15
72	17,313	90	84.8%	76	54.3%	41	90.4%	37	80.0%	30	33.1%	10	6.0%	0.6	0.141	0.009	0.15
73	17,085	89	84.8%	75	54.3%	41	90.4%	37	80.0%	29	33.1%	10	6.0%	0.6	0.139	0.009	0.15
74	16,835	87	84.8%	74	54.3%	40	90.4%	36	80.0%	29	33.1%	10	6.0%	0.6	0.136	0.008	0.14
75	16,561	85	85.8%	73	54.3%	40	90.4%	36	80.0%	29	33.1%	9	6.0%	0.6	0.135	0.008	0.14
76	16,260	83	85.8%	71	54.3%	39	90.4%	35	80.0%	28	33.1%	9	6.0%	0.6	0.132	0.007	0.14
77	15,929	81	85.8%	70	54.3%	38	90.4%	34	80.0%	27	33.1%	9	6.0%	0.5	0.128	0.007	0.14
78	15,567	79	85.8%	68	54.3%	37	90.4%	33	80.0%	27	33.1%	9	6.0%	0.5	0.125	0.006	0.13
79	15,171	76	85.8%	66	54.3%	36	90.4%	32	80.0%	26	33.1%	9	6.0%	0.5	0.121	0.006	0.13
Total to Age 79	**1,173,570**	**65,912**	***77.0%***	**50,763**	***54.3%***	**27,564**		**24,918**		**19,934**	**33.1%**	**6,598**	***6.0%***	**396**	***108.7***	***5.9***	***114.6***

Table 11: QALYs Gained Through Brief Interventions (BI) for Unhealthy Drug Use (UDU)

Males, between the Ages of 18 and 59/69/79

In a British Columbia Birth Cohort of 40,000

Age	Total Life Years	# with UDU (Table 5)	Annual GP Visits % (Table 9)	Annual GP Visits #	Screened In Depth at GP %	Screened In Depth at GP #	Positive Basic Screen Sensitivity	Positive Basic Screen #	Positive Detailed Screen Sensitivity	Positive Detailed Screen #	Offered & Accepting BI %	Offered & Accepting BI #	Benefitting from a BI %	Benefitting from a BI #	QALYs Gained: Living with UDU	QALYs Gained: Death Avoided	Total QALYs Gained
18	19,870	2,521	53.0%	1,337	54.3%	726	90.4%	656	80.0%	525	33.1%	174	6.0%	10	3.208	0.013	3.22
19	19,858	2,520	53.0%	1,336	54.3%	726	90.4%	656	80.0%	525	33.1%	174	6.0%	10	3.206	0.350	3.56
20	19,843	5,860	45.8%	2,682	54.3%	1,456	90.4%	1,316	80.0%	1,053	33.1%	349	6.0%	21	6.435	0.297	6.73
21	19,826	5,857	45.8%	2,680	54.3%	1,455	90.4%	1,316	80.0%	1,053	33.1%	348	6.0%	21	6.432	0.292	6.72
22	19,807	5,853	45.8%	2,678	54.3%	1,454	90.4%	1,315	80.0%	1,052	33.1%	348	6.0%	21	6.427	0.287	6.71
23	19,786	5,849	45.8%	2,676	54.3%	1,453	90.4%	1,314	80.0%	1,051	33.1%	348	6.0%	21	6.422	0.282	6.70
24	19,763	5,844	45.8%	2,674	54.3%	1,452	90.4%	1,313	80.0%	1,050	33.1%	348	6.0%	21	6.418	0.277	6.69
25	19,739	5,839	52.4%	3,058	54.3%	1,661	90.4%	1,501	80.0%	1,201	33.1%	398	6.0%	24	7.338	0.312	7.65
26	19,714	5,834	52.4%	3,056	54.3%	1,659	90.4%	1,500	80.0%	1,200	33.1%	397	6.0%	24	7.332	0.306	7.64
27	19,689	5,829	52.4%	3,053	54.3%	1,658	90.4%	1,499	80.0%	1,199	33.1%	397	6.0%	24	7.326	0.301	7.63
28	19,662	5,824	52.4%	3,050	54.3%	1,656	90.4%	1,497	80.0%	1,198	33.1%	396	6.0%	24	7.319	0.295	7.61
29	19,635	5,818	52.4%	3,047	54.3%	1,655	90.4%	1,496	80.0%	1,197	33.1%	396	6.0%	24	7.312	0.289	7.60
30	19,607	3,933	51.7%	2,032	54.3%	1,103	90.4%	997	80.0%	798	33.1%	264	6.0%	16	4.747	0.280	5.03
31	19,579	3,929	51.7%	2,030	54.3%	1,102	90.4%	996	80.0%	797	33.1%	264	6.0%	16	4.742	0.275	5.02
32	19,550	3,925	51.7%	2,027	54.3%	1,101	90.4%	995	80.0%	796	33.1%	264	6.0%	16	4.737	0.269	5.01
33	19,520	3,921	51.7%	2,025	54.3%	1,100	90.4%	994	80.0%	795	33.1%	263	6.0%	16	4.732	0.264	5.00
34	19,489	3,916	51.7%	2,023	54.3%	1,099	90.4%	993	80.0%	794	33.1%	263	6.0%	16	4.727	0.258	4.99
35	19,458	3,912	63.1%	2,470	54.3%	1,341	90.4%	1,212	80.0%	970	33.1%	321	6.0%	19	5.771	0.309	6.08
36	19,425	3,907	63.1%	2,467	54.3%	1,340	90.4%	1,211	80.0%	969	33.1%	321	6.0%	19	5.765	0.302	6.07
37	19,392	3,902	63.1%	2,464	54.3%	1,338	90.4%	1,210	80.0%	968	33.1%	320	6.0%	19	5.757	0.296	6.05
38	19,357	3,897	63.1%	2,461	54.3%	1,336	90.4%	1,208	80.0%	966	33.1%	320	6.0%	19	5.750	0.289	6.04
39	19,321	3,892	63.1%	2,458	54.3%	1,334	90.4%	1,206	80.0%	965	33.1%	319	6.0%	19	5.742	0.282	6.02
40	19,283	1,956	62.8%	1,227	54.3%	667	90.4%	603	80.0%	482	33.1%	160	6.0%	10	2.752	0.418	3.17
41	19,245	1,953	62.8%	1,226	54.3%	666	90.4%	602	80.0%	481	33.1%	159	6.0%	10	2.748	0.408	3.16
42	19,204	1,950	62.8%	1,224	54.3%	665	90.4%	601	80.0%	481	33.1%	159	6.0%	10	2.744	0.398	3.14
43	19,162	1,947	62.8%	1,222	54.3%	663	90.4%	600	80.0%	480	33.1%	159	6.0%	10	2.739	0.388	3.13
44	19,117	1,943	62.8%	1,220	54.3%	662	90.4%	599	80.0%	479	33.1%	159	6.0%	10	2.735	0.378	3.11
45	19,071	1,940	68.5%	1,328	54.3%	721	90.4%	652	80.0%	522	33.1%	173	6.0%	10	2.978	0.402	3.38
46	19,022	1,936	68.5%	1,326	54.3%	720	90.4%	651	80.0%	521	33.1%	172	6.0%	10	2.972	0.391	3.36
47	18,970	1,932	68.5%	1,323	54.3%	718	90.4%	649	80.0%	519	33.1%	172	6.0%	10	2.966	0.380	3.35
48	18,915	1,928	68.5%	1,320	54.3%	717	90.4%	648	80.0%	518	33.1%	172	6.0%	10	2.960	0.370	3.33
49	18,857	1,923	68.5%	1,317	54.3%	715	90.4%	646	80.0%	517	33.1%	171	6.0%	10	2.953	0.359	3.31
50	18,795	1,751	65.6%	1,149	54.3%	624	90.4%	564	80.0%	451	33.1%	149	6.0%	9	2.473	0.334	2.81
51	18,729	1,746	65.6%	1,146	54.3%	622	90.4%	562	80.0%	450	33.1%	149	6.0%	9	2.467	0.324	2.79
52	18,659	1,741	65.6%	1,143	54.3%	620	90.4%	561	80.0%	449	33.1%	149	6.0%	9	2.460	0.313	2.77
53	18,583	1,736	65.6%	1,139	54.3%	619	90.4%	559	80.0%	447	33.1%	148	6.0%	9	2.452	0.303	2.76
54	18,503	1,730	65.6%	1,135	54.3%	617	90.4%	557	80.0%	446	33.1%	148	6.0%	9	2.444	0.293	2.74
55	18,417	1,724	72.8%	1,256	54.3%	682	90.4%	616	80.0%	493	33.1%	163	6.0%	10	2.704	0.314	3.02
56	18,325	1,717	72.8%	1,251	54.3%	679	90.4%	614	80.0%	491	33.1%	163	6.0%	10	2.693	0.303	3.00
57	18,226	1,710	72.8%	1,246	54.3%	677	90.4%	612	80.0%	489	33.1%	162	6.0%	10	2.682	0.292	2.97
58	18,120	1,703	72.8%	1,240	54.3%	674	90.4%	609	80.0%	487	33.1%	161	6.0%	10	2.670	0.281	2.95
59	18,006	1,695	72.8%	1,234	54.3%	670	90.4%	606	80.0%	485	33.1%	160	6.0%	10	2.657	0.270	2.93
Total to Age 59	**807,096**	**139,246**	**56.3%**	**78,456**	**54.3%**	**42,601**		**38,512**		**30,809**	**33.1%**	**10,198**	**6.0%**	**612**	***181.9***	***13.0***	***194.9***
60	17,884	947	82.5%	781	54.3%	424	90.4%	383	80.0%	307	33.1%	101	6.0%	6	1.638	0.089	1.73
61	17,752	941	82.5%	776	54.3%	422	90.4%	381	80.0%	305	33.1%	101	6.0%	6	1.629	0.085	1.71
62	17,610	936	82.5%	772	54.3%	419	90.4%	379	80.0%	303	33.1%	100	6.0%	6	1.619	0.081	1.70
63	17,458	929	82.5%	766	54.3%	416	90.4%	376	80.0%	301	33.1%	100	6.0%	6	1.608	0.078	1.69
64	17,293	922	82.5%	761	54.3%	413	90.4%	373	80.0%	299	33.1%	99	6.0%	6	1.596	0.074	1.67
65	17,116	915	84.7%	775	54.3%	421	90.4%	380	80.0%	304	33.1%	101	6.0%	6	1.625	0.072	1.70
66	16,925	907	84.7%	768	54.3%	417	90.4%	377	80.0%	302	33.1%	100	6.0%	6	1.611	0.069	1.68
67	16,719	898	84.7%	761	54.3%	413	90.4%	373	80.0%	299	33.1%	99	6.0%	6	1.596	0.065	1.66
68	16,496	889	84.7%	753	54.3%	409	90.4%	369	80.0%	296	33.1%	98	6.0%	6	1.579	0.062	1.64
69	16,256	879	84.7%	744	54.3%	404	90.4%	365	80.0%	292	33.1%	97	6.0%	6	1.561	0.058	1.62
Total to Age 69	**978,605**	**148,410**	**58.0%**	**86,112**	**54.3%**	**46,759**		**42,270**		**33,816**	**33.1%**	**11,193**	**6.0%**	**672**	***198.0***	***13.8***	***211.7***
70	15,997	212	85.9%	182	54.3%	99	90.4%	89	80.0%	71	33.1%	24	6.0%	1	0.361	0.056	0.42
71	15,718	209	85.9%	179	54.3%	97	90.4%	88	80.0%	70	33.1%	23	6.0%	1	0.356	0.052	0.41
72	15,416	205	85.9%	176	54.3%	96	90.4%	87	80.0%	69	33.1%	23	6.0%	1	0.351	0.049	0.40
73	15,092	202	85.9%	173	54.3%	94	90.4%	85	80.0%	68	33.1%	23	6.0%	1	0.345	0.045	0.39
74	14,742	198	85.9%	170	54.3%	92	90.4%	84	80.0%	67	33.1%	22	6.0%	1	0.338	0.042	0.38
75	14,365	194	90.4%	175	54.3%	95	90.4%	86	80.0%	69	33.1%	23	6.0%	1	0.349	0.041	0.39
76	13,960	190	90.4%	171	54.3%	93	90.4%	84	80.0%	67	33.1%	22	6.0%	1	0.341	0.038	0.38
77	13,526	185	90.4%	167	54.3%	91	90.4%	82	80.0%	66	33.1%	22	6.0%	1	0.332	0.035	0.37
78	13,061	180	90.4%	162	54.3%	88	90.4%	80	80.0%	64	33.1%	21	6.0%	1	0.323	0.032	0.35
79	12,563	174	90.4%	157	54.3%	85	90.4%	77	80.0%	62	33.1%	20	6.0%	1	0.313	0.029	0.34
Total	**1,123,045**	**150,359**	***58.4%***	**87,827**	**54.3%**	**47,690**		**43,112**		**34,489**	**33.1%**	**11,416**	***6.0%***	**685**	***201.4***	***14.2***	***215.6***

Potential Harms Associated with the Interventions

- The USPSTF notes that their recommendation statement applies to "settings and populations for which services for accurate diagnosis, effective treatment, and appropriate care can be offered or referred. The net benefit assessment does not apply to settings and populations for which treatment is not provided or the result of screening is punitive."[1653]
- Four studies of psychosocial interventions reported no adverse events, in either the experimental of control groups.[1654]

Summary of CPB – Males and Females

- Other assumptions used in assessing CPB are detailed in the Reference Document.

Based on these assumptions, the CPB associated with screening and brief behavioural interventions to reduce unhealthy drug use in adults 18 years to 69 years old in a British Columbia birth cohort of 40,000 is 325 QALYs, 113 QALYs in females and 212 QALYs in males (Table 12, rows *w*, *x*, *y*). The CPB of 325 represents the gap between no coverage and the 'best in the world' screening coverage estimated at 54.3% of those with an annual visit to a primary care provider. In addition, it assumes that 33.1% of individuals identified with unhealthy drug use would receive a brief intervention.

Table 12: CPB of Screening for Unhealthy Drug Use and Brief Intervention
Ages 18 - 69
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
	Total Burden (QALYs) in Birth Cohort		
a	Upper age limit used in analysis	69	√
b	Life years lived between the ages of 18 and 69 - Females	1,007,621	Table 3
c	Life years lived between the ages of 18 and 69 - Males	978,605	Table 3
d	Life years with unhealthy drug use (excluding cannabis) - Females	32,616	Table 3
e	Life years with cannabis use disorder - Females	32,442	Table 3
f	Life years with unhealthy drug use (excluding cannabis) - Males	88,787	Table 3
g	Life years with cannabis use disorder - Males	59,623	Table 3
h	Disability weight unhealthy drug use (excluding cannabis)	0.436	Table 4
i	Disability weight cannabis use disorder	0.189	Table 4
j	QALYs lost with unhealthy drug use - Females	17,938	Table 5
k	QALYs lost with unhealthy drug use - Males	44,055	Table 5
l	Life years lost attributable to unhealthy drug use - Females	962	Table 8
m	Life years lost attributable to unhealthy drug use - Males	2,931	Table 8
n	Total QALYs lost - Females	18,900	= j + l
o	Total QALYs lost - Males	46,986	= k + m
p	***Total QALYs lost***	***65,886***	
	Clinically Preventable Burden (CPB)		
q	Screening frequency (in years)	1	√
r	Proportion screened with basic screen	54.3%	√
s	Sensitivity of basic screen	90%	√
t	Sensitivity of detailed screen	80.0%	√
u	Proportion of positive in depth screens accepting behavioural intervention	33.1%	√
v	Cessation of unhealthy drug use in those receiving behavioural intervention	6.0%	√
w	QALYs gained - Females	113	Table 10
x	QALYs gained - Males	212	Table 11
y	**Total QALYs gained (CPB)**	**325**	= w + x

√ = Estimates from the literature

[1653] US Preventive Services Task Force. Screening for Unhealthy Drug Use: US Preventive Services Task Force Recommendation Statement. *JAMA*. 2020: 323(22); 2301-2309.
[1654] Patnode C, Perdue L, Rushkin M et al. Screening for Unhealthy Drug Use: Updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2020: 323(22); 2310-2328.

Sensitivity Analysis – Males and Females

We also modified several major assumptions and recalculated the CPB as follows:

- Reduced QoL impact. Use the lower limit of the disability weights from the GBD Study for opioid use (mild = .221, severe = .510), cocaine use (mild = .074, severe = .324), amphetamine use (mild = .051, severe = .329), and cannabis use disorder (mild = .024, severe = .178). (Aggregate weights calculated in Table 4 and shown in Table 12, rows *h* & *i*): CPB = 232
- Increased QoL impact. Use the upper limit of the disability weights from the GBD Study for opioid use (mild = .473, severe = .843), cocaine use (mild = .165, severe = .634), amphetamine use (mild = .114, severe = .637), and cannabis use disorder (mild = .060, severe = .364). (Aggregate weights calculated in Table 4 and shown in Table 12, rows *h* & *i*): CPB = 416
- Assume that the proportion of positively screened individuals receiving behavioural intervention increases from 33.1% to 65.5% (Table 12, row *u*): CPB = **643**
- Assume that the drug use cessation rate resulting from behavioural intervention decreases from 6% to 2% (Table 12, row *v*): CPB = **108**
- Assume that the drug use cessation rate resulting from behavioural intervention increases from 6% to 10% (Table 12, row *v*): CPB = 542
- Model from ages 18 through 79 (an additional 10 years modelled above the baseline age of 69 – Table 12, row *a*): CPB = 330
- Model from ages 18 through 59 (a reduction of 10 years modelled compared to baseline age of 69 – Table 12, row *a*): CPB = 301

Summary of CPB – Females Only

We ran the same analyses, with the same assumptions as above, but for females only. The CPB associated with screening and brief behavioural interventions to reduce unhealthy drug use in females 18 years to 69 years old in a British Columbia birth cohort of 40,000 is 113 QALYs. (Table 13, row *p*). The CPB of 113 represents the gap between no coverage and the 'best in the world' screening coverage estimated at 54.3% of those with an annual visit to a primary care provider. In addition, it assumes that 33.1% of individuals identified with unhealthy drug use would receive a brief intervention.

Table 13: CPB of Screening for Unhealthy Drug Use and Brief Intervention Females, Ages 18 - 69 In a BC Birth Cohort of 40,000			
Row Label	**Variable**	**Base case**	**Data Source**
	Total Burden (QALYs) in Birth Cohort		
a	Upper age limit used in analysis	69	√
b	Life years lived between the ages of 18 and 69 - Females	1,007,621	Table 3
c	Life years with unhealthy drug use (excluding cannabis) - Females	32,616	Table 3
d	Life years with cannabis use disorder - Females	32,442	Table 3
e	Disability weight unhealthy drug use (excluding cannabis)	0.436	Table 4
f	Disability weight cannabis use disorder	0.189	Table 4
g	QALYs lost with unhealthy drug use - Females	17,938	Table 5
h	Life years lost attributable to unhealthy drug use - Females	962	Table 8
i	Total QALYs lost - Females	18,900	= g + h
	Clinically Preventable Burden (CPB)		
j	Screening frequency (in years)	1	√
k	Proportion screened with basic screen	54.3%	√
l	Sensitivity of basic screen	90%	√
m	Sensitivity of detailed screen	80.0%	√
n	Proportion of positive in depth screens accepting behavioural intervention	33.1%	√
o	Cessation of unhealthy drug use in those receiving behavioural intervention	6.0%	√
p	QALYs gained - Females	113	Table 10
q	**Total QALYs gained (CPB)**	**113**	= p

√ = Estimates from the literature

Sensitivity Analysis – Females Only

We also modified several major assumptions and recalculated the CPB for females only as follows:

- Reduced QoL impact. Use the lower limit of the disability weights from the GBD Study for opioid use (mild = .221, severe = .510), cocaine use (mild = .074, severe = .324), amphetamine use (mild = .051, severe = .329), and cannabis use disorder (mild = .024, severe = .178). (Aggregate weights calculated in Table 4 and shown in Table 13, rows *e* & *f*): CPB = 80
- Increased QoL impact. Use the upper limit of the disability weights from the GBD Study for opioid use (mild = .473, severe = .843), cocaine use (mild = .165, severe = .634), amphetamine use (mild = .114, severe = .637), and cannabis use disorder (mild = .060, severe = .364). (Aggregate weights calculated in Table 4 and shown in Table 13, rows *e* & *f*): CPB = 146
- Assume that the proportion of positively screened individuals receiving behavioural intervention increases from 33.1% to 65.5% (Table 13, row *n*): CPB = **224**
- Assume that the drug use cessation rate resulting from behavioural intervention decreases from 6% to 2% (Table 13, row *o*): CPB = **38**
- Assume that the drug use cessation rate resulting from behavioural intervention increases from 6% to 10% (Table 13, row *o*): CPB = 189
- Model from ages 18 through 79 (an additional 10 years modelled above the baseline age of 69 – Table 13, row *a*): CPB = 115

- Model from ages 18 through 59 (a reduction of 10 years modelled compared to baseline age of 69 – Table 13, row *a*): CPB = 106

Summary of CPB – Males Only

We ran the same analyses, with the same assumptions as above, but for males only. The CPB associated with screening and brief behavioural interventions to reduce unhealthy drug use in males 18 years to 69 years old in a British Columbia birth cohort of 40,000 is 212 QALYs. (Table 14, row *p*). The CPB of 212 represents the gap between no coverage and the 'best in the world' screening coverage estimated at 54.3% of those with an annual visit to a primary care provider. In addition, it assumes that 33.1% of individuals identified with unhealthy drug use would receive a brief intervention.

Table 14: CPB of Screening for Unhealthy Drug Use and Brief Intervention
Males, Ages 18 - 69
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
	Total Burden (QALYs) in Birth Cohort		
a	Upper age limit used in analysis	69	√
b	Life years lived between the ages of 18 and 69 - Males	978,605	Table 3
c	Life years with unhealthy drug use (excluding cannabis) - Males	88,787	Table 3
d	Life years with cannabis use disorder - Males	59,623	Table 3
e	Disability weight unhealthy drug use (excluding cannabis)	0.436	Table 4
f	Disability weight cannabis use disorder	0.189	Table 4
g	QALYs lost with unhealthy drug use - Males	44,055	Table 5
h	Life years lost attributable to unhealthy drug use - Males	2,931	Table 8
i	Total QALYs lost - Males	46,986	= g + h
	Clinically Preventable Burden (CPB)		
j	Screening frequency (in years)	1	√
k	Proportion screened with basic screen	54.3%	√
l	Sensitivity of basic screen	90%	√
m	Sensitivity of detailed screen	80.0%	√
n	Proportion of positive in depth screens accepting behavioural intervention	33.1%	√
o	Cessation of unhealthy drug use in those receiving behavioural intervention	6.0%	√
p	QALYs gained - Males	212	Table 11
q	**Total QALYs gained (CPB)**	**212**	= p

√ = Estimates from the literature

Sensitivity Analysis – Males Only

We also modified several major assumptions and recalculated the CPB for males only as follows:

- Reduced QoL impact. Use the lower limit of the disability weights from the GBD Study for opioid use (mild = .221, severe = .510), cocaine use (mild = .074, severe = .324), amphetamine use (mild = .051, severe = .329), and cannabis use disorder (mild = .024, severe = .178). (Aggregate weights calculated in Table 4 and shown in Table 14, rows *e* & *f*): CPB = 152
- Increased QoL impact. Use the upper limit of the disability weights from the GBD Study for opioid use (mild = .473, severe = .843), cocaine use (mild = .165, severe = .634), amphetamine use (mild = .114, severe = .637), and cannabis use disorder (mild = .060, severe = .364). (Aggregate weights calculated in Table 4 and shown in Table 14, rows *e* & *f*): CPB = 270

- Assume that the proportion of positively screened individuals receiving behavioural intervention increases from 33.1% to 65.5% (Table 14, row *n*): CPB = **419**
- Assume that the drug use cessation rate resulting from behavioural intervention decreases from 6% to 2% (Table 14, row *o*): CPB = **71**
- Assume that the drug use cessation rate resulting from behavioural intervention increases from 6% to 10% (Table 14, row *o*): CPB = 353
- Model from ages 18 through 79 (an additional 10 years modelled above the baseline age of 69 – Table 14, row *a*): CPB = 216
- Model from ages 18 through 59 (a reduction of 10 years modelled compared to baseline age of 69 – Table 14, row *a*): CPB = 195

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with screening and brief behavioural interventions to reduce unhealthy drug use in adults 18 to 69 years of age in a British Columbia birth cohort of 40,000.

In estimating CE, we made the following assumptions:

Number of Screens and Brief Behavioural Interventions

- We assume that brief interventions are given based on a positive in-depth screen, which includes individuals with both true- and false-positive screen results.
- Tables 15 and 16 provide an estimate of the number of basic and full screens required between the ages of 18 and 69 in a BC birth cohort of 40,000 as well as the total number of positive screen results. To calculate this we first multiply the GP screening rate (54.3%) by annual GP visits. We then take the true positive basic screen results from Tables 10 and 11 and divide by the positive predictive value of the basic screen (55.1%) to get the number of positive basic screens (including false positives). This gives us the total number of detailed screens that would be administered. We perform a similar calculation on the true positives from the detailed screen (see Tables 10 and 11) using a positive predictive value of 94.2%. The result is the total number of positive detailed screens (including false positives). Furthermore, we assume that patients are offered and accept a brief intervention at a rate of 33.1%, regardless of whether their screen was a true- or false-positive. On the other hand, the benefits of a brief intervention are only realized when the individual is truly positive for unhealthy drug use. That is, there are costs associated with providing a brief intervention to an individual who is false-positive but no benefits.
- Based on these assumptions, between the ages of 18 and 69 in a BC birth cohort of 40,000 430,165 basic screens would be completed in females and 339,745 in males followed by 24,560 detailed screens in females and 42,270 in males. The detailed screening would result in 20,858 positive (both true- and false-positive) screens in females and 35,898 in males. The positive screens would be followed by 7,761 brief interventions in females and 11,882 in males (Tables 15 & 16).

Table 15: Number Screened and Accepting Behavioural Intervention

Females, between the Ages of 18 and 59/69/79

In a British Columbia Birth Cohort of 40,000

Age	Total Life Years	Annual GP Visits % (Table 9)	Annual GP Visits #	GP Basic Screening Rate %	Basic Screens Conducted #	True Positive Basic Screens # (Table	Pos. Pred. Value Basic Screen %	Total Positive Basic Screens #	True Positive Detailed Screens # (Table	Detailed Screen PPV %	Total Detailed Positive Screens #	Total Accepting BI %	Total Accepting BI #
18	19,891	65.0%	12,931	54%	7,021	353	55%	640	282	94%	300	33%	99
19	19,885	65.0%	12,927	54%	7,019	353	55%	640	282	94%	299	33%	99
20	19,878	66.0%	13,117	54%	7,123	832	55%	1,510	666	94%	707	33%	234
21	19,871	66.0%	13,113	54%	7,120	832	55%	1,509	665	94%	706	33%	234
22	19,863	66.0%	13,108	54%	7,117	831	55%	1,508	665	94%	706	33%	234
23	19,855	66.0%	13,102	54%	7,115	831	55%	1,507	664	94%	705	33%	233
24	19,847	66.0%	13,097	54%	7,112	830	55%	1,506	664	94%	705	33%	233
25	19,839	79.5%	15,767	54%	8,562	999	55%	1,812	799	94%	848	33%	281
26	19,830	79.5%	15,760	54%	8,558	998	55%	1,811	798	94%	847	33%	280
27	19,821	79.5%	15,753	54%	8,554	997	55%	1,809	798	94%	847	33%	280
28	19,811	79.5%	15,745	54%	8,550	996	55%	1,808	797	94%	846	33%	280
29	19,801	79.5%	15,737	54%	8,545	995	55%	1,806	796	94%	845	33%	280
30	19,790	81.7%	16,168	54%	8,779	691	55%	1,255	553	94%	587	33%	194
31	19,779	81.7%	16,159	54%	8,774	691	55%	1,254	553	94%	587	33%	194
32	19,767	81.7%	16,149	54%	8,769	690	55%	1,252	552	94%	586	33%	194
33	19,755	81.7%	16,139	54%	8,764	689	55%	1,251	551	94%	585	33%	194
34	19,742	81.7%	16,129	54%	8,758	688	55%	1,250	551	94%	585	33%	194
35	19,729	79.8%	15,751	54%	8,553	672	55%	1,220	538	94%	571	33%	189
36	19,715	79.8%	15,740	54%	8,547	671	55%	1,218	537	94%	570	33%	189
37	19,700	79.8%	15,728	54%	8,540	670	55%	1,217	536	94%	569	33%	188
38	19,685	79.8%	15,716	54%	8,534	670	55%	1,215	536	94%	569	33%	188
39	19,669	79.8%	15,703	54%	8,527	669	55%	1,214	535	94%	568	33%	188
40	19,652	76.4%	15,006	54%	8,148	321	55%	583	257	94%	273	33%	90
41	19,634	76.4%	14,992	54%	8,141	321	55%	582	257	94%	272	33%	90
42	19,615	76.4%	14,977	54%	8,133	320	55%	581	256	94%	272	33%	90
43	19,594	76.4%	14,961	54%	8,124	320	55%	580	256	94%	272	33%	90
44	19,572	76.4%	14,945	54%	8,115	319	55%	579	255	94%	271	33%	90
45	19,549	78.3%	15,300	54%	8,308	327	55%	593	261	94%	277	33%	92
46	19,524	78.3%	15,280	54%	8,297	326	55%	592	261	94%	277	33%	92
47	19,497	78.3%	15,259	54%	8,286	325	55%	591	260	94%	276	33%	91
48	19,469	78.3%	15,237	54%	8,274	325	55%	589	260	94%	276	33%	91
49	19,438	78.3%	15,213	54%	8,261	324	55%	588	259	94%	275	33%	91
50	19,405	81.5%	15,814	54%	8,587	307	55%	557	246	94%	261	33%	86
51	19,370	81.5%	15,785	54%	8,571	306	55%	556	245	94%	260	33%	86
52	19,332	81.5%	15,754	54%	8,555	305	55%	554	244	94%	259	33%	86
53	19,291	81.5%	15,721	54%	8,536	304	55%	552	244	94%	259	33%	86
54	19,247	81.5%	15,685	54%	8,517	303	55%	551	243	94%	258	33%	85
55	19,199	82.0%	15,735	54%	8,544	304	55%	552	243	94%	258	33%	85
56	19,148	82.0%	15,692	54%	8,521	303	55%	550	242	94%	257	33%	85
57	19,092	82.0%	15,647	54%	8,496	302	55%	547	241	94%	256	33%	85
58	19,032	82.0%	15,597	54%	8,469	300	55%	545	240	94%	255	33%	84
59	18,966	82.0%	15,544	54%	8,440	299	55%	542	239	94%	254	33%	84
Total to Age 59	**823,150**		**637,684**		**346,263**	**22,909**		**41,577**	**18,327**		**19,456**		**6,440**
60	18,895	80.9%	15,282	54%	8,298	165	55%	299	132	94%	140	94%	132
61	18,817	80.9%	15,219	54%	8,264	164	55%	297	131	94%	139	94%	131
62	18,733	80.9%	15,151	54%	8,227	163	55%	295	130	94%	138	94%	130
63	18,641	80.9%	15,077	54%	8,187	162	55%	293	129	94%	137	94%	129
64	18,541	80.9%	14,996	54%	8,143	161	55%	291	128	94%	136	94%	128
65	18,432	86.7%	15,986	54%	8,681	171	55%	310	137	94%	145	94%	137
66	18,312	86.7%	15,883	54%	8,624	169	55%	307	135	94%	144	94%	135
67	18,181	86.7%	15,769	54%	8,563	168	55%	304	134	94%	142	94%	134
68	18,038	86.7%	15,645	54%	8,495	166	55%	301	133	94%	141	94%	133
69	17,881	86.7%	15,509	54%	8,421	164	55%	298	131	94%	139	94%	131
Total to Age 69	**1,007,621**		**792,200**		**430,165**	**24,560**		**44,574**	**19,648**		**20,858**		**7,761**
70	17,709	84.8%	15,015	54%	8,153	39	55%	70	31	94%	33	94%	31
71	17,520	84.8%	14,855	54%	8,066	38	55%	69	30	94%	32	94%	30
72	17,313	84.8%	14,679	54%	7,971	37	55%	68	30	94%	32	94%	30
73	17,085	84.8%	14,486	54%	7,866	37	55%	67	29	94%	31	94%	29
74	16,835	84.8%	14,274	54%	7,751	36	55%	66	29	94%	31	94%	29
75	16,561	85.8%	14,215	54%	7,719	36	55%	65	29	94%	30	94%	29
76	16,260	85.8%	13,956	54%	7,578	35	55%	64	28	94%	30	94%	28
77	15,929	85.8%	13,673	54%	7,424	34	55%	62	27	94%	29	94%	27
78	15,567	85.8%	13,362	54%	7,256	33	55%	60	27	94%	28	94%	27
79	15,171	85.8%	13,022	54%	7,071	32	55%	58	26	94%	27	94%	26
Total to Age 79	***1,173,570***		***933,738***		***507,020***	***24,918***		***45,223***	***19,934***		***21,162***		***8,047***

Table 16: Number Screened and Accepting Behavioural Intervention

Males, between the Ages of 18 and 59/69/79

In a British Columbia Birth Cohort of 40,000

Age	Total Life Years	Annual GP Visits % (Table 9)	Annual GP Visits #	GP Basic Screening Rate %	Basic Screens Conducted #	True Positive Basic Screens # (Table	Pos. Pred. Value Basic Screen %	Total Positive Basic Screens #	True Positive Detailed Screens # (Table	Detailed Screen PPV %	Total Detailed Positive Screens #	Total Accepting BI %	Total Accepting BI #
18	19,870	53.0%	10,535	54%	5,720	656	55%	1,191	525	94%	557	33%	184
19	19,858	53.0%	10,528	54%	5,717	656	55%	1,190	525	94%	557	33%	184
20	19,843	45.8%	9,080	54%	4,931	1,316	55%	2,389	1,053	94%	1,118	33%	370
21	19,826	45.8%	9,073	54%	4,926	1,316	55%	2,388	1,053	94%	1,117	33%	370
22	19,807	45.8%	9,064	54%	4,922	1,315	55%	2,386	1,052	94%	1,117	33%	370
23	19,786	45.8%	9,054	54%	4,916	1,314	55%	2,384	1,051	94%	1,116	33%	369
24	19,763	45.8%	9,044	54%	4,911	1,313	55%	2,383	1,050	94%	1,115	33%	369
25	19,739	52.4%	10,338	54%	5,613	1,501	55%	2,724	1,201	94%	1,275	33%	422
26	19,714	52.4%	10,325	54%	5,606	1,500	55%	2,722	1,200	94%	1,274	33%	422
27	19,689	52.4%	10,311	54%	5,599	1,499	55%	2,720	1,199	94%	1,273	33%	421
28	19,662	52.4%	10,297	54%	5,591	1,497	55%	2,717	1,198	94%	1,272	33%	421
29	19,635	52.4%	10,283	54%	5,584	1,496	55%	2,715	1,197	94%	1,270	33%	420
30	19,607	51.7%	10,129	54%	5,500	997	55%	1,810	798	94%	847	33%	280
31	19,579	51.7%	10,114	54%	5,492	996	55%	1,808	797	94%	846	33%	280
32	19,550	51.7%	10,099	54%	5,484	995	55%	1,806	796	94%	845	33%	280
33	19,520	51.7%	10,083	54%	5,475	994	55%	1,804	795	94%	844	33%	279
34	19,489	51.7%	10,068	54%	5,467	993	55%	1,802	794	94%	843	33%	279
35	19,458	63.1%	12,286	54%	6,671	1,212	55%	2,200	970	94%	1,030	33%	341
36	19,425	63.1%	12,265	54%	6,660	1,211	55%	2,198	969	94%	1,028	33%	340
37	19,392	63.1%	12,244	54%	6,648	1,210	55%	2,195	968	94%	1,027	33%	340
38	19,357	63.1%	12,222	54%	6,637	1,208	55%	2,192	966	94%	1,026	33%	340
39	19,321	63.1%	12,199	54%	6,624	1,206	55%	2,189	965	94%	1,024	33%	339
40	19,283	62.8%	12,104	54%	6,572	603	55%	1,094	482	94%	512	33%	169
41	19,245	62.8%	12,079	54%	6,559	602	55%	1,092	481	94%	511	33%	169
42	19,204	62.8%	12,054	54%	6,545	601	55%	1,090	481	94%	510	33%	169
43	19,162	62.8%	12,027	54%	6,531	600	55%	1,089	480	94%	509	33%	169
44	19,117	62.8%	11,999	54%	6,516	599	55%	1,087	479	94%	508	33%	168
45	19,071	68.5%	13,057	54%	7,090	652	55%	1,183	522	94%	554	33%	183
46	19,022	68.5%	13,024	54%	7,072	651	55%	1,181	521	94%	553	33%	183
47	18,970	68.5%	12,988	54%	7,052	649	55%	1,178	519	94%	551	33%	183
48	18,915	68.5%	12,950	54%	7,032	648	55%	1,176	518	94%	550	33%	182
49	18,857	68.5%	12,911	54%	7,010	646	55%	1,173	517	94%	549	33%	182
50	18,795	65.6%	12,333	54%	6,697	564	55%	1,024	451	94%	479	33%	159
51	18,729	65.6%	12,290	54%	6,674	562	55%	1,021	450	94%	478	33%	158
52	18,659	65.6%	12,244	54%	6,649	561	55%	1,018	449	94%	476	33%	158
53	18,583	65.6%	12,195	54%	6,622	559	55%	1,015	447	94%	475	33%	157
54	18,503	65.6%	12,142	54%	6,593	557	55%	1,011	446	94%	473	33%	157
55	18,417	72.8%	13,416	54%	7,285	616	55%	1,119	493	94%	524	33%	173
56	18,325	72.8%	13,348	54%	7,248	614	55%	1,115	491	94%	522	33%	173
57	18,226	72.8%	13,276	54%	7,209	612	55%	1,110	489	94%	519	33%	172
58	18,120	72.8%	13,199	54%	7,167	609	55%	1,105	487	94%	517	33%	171
59	18,006	72.8%	13,116	54%	7,122	606	55%	1,100	485	94%	515	33%	170
Total to Age 59	**807,096**		**482,392**		**261,939**	**38,512**		**69,894**	**30,809**		**32,706**		**10,826**
60	17,884	82.5%	14,750	54%	8,010	383	55%	696	307	94%	326	33%	108
61	17,752	82.5%	14,642	54%	7,951	381	55%	692	305	94%	324	33%	107
62	17,610	82.5%	14,525	54%	7,887	379	55%	687	303	94%	322	33%	106
63	17,458	82.5%	14,399	54%	7,819	376	55%	683	301	94%	320	33%	106
64	17,293	82.5%	14,264	54%	7,745	373	55%	678	299	94%	317	33%	105
65	17,116	84.7%	14,492	54%	7,869	380	55%	690	304	94%	323	33%	107
66	16,925	84.7%	14,330	54%	7,781	377	55%	684	302	94%	320	33%	106
67	16,719	84.7%	14,156	54%	7,687	373	55%	678	299	94%	317	33%	105
68	16,496	84.7%	13,967	54%	7,584	369	55%	671	296	94%	314	33%	104
69	16,256	84.7%	13,764	54%	7,474	365	55%	663	292	94%	310	33%	103
Total to Age 69	**978,605**		**625,681**		**339,745**	**42,270**		**76,715**	**33,816**		**35,898**		**11,882**
70	15,997	85.9%	13,738	54%	7,460	89	55%	162	71	94%	76	33%	25
71	15,718	85.9%	13,498	54%	7,329	88	55%	160	70	94%	75	33%	25
72	15,416	85.9%	13,239	54%	7,189	87	55%	157	69	94%	74	33%	24
73	15,092	85.9%	12,960	54%	7,037	85	55%	155	68	94%	72	33%	24
74	14,742	85.9%	12,659	54%	6,874	84	55%	152	67	94%	71	33%	23
75	14,365	90.4%	12,980	54%	7,048	86	55%	156	69	94%	73	33%	24
76	13,960	90.4%	12,614	54%	6,849	84	55%	153	67	94%	71	33%	24
77	13,526	90.4%	12,222	54%	6,636	82	55%	149	66	94%	70	33%	23
78	13,061	90.4%	11,801	54%	6,408	80	55%	145	64	94%	68	33%	22
79	12,563	90.4%	11,352	54%	6,164	77	55%	140	62	94%	66	33%	22
Total	***1,123,045***		***752,743***		***408,739***	***43,112***		***78,243***	***34,489***		***36,613***		***12,119***

Cost of Screening and Interventions

- A time and motion study of SBIRT activities found that a pre-screen (1-4 questions about substance use) took on average of 1:19 minutes, a full-screen (e.g. *Alcohol, Smoking and Substance Involvement Screening Test* [ASSIST]) took an average of 4:28 minutes in direct patient contact with an additional 9:30 minutes in support time and a brief intervention took an average of 6:51 minutes in direct patient contact with an additional 10:08 minutes in support time. Referral to treatment took an average of 4:38 minutes in direct patient contact and 19:19 minutes in support time.[1655]
- A cost analysis of the first 7 SBIRT programs funded by SAMHSA in the US found a mean cost per screen of $69 (in 2007 USD), ranging from $46 to $87 per screen ($77 [2022 CAD], ranging from $51 to $96). Costs included service delivery, quality assurance, program administration, space, materials/equipment and contracted services. Services costs for each program included screening, brief intervention and referral to treatment for both alcohol and unhealthy drug use.[1656]
- Zarkin et al estimated direct service delivery costs (e.g. not including support service or overhead costs) for drug screening to be $2.30 (in 2011 USD, taking an average of 4 minutes to complete) and a brief intervention to be $6.16 (taking 15 minutes to complete).[1657]
- Barbosa and colleagues took a unit cost approach, which included labour, materials and space cost, to estimate the average cost of SBIRT components in emergency department and out-patient settings. They determined the cost of a screen to be $5.29 and a brief intervention to be $9.15 (2012 USD). This equates to $5.42 and $9.37 respectively in 2022 CAD.
- "The management of patients who screen positive is usually accompanied by other interventions, including testing for blood-borne pathogens; assessment of misuse of, abuse of, or dependence on alcohol or tobacco; assessment of potentially coexisting mental health disorders; and pain management for patients with pain who are abusing opioids."[1658]
- We use the time estimates by Cowell et al[1659] to estimate the costs of screening and the brief intervention.
- A basic screening test would take 1:19 minutes.
- If the basic screening is followed by an in-depth screen, an additional 13:58 minutes are required (4:28 in direct contact and 9:30 in support time) for a total screening time of 15:17 minutes.
- A brief intervention would require 16:59 minutes (6:51 in direct contact and 10:08 in support time). We assume that this intervention would take place at a subsequent visit.

[1655] Cowell A, Dowd W, Landwehr J et al. A time and motion study of Screening, Brief Interventions and Referral to Treatment implementation in health-care settings. *Addiction*. 2017: 112 (Suppl. 2); 65-72.
[1656] Bray J, Mallonee E, Dowd W et al. Program- and service-level costs of seven screening, brief intervention, and referral to treatment programs. *Substance Abuse and Rehabilitation*. 2014; 5: 63-73.
[1657] Zarkin G, Bray J, Hinde J et al. Costs of screening and brief interventions for illicit drug use in primary care settings. *Journal of Studies on Alcohol and Drugs*. 2015: 76(2); 222-8.
[1658] US Preventive Services Task Force. Screening for Unhealthy Drug Use: US Preventive Services Task Force Recommendation Statement. *JAMA*. 2020: 323(22); 2301- 09.
[1659] Cowell A, Dowd W, Landwehr J et al. A time and motion study of Screening, Brief Interventions and Referral to Treatment implementation in health-care settings. *Addiction*. 2017: 112 (Suppl. 2); 65-72.

- The estimated cost of a visit to a GP of $35.97 is based on the average cost of an office visit between the ages of 2 and 79 (see Reference Document). We assume 10 minutes for the average GP visit with a cost of $3.597 per minute.
- Patient time costs resulting from receiving, as well as travelling to and from, a service are valued based on the average hourly wage rate in BC in 2022 ($31.49[1660]) plus 18% benefits for an average cost per hour of $37.16. In the absence of specific data on the amount of time required, we assume two hours per service for both the in-depth screening and the brief intervention. If just a basic screening test is required (lasting approximately 1:19 minute), then we assume that 20% of the visit is for the basic screening and that other 'interventions' will occur during the 10-minute visit.

Costs Avoided Due to a Reduction in Unhealthy Drug Use

- In addition to a reduced life expectancy and quality of life, unhealthy drug use is also associated with higher *annual medical care costs* (e.g., hospitalization, physician, drug, etc.) and *criminal justice costs* than no unhealthy drug use.
- The Canadian Institute for Substance Use Research (CISUR) and the Canadian Centre on Substance Use and Addiction (CCSUA) estimated the annual costs of unhealthy drug use in Canada to be $11,811 million in 2014. Of this amount, $990 million (8.4%) was for healthcare costs, $3,899 million (33%) for indirect costs (short- and long-term disability, premature mortality), $5,802 million (49%) for criminal justice costs and $1,120 million (9.5%) for 'other' costs (primarily motor vehicle damage).[1661]
- In Belgium, Lievens et al estimated the annual health care (including prevention) and crime costs associated with unhealthy drug use to be €731 million (in 2012 Euros or $1,257 million in 2022 C$).[1662] Of the total €731 million, €259 million (35%) was for health care costs and €473 million (65%) was for crime costs.
- In Spain, Rivera et al estimated the annual health care and crime costs (including prevention) associated with unhealthy drug use to be between €1,206 and €1,420 million (in 2012 Euros or between $2,511 and $2,958 million in 2022 C$).[1663] Of this total, between 57% and 63% was for health care costs.
- In France, Kopp & Ogrodnik estimated the annual health care, law enforcement and prevention costs associated with unhealthy drug use to be €7,903 per user (in 2010 Euros or $13,879 in 2022 C$).[1664] Of the total, €4,860 (61% or $8,535 in 2022 C$) was for excess healthcare costs and €3,043 (39% or $5,344 in 2012 C$) for law enforcement and prevention.
- The CISUR and CCSUA analysis also estimated the annual costs of unhealthy drug use in BC to be $1,671 million in 2014. Of this amount, $227 million (14%) was for

[1660] BC Stats. *Earning & Employment Trends – August 2022*. Available at https://www2.gov.bc.ca/assets/gov/data/statistics/people-population-community/income/earnings_and_employment_trends_data_tables.pdf. Accessed September 2022.
[1661] Canadian Substance Use Costs and Harms Scientific Working Group. *Canadian substance use costs and harms (2007 – 2014)*. 2018. Prepared by the Canadian Institute for Substance Use Research and the Canadian Centre on Substance Use and Addiction. Ottawa, Ontario.
[1662] Lievens D, Laenen F, Verhaeghe N et al. Economic consequences of legal and illegal drugs: The case of social cost in Belgium. *International Journal of Drug Policy*. 2017; 44: 50-57.
[1663] Rivera B, Casal B, Currais L. The social cost of illicit drug use in Spain. *International Journal of Drug Policy*. 2017; 44: 92-104.
[1664] Kopp P & Ogrodnik M. The social cost of drugs in France in 2010. *The European Journal of Health Economics*. 2017; 18: 883-92.

healthcare costs, $718 million (43%) for criminal justice costs, $147 million (8.8%) for motor vehicle damage and $580 million (35%) for indirect costs.[1665]

- Earlier we estimated that 5.28% of the BC adult population had unhealthy drug use (excluding cannabis) and a further 4.07% had cannabis use disorder, or 9.35% of BC adults ages 18 and older. If this proportion holds for 2014, then we would expect approximately 361,000 BC adults with unhealthy drug use in BC in 2014.[1666] The direct cost estimate from the CISUR and CCSUA analysis for BC in 2014 is $1,092 million or $3,022 per unhealthy drug user ($3,405 in 2022 C$). This $3,405 annual excess cost consists of $715 (21%) for healthcare costs, $2,247 (66%) for criminal justice costs and $443 (13%) for motor vehicle damage costs.

- For modelling purposes, we assume that a year without unhealthy drug use is associated with $8,642 (($3,405 + $13,879[1667])/2) in direct costs avoided, including healthcare and criminal justice costs. We modify this to $3,405 and $13,879 in the sensitivity analysis.

- A specific area in which both short- and long-term health care costs may be avoided is in the care of children exposed to substances in utero.

- As an example of potential short-term health care costs, infants born to opioid-dependent women have historically been separated from their mothers and admitted to a higher care nursery or neonatal intensive care unit (NICU), primarily to provide treatment for neonatal abstinence syndrome. Separation of the mother-infant dyad in the early postpartum period, however, is detrimental to the development of mother-infant bonding and attachment and the long term health of the infant, especially for substance-exposed infants. Rooming-in, the practice of caring for mother and newborn in the same room immediately after birth, has been shown to increase the likelihood of breastfeeding during the hospital stay, reduce admissions to the NICU while also reducing the use of pharmacotherapy for the infant, and increasing the odds of the baby being discharged home with the mother, all while improving the experience of the early post-partum period for the mother.[1668,1669]

- The existence of long-term health effects (and thus costs) in children exposed to substances in utero is more controversial (with the exception of tobacco and alcohol use).[1670] When adverse birth outcomes are observed, questions arise as to whether these outcomes result from the substances used or from the context within which the pregnancy occurs and the child is raised.[1671,1672]

[1665] Canadian Substance Use Costs and Harms Scientific Working Group. *Canadian Substance Use Costs and Harms in the Provinces and Territories (2007 – 2014)*. 2018. Prepared by the Canadian Institute for Substance Use Research and the Canadian Centre on Substance Use and Addiction. Ottawa, Ontario.
[1666] The estimated population of BC adults ages 18 and older as of July 1, 2014 is 3,864,319 as per BC Stats. Available online at https://bcstats.shinyapps.io/popApp/. Accessed November 2021.
[1667] Kopp P & Ogrodnik M. The social cost of drugs in France in 2010. *The European Journal of Health Economics*. 2017; 18: 883-92.
[1668] Abrahams R, MacKay-Dunn M, Nevmerjitskaia V et al. An evaluation of rooming-in among substance-exposed newborns in British Columbia. *Journal of Obstetrics and Gynaecology Canada*. 2010; 32(9): 866-71.
[1669] Newman A, Davies G, Dow K et al. Rooming-in care for infants of opioid-dependent mothers: Implementation and evaluation at a tertiary care hospital. *Canadian Family Physician*. 2015; 61: e555-61.
[1670] Dr. Nancy Poole. Director, BC Centre of Excellence for Women's Health and Prevention Lead, CanFASD Research Network. Personal communication. January 2022.
[1671] Schempf A and Strobino D. Illicit drug use and adverse birth outcomes: Is it drugs or context? *Journal of Urban Health*. 2008; 85(6): 858-73.
[1672] Louw K. Substance use in pregnancy: The medical challenge. *Obstetric Medicine*. 2018; 11(2): 54 - 66.

- For modelling purposes, we have assumed that any potential short- and long-term health care costs associated with the care of children exposed to substances in utero is included in the annual costs avoided calculated above.
- Table 17 shows the costs avoided for females and males as a result of a ‘successful’ brief intervention.

Table 17: Costs Avoided Due to a Reduction in Unhealthy Drug Use Between the Ages of 18 and 59/69/79

In a British Columbia Birth Cohort of 40,000

	Female			*Male*		
Age	Benefitting from a BI # (Table 10)	Costs Avoided Annually per Individual	Total Cost Avoided	Benefitting from a BI # (Table 11)	Costs Avoided Annually per Individual	Total Cost Avoided
18	5.6	$8,642	$48,427	10.4	$8,642	$90,095
19	5.6	$8,642	$48,403	10.4	$8,642	$90,052
20	13.2	$8,642	$114,261	20.9	$8,642	$180,752
21	13.2	$8,642	$114,191	20.9	$8,642	$180,642
22	13.2	$8,642	$114,115	20.9	$8,642	$180,521
23	13.2	$8,642	$114,031	20.9	$8,642	$180,389
24	13.2	$8,642	$113,943	20.9	$8,642	$180,248
25	15.9	$8,642	$137,121	23.9	$8,642	$206,114
26	15.9	$8,642	$137,005	23.8	$8,642	$205,940
27	15.8	$8,642	$136,884	23.8	$8,642	$205,758
28	15.8	$8,642	$136,760	23.8	$8,642	$205,571
29	15.8	$8,642	$136,630	23.8	$8,642	$205,376
30	11.0	$8,642	$94,932	15.8	$8,642	$136,929
31	11.0	$8,642	$94,836	15.8	$8,642	$136,792
32	11.0	$8,642	$94,738	15.8	$8,642	$136,650
33	11.0	$8,642	$94,637	15.8	$8,642	$136,504
34	10.9	$8,642	$94,532	15.8	$8,642	$136,352
35	10.7	$8,642	$92,272	19.3	$8,642	$166,472
36	10.7	$8,642	$92,163	19.2	$8,642	$166,275
37	10.7	$8,642	$92,049	19.2	$8,642	$166,070
38	10.6	$8,642	$91,932	19.2	$8,642	$165,857
39	10.6	$8,642	$91,809	19.2	$8,642	$165,636
40	5.1	$8,642	$44,118	9.6	$8,642	$82,732
41	5.1	$8,642	$44,053	9.6	$8,642	$82,611
42	5.1	$8,642	$43,985	9.5	$8,642	$82,484
43	5.1	$8,642	$43,914	9.5	$8,642	$82,350
44	5.1	$8,642	$43,839	9.5	$8,642	$82,209
45	5.2	$8,642	$44,853	10.4	$8,642	$89,513
46	5.2	$8,642	$44,767	10.3	$8,642	$89,341
47	5.2	$8,642	$44,676	10.3	$8,642	$89,159
48	5.2	$8,642	$44,579	10.3	$8,642	$88,965
49	5.1	$8,642	$44,476	10.3	$8,642	$88,760
50	4.9	$8,642	$42,155	9.0	$8,642	$77,434
51	4.9	$8,642	$42,043	8.9	$8,642	$77,229
52	4.9	$8,642	$41,923	8.9	$8,642	$77,010
53	4.8	$8,642	$41,795	8.9	$8,642	$76,774
54	4.8	$8,642	$41,658	8.9	$8,642	$76,522
55	4.8	$8,642	$41,745	9.8	$8,642	$84,643
56	4.8	$8,642	$41,586	9.8	$8,642	$84,319
57	4.8	$8,642	$41,415	9.7	$8,642	$83,972
58	4.8	$8,642	$41,230	9.7	$8,642	$83,598
59	4.7	$8,642	$41,031	9.6	$8,642	$83,193
Total to Age 59	**364**		**$3,145,512**	**612**		**$5,287,811**
60	2.6	$8,642	$22,623	6.1	$8,642	$52,630
61	2.6	$8,642	$22,494	6.1	$8,642	$52,331
62	2.6	$8,642	$22,355	6.0	$8,642	$52,007
63	2.6	$8,642	$22,205	6.0	$8,642	$51,657
64	2.6	$8,642	$22,042	5.9	$8,642	$51,279
65	2.7	$8,642	$23,449	6.0	$8,642	$52,218
66	2.7	$8,642	$23,244	6.0	$8,642	$51,762
67	2.7	$8,642	$23,021	5.9	$8,642	$51,267
68	2.6	$8,642	$22,780	5.9	$8,642	$50,729
69	2.6	$8,642	$22,518	5.8	$8,642	$50,146
Total to Age 69	**390**		**$3,372,242**	**672**		**$5,803,837**
70	0.6	$8,642	$5,301	1.4	$8,642	$12,248
71	0.6	$8,642	$5,228	1.4	$8,642	$12,078
72	0.6	$8,642	$5,148	1.4	$8,642	$11,893
73	0.6	$8,642	$5,061	1.4	$8,642	$11,693
74	0.6	$8,642	$4,966	1.3	$8,642	$11,475
75	0.6	$8,642	$4,924	1.4	$8,642	$11,825
76	0.6	$8,642	$4,812	1.3	$8,642	$11,555
77	0.5	$8,642	$4,690	1.3	$8,642	$11,262
78	0.5	$8,642	$4,558	1.3	$8,642	$10,946
79	0.5	$8,642	$4,416	1.2	$8,642	$10,604
Total to Age 79	***396***		**$3,421,346**	***685***		***$5,919,415***

Summary of CE – Males and Females

- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the CE associated with screening and a brief behavioural intervention to reduce unhealthy drug use in adults 18 to 69 years old in a British Columbia birth cohort of 40,000 is $62,440 / QALY (Table 18, row *ai*).

Table 18: CE of Screening for Unhealthy Drug Use and Brief Intervention
Ages 18 - 69
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
	Cost of Screening		
a	Screening frequency (in years)	1	√
b	Lifetime basic screens conducted, females	430,165	Table 15
c	Lifetime basic screens conducted, males	339,745	Table 16
d	Lifetime detailed screens conducted, females	24,560	Table 15
e	Lifetime detailed screens conducted, males	42,270	Table 16
f	Cost of 10-minute office visit	$35.97	Ref. Doc.
g	Cost per minute of GP time	$3.60	= f / 10
h	Patient time costs / hour	$37.16	Ref. Doc.
i	Lifetime basic screens only, females	405,604	= b - d
j	Lifetime basic screens only, males	297,475	= c - e
k	Total lifetime basic screens only	703,079	= i + j
l	GP time for basic screen only (in minutes)	1.32	√
m	Patient time, basic screen only (in hours)	0.4	√
n	Total cost of basic screen only	$13,780,384	= (k * l * g) + (k * m * h)
o	GP time for basic and detailed screen (in minutes)	15.28	√
p	Total lifetime detailed screens	66,830	= d + e
q	Patient time, detailed screen (in hours)	2	√
r	Total cost of basic and detailed screens	$8,640,772	= (p * o * g) + (p * q * h)
s	Total cost of screening, lifetime	$22,421,155	= n + r
	Cost of Brief Intervention		
t	Lifetime brief interventions, female	7,761	Table 15
u	Lifetime brief interventions, male	11,882	Table 16
v	Total lifetime brief interventions	19,643	= t + u
w	GP time for brief intervention (in minutes)	16.98	√
x	Patient time, brief intervention (in hours)	2	√
y	Total cost of brief intervention	$2,659,857	= (v * w * g) + (v * x * h)
	Costs Avoided due to Brief Intervention		
z	Annual Cost of Unhealthy Drug Use	$8,642	√
aa	Lifetime cost savings, female	$3,372,242	Table 17
ab	Lifetime cost savings, male	$5,803,837	Table 17
ac	Lifetime cost savings, total	$9,176,079	= aa + ab
	Net Cost of Screening and Brief Intervention		
ad	Net Cost of Screening and Brief Intervention	$15,904,933	= s + y - ac
ae	QALYs saved	325	Table 12
af	CE ($/QALY Saved)	$48,951	= ad / ae
ag	Net Cost of Screening and Brief Intervention, 1.5% Discount	$15,709,676	Calculated
ah	QALYs saved, 1.5% Discount	252	Calculated
ai	**CE ($/QALY Saved), 1.5% Discount**	**$62,440**	= ag / ah

√ = Estimates from the literature

Sensitivity Analysis – Males and Females

We also modified several major assumptions and recalculated the CE as follows:

- Reduced QoL impact. Use the lower limit of the disability weights from the GBD Study for opioid use (mild = .221, severe = .510), cocaine use (mild = .074, severe = .324), amphetamine use (mild = .051, severe = .329), and Cannabis Use Disorder (mild = .024, severe = .178). (Aggregate weights calculated in Table 4 and shown in Table 12, rows *g* & *h*): CE = $81,539
- Increased QoL impact. Use the upper limit of the disability weights from the GBD Study for opioid use (mild = .473, severe = .843), cocaine use (mild = .165, severe = .634), amphetamine use (mild = .114, severe = .637), and Cannabis Use Disorder (mild = .060, severe = .364). (Aggregate weights calculated in Table 4 and shown in Table 12, rows *g* & *h*): CE = $48,699
- Assume that the proportion of positively screened individuals receiving a brief behavioural intervention increases from 33.1% to 65.5% (Table 12, row *u*): CE = **$21,441**
- Assume that the drug use cessation rate resulting from a brief behavioural intervention decreases from 6% to 2% (Table 12, row *v*): CE = **$243,536**
- Assume that the drug use cessation rate resulting from a brief behavioural intervention increases from 6% to 10% (Table 12, row *v*): CE = $26,221
- Assume that the annual costs avoided as a result of a 'successful' brief intervention decreases from $8,642 to $3,405 (Table 18, row *z*): CE = $79,473
- Assume that the annual costs avoided as a result of a 'successful' brief intervention increases from $8,642 to $13,879 (Table 18, row *z*): CE = $45,407
- Model from ages 18 through 79 (an additional 10 years modelled above the baseline age of 69 – Table 12, row *a*): CE = $67,175
- Model from ages 18 through 59 (a reduction of 10 years modelled compared to the baseline age of 69 – Table 12, row *a*): CE = $57,372
- Assume screening and intervention occur every three years rather than every year (Table 18, row *a*): CE = $29,244
- Assume screening and intervention occur every five years rather than every year (Table 18, row *a*): CE = $22,605

Summary of CE – Females Only

We ran the same analyses, with the same assumptions as above, but for females only. The CE associated with screening and a brief behavioural intervention to reduce unhealthy drug use in females 18 to 69 years old in a British Columbia birth cohort of 40,000 is $88,908 / QALY (Table 19, row *aa*).

Table 19: CE of Screening for Unhealthy Drug Use and Brief Intervention
Females, Ages 18 - 69
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
	Cost of Screening		
a	Screening frequency (in years)	1	√
b	Lifetime basic screens conducted, females	430,165	Table 15
c	Lifetime in depth screens conducted, females	24,560	Table 15
d	Cost of 10-minute office visit	$34.85	Ref. Doc.
e	Cost per minute of GP time	$3.49	= d / 10
f	Patient time costs / hour	$37.16	Ref. Doc.
g	Lifetime basic screens only, females	405,604	= b - c
h	GP time for basic screen only (in minutes)	1.32	√
i	Patient time, basic screen only (in hours)	0.4	√
j	Total cost of basic screen only	$7,890,049	= (g * h * e) + (g * i * f)
k	GP time for basic and in-depth screen (in minutes)	15.28	√
l	Total lifetime in-depth screens	24,560	= c
m	Patient time, in depth screen (in hours)	2	√
n	Total cost of basic and in depth screens	$3,133,474	= (l * k * e) + (l * m * f)
o	Total cost of screening, lifetime	$11,023,523	= j + n
	Cost of Brief Intervention		
p	Lifetime brief interventions, female	7,761	Table 15
q	GP time for brief intervention (in minutes)	16.98	√
r	Patient time, brief intervention (in hours)	2	√
s	Total cost of brief intervention	$1,036,131	= (p * q * e) + (p * r * f)
	Costs Avoided due to Brief Intervention		
t	Annual Cost of Unhealthy Drug Use	$8,642	√
u	Lifetime cost savings, female	$3,372,242	Table 17
	Net Cost of Screening and Brief Intervention		
v	Net Cost of Screening and Brief Intervention	$8,687,411	= o + s - u
w	QALYs saved	113	Table 13
x	CE ($/QALY Saved)	$76,761	= v / w
y	Net Cost of Screening and Brief Intervention, 1.5% Discount	$7,900,199	Calculated
z	QALYs saved, 1.5% Discount	89	Calculated
aa	**CE ($/QALY Saved), 1.5% Discount**	**$88,908**	= y / z

√ = Estimates from the literature

Sensitivity Analysis – Females Only

We also modified several major assumptions and recalculated the CE as follows:

- Reduced QoL impact. Use the lower limit of the disability weights from the GBD Study for opioid use (mild = .221, severe = .510), cocaine use (mild = .074, severe = .324), amphetamine use (mild = .051, severe = .329), and Cannabis Use Disorder (mild = .024, severe = .178). (Aggregate weights calculated in Table 4 and shown in Table 13, rows *e* & *f*): CE = $125,396
- Increased QoL impact. Use the upper limit of the disability weights from the GBD Study for opioid use (mild = .473, severe = .843), cocaine use (mild = .165, severe = .634), amphetamine use (mild = .114, severe = .637), and Cannabis Use Disorder (mild = .060, severe = .364). (Aggregate weights calculated in Table 4 and shown in Table 13, rows *e* & *f*): CE = $68,947
- Assume that the proportion of positively screened individuals receiving a brief behavioural intervention increases from 33.1% to 65.5% (Table 13, row *n*): CE = **$34,159**
- Assume that the drug use cessation rate resulting from a brief behavioural intervention decreases from 6% to 2% (Table 13, row *o*): CE = **$325,968**
- Assume that the drug use cessation rate resulting from a brief behavioural intervention increases from 6% to 10% (Table 13, row *o*): CE = $41,496
- Assume that the annual costs avoided as a result of a 'successful' brief intervention decreases from $8,642 to $3,405 (Table 19, row *t*): CE = $106,859
- Assume that the annual costs avoided as a result of a 'successful' brief intervention increases from $8,642 to $13,879 (Table 19, row *t*): CE = $70,958
- Model from ages 18 through 79 (an additional 10 years modelled above the baseline age of 69 – Table 13, row *a*): CE = $96,141
- Model from ages 18 through 59 (a reduction of 10 years modelled compared to the baseline age of 69 – Table 13, row *a*): CE = $80,896
- Assume screening and intervention occur every three years rather than every year (Table 19, row *a*): CE = $38,521
- Assume screening and intervention occur every five years rather than every year (Table 19, row *a*): CE = $28,444

Summary of CE – Males Only

We ran the same analyses, with the same assumptions as above, but for males only. The CE associated with screening and a brief behavioural intervention to reduce unhealthy drug use in males 18 to 69 years old in a British Columbia birth cohort of 40,000 is $47,988 / QALY (Table 20, row *aa*).

Table 20: CE of Screening for Unhealthy Drug Use and Brief Intervention
Males, Ages 18 - 69
In a BC Birth Cohort of 40,000

Row Label	Variable	Base case	Data Source
	Cost of Screening		
a	Screening frequency (in years)	1	√
b	Lifetime basic screens conducted, males	339,745	Table 16
c	Lifetime in depth screens conducted, males	42,270	Table 16
d	Cost of 10-minute office visit	$34.85	Ref. Doc.
e	Cost per minute of GP time	$3.49	= d / 10
f	Patient time costs / hour	$37.16	Ref. Doc.
g	Lifetime basic screens only, males	297,475	= b - c
h	GP time for basic screen only (in minutes)	1.32	√
i	Patient time, basic screen only (in hours)	0.4	√
j	Total cost of basic screen only	$5,786,654	= (g * h * e) + (g * i * f)
k	GP time for basic and in-depth screen (in minutes)	15.28	√
l	Total lifetime in-depth screens	42,270	= c
m	Patient time, in depth screen (in hours)	2	√
n	Total cost of basic and in depth screens	$5,392,902	= (l * k * e) + (l * m * f)
o	Total cost of screening, lifetime	$11,179,556	= j + n
	Cost of Brief Intervention		
p	Lifetime brief interventions, male	11,882	Table 16
q	GP time for brief intervention (in minutes)	16.98	√
r	Patient time, brief intervention (in hours)	2	√
s	Total cost of brief intervention	$1,586,363	= (p * q * e) + (p * r * f)
	Costs Avoided due to Brief Intervention		
z	Annual Cost of Unhealthy Drug Use	$8,642	√
ab	Lifetime cost savings, male	$5,803,837	Table 17
	Net Cost of Screening and Brief Intervention		
v	Net Cost of Screening and Brief Intervention	$6,962,082	= o + s - u
w	QALYs saved	212	Table 14
x	CE ($/QALY Saved)	$32,881	= v / w
y	Net Cost of Screening and Brief Intervention, 1.5% Discount	$7,809,477	Calculated
z	QALYs saved, 1.5% Discount	163	Calculated
aa	**CE ($/QALY Saved), 1.5% Discount**	**$47,988**	= y / z

√ = Estimates from the literature

Sensitivity Analysis – Males Only

We also modified several major assumptions and recalculated the CE as follows:

- Reduced QoL impact. Use the lower limit of the disability weights from the GBD Study for opioid use (mild = .221, severe = .510), cocaine use (mild = .074, severe = .324), amphetamine use (mild = .051, severe = .329), and Cannabis Use Disorder (mild = .024, severe = .178). (Aggregate weights calculated in Table 4 and shown in Table 14, rows *e* & *f*): CE = $67,059
- Increased QoL impact. Use the upper limit of the disability weights from the GBD Study for opioid use (mild = .473, severe = .843), cocaine use (mild = .165, severe = .634), amphetamine use (mild = .114, severe = .637), and Cannabis Use Disorder (mild = .060, severe = .364). (Aggregate weights calculated in Table 4 and shown in Table 14, rows *e* & *f*): CE = $37,545
- Assume that the proportion of positively screened individuals receiving a brief behavioural intervention increases from 33.1% to 65.5% (Table 14, row *n*): CE = **$14,497**
- Assume that the drug use cessation rate resulting from a brief behavioural intervention decreases from 6% to 2% (Table 14, row *o*: CE = **$198,526**
- Assume that the drug use cessation rate resulting from a brief behavioural intervention increases from 6% to 10% (Table 12, row *o*): CE = $17,881
- Assume that the annual costs avoided as a result of a 'successful' brief intervention decreases from $8,642 to $3,405 (Table 20, row *z*): CE = $64,520
- Assume that the annual costs avoided as a result of a 'successful' brief intervention increases from $8,642 to $13,879 (Table 20, row *z*): CE = $31,456
- Model from ages 18 through 79 (an additional 10 years modelled above the baseline age of 69 – Table 14, row *a*): CE = $51,412
- Model from ages 18 through 59 (a reduction of 10 years modelled compared to the baseline age of 69 – Table 14, row *a*): CE = $44,331
- Assume screening and intervention occur every three years rather than every year (Table 20, row *a*): CE = $24,179
- Assume screening and intervention occur every five years rather than every year (Table 20, row *a*): CE = $19,417

Summary – Males and Females

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening and a brief behavioural intervention for the prevention of unhealthy drug use is estimated to be 252 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $62,440 / QALY (see Table 21).

Table 21: Screening for Unhealthy Drug Use and Brief Intervention in a Birth Cohort of 40,000
Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume No Current Service			
1.5% Discount Rate	**252**	84	498
3% Discount Rate	200	67	396
0% Discount Rate	325	108	643
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$62,440**	$21,441	$243,536
3% Discount Rate	$58,322	$19,423	$230,963
0% Discount Rate	$48,951	$14,544	$203,337
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	**$4,271**	Cost-saving	$69,029
3% Discount Rate	$3,299	Cost-saving	$65,896
0% Discount Rate	Cost-saving	Cost-saving	$47,505

Summary – Females Only

Applying a 1.5% discount rate, the CPB associated with screening and a brief behavioural intervention for the prevention of unhealthy drug use is estimated to be 89 QALYs while the CE is estimated to be $88,908 / QALY (see Table 22).

Table 22: Screening for Unhealthy Drug Use and Brief Intervention in a Birth Cohort of 40,000
Summary, Females

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume No Current Service			
1.5% Discount Rate	**89**	30	176
3% Discount Rate	71	24	141
0% Discount Rate	113	38	224
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$88,908**	$34,159	$325,968
3% Discount Rate	$82,083	$30,831	$305,204
0% Discount Rate	$76,761	$27,804	$289,875
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	**$10,173**	Cost-saving	$89,761
3% Discount Rate	$8,525	Cost-saving	$84,529
0% Discount Rate	$2,265	Cost-saving	$66,390

Summary – Males Only

Applying a 1.5% discount rate, the CPB associated with screening and a brief behavioural intervention for the prevention of unhealthy drug use is estimated to be 163 QALYs while the CE is estimated to be $47,988 / QALY (see Table 23).

Table 23: Screening for Unhealthy Drug Use and Brief Intervention in a Birth Cohort of 40,000
Summary, Males

	Base Case	Range	
CPB (Potential QALYs Gained)			
	Assume No Current Service		
1.5% Discount Rate	**163**	54	322
3% Discount Rate	129	43	254
0% Discount Rate	212	71	419
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$47,988**	$14,497	$198,526
3% Discount Rate	$45,107	$13,078	$189,674
0% Discount Rate	$32,881	$6,763	$153,463
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	**$1,049**	Cost-saving	$57,709
3% Discount Rate	$393	Cost-saving	$55,533
0% Discount Rate	Cost-saving	Cost-saving	$33,792

Canadian Task Force on Preventive Health Care (2015)

We recommend measuring height and weight and calculating BMI at appropriate primary care visits. (Strong recommendation; very low-quality evidence)

We recommend that practitioners not offer formal, structured interventions aimed at preventing weight gain in normal-weight adults. (Weak recommendation; very low-quality evidence)

For adults who are obese (BMI 30–39.9) and are at high risk of diabetes, we recommend that practitioners offer or refer to structured behavioural interventions aimed at weight loss. (Strong recommendation; moderate-quality evidence)

For adults who are overweight or obese, we recommend that practitioners offer or refer to structured behavioural interventions aimed at weight loss. (Weak recommendation; moderate-quality evidence)

For adults who are overweight or obese, we recommend that practitioners not routinely offer pharmacologic interventions (orlistat or metformin) aimed at weight loss. (Weak recommendation; moderate-quality evidence)[1673]

United States Preventive Services Task Force Recommendations (2012)

The USPSTF recommends screening all adults for obesity. Clinicians should offer or refer patients with a body mass index (BMI) of 30 kg/m^2 or higher to intensive, multicomponent behavioral interventions. This is a B recommendation.

Intensive, multicomponent behavioral interventions for obese adults include the following components:

- *Behavioral management activities, such as setting weight-loss goals*
- *Improving diet or nutrition and increasing physical activity*
- *Addressing barriers to change*
- *Self-monitoring*
- *Strategizing how to maintain lifestyle changes*

The USPSTF found that the most effective interventions were comprehensive and of high intensity (12 to 26 sessions in a year).

Behavioral intervention participants lost an average of 6% of their baseline weight (4 to 7 kg [8.8 to 15.4 lb]) in the first year with 12 to 26 treatment sessions compared with little or no weight loss in the control group participants. A weight loss of 5% is considered clinically important by the U.S. Food and Drug Administration (FDA).[1674]

[1673] Canadian Task Force on Preventive Health Care. Recommendations for prevention of weight gain and use of behavioural and pharmacologic interventions to manage overweight and obesity in adults in primary care. *Canadian Medical Association Journal*. 2015; 187(3): 184-95.
[1674] Moyer VA. Screening for and management of obesity in adults: US Preventive Services Task Force recommendation statement. *Annals of Internal Medicine*. 2012; 157(5): 373-8.

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with screening for and management of obesity in adults aged 18 or older in a British Columbia birth cohort of 40,000.

In modelling CPB, we made the following assumptions:

- Based on 2014 prevalence rates of obesity (based on self-reported height and weight) by age group and sex in BC,[1675] a total of 343,441 life years lived between the ages of 18 and 79 in a birth cohort of 40,000 individuals are in the obese class I or II category (Tables 1 & 2, Table 3, row *a*).

Table 1: Prevalence of Excess Weight in a *Male* Birth Cohort of 20,000

Age Group	Individuals in Birth Cohort	Years of Life in Birth Cohort	Prevalence of Excess Weight				# of Years with Excess Weight			
			Overweight	Class I	Class II	Class III	Overweight	Class I	Class II	Class III
18-19	19,870	39,740	19.3%	4.8%	0.3%	0.2%	7,654	1,903	118	61
20-24	19,815	99,073	31.2%	7.7%	0.7%	0.2%	30,916	7,629	660	211
25-29	19,701	98,505	36.6%	9.3%	2.4%	0.8%	36,021	9,176	2,368	745
30-34	19,564	97,819	42.7%	14.4%	4.6%	0.0%	41,727	14,069	4,471	0
35-39	19,408	97,038	27.8%	21.0%	3.6%	0.1%	27,022	20,414	3,472	117
40-44	19,223	96,115	37.4%	20.2%	3.5%	0.1%	35,903	19,450	3,361	56
45-49	18,993	94,967	45.4%	10.4%	5.5%	0.2%	43,117	9,862	5,236	193
50-54	18,690	93,451	37.1%	25.8%	1.3%	0.3%	34,665	24,111	1,213	286
55-59	18,270	91,351	47.3%	11.4%	2.0%	1.6%	43,247	10,394	1,825	1,452
60-64	17,673	88,366	41.2%	15.8%	3.1%	1.7%	36,384	13,992	2,776	1,541
65-69	16,810	84,050	44.9%	16.2%	4.2%	0.2%	37,712	13,622	3,515	155
70-74	15,550	77,750	47.7%	17.4%	3.6%	0.4%	37,060	13,530	2,780	305
75-79	13,720	68,602	34.3%	8.0%	3.0%	0.7%	23,554	5,481	2,088	482
Total Ages 18-79		**1,126,829**	**38.6%**	**14.5%**	**3.0%**	**0.5%**	**434,983**	**163,633**	**33,884**	**5,605**

Table 2: Prevalence of Excess Weight in a *Female* Birth Cohort of 20,000

Age Group	Individuals in Birth Cohort	Years of Life in Birth Cohort	Prevalence of Excess Weight				# of Years with Excess Weight			
			Overweight	Class I	Class II	Class III	Overweight	Class I	Class II	Class III
18-19	19,891	39,782	10.2%	3.5%	0.0%	0.0%	4,050	1,403	0	0
20-24	19,867	99,333	17.7%	3.5%	1.0%	0.0%	17,583	3,489	957	0
25-29	19,825	99,124	15.2%	4.0%	4.2%	0.2%	15,076	3,926	4,116	150
30-34	19,773	98,864	20.2%	5.7%	3.7%	1.9%	19,940	5,639	3,671	1,916
35-39	19,707	98,536	21.7%	11.0%	5.5%	2.0%	21,426	10,831	5,426	2,017
40-44	19,624	98,118	23.9%	10.7%	1.2%	4.0%	23,484	10,479	1,213	3,939
45-49	19,509	97,547	29.4%	6.2%	0.5%	0.9%	28,717	6,072	515	917
50-54	19,349	96,744	30.3%	15.4%	2.2%	1.3%	29,346	14,851	2,163	1,262
55-59	19,116	95,582	28.1%	8.2%	3.1%	2.1%	26,882	7,853	2,944	2,008
60-64	18,770	93,850	27.3%	14.4%	6.0%	3.0%	25,632	13,523	5,643	2,783
65-69	18,238	91,189	34.5%	11.6%	5.0%	1.2%	31,437	10,554	4,548	1,067
70-74	17,402	87,008	24.6%	9.4%	5.9%	1.9%	21,385	8,175	5,146	1,649
75-79	16,072	80,358	28.0%	14.3%	1.6%	0.9%	22,496	11,484	1,302	723
Total Ages 18-79		**1,176,036**	**24.4%**	**9.2%**	**3.2%**	**1.6%**	**287,454**	**108,279**	**37,644**	**18,432**

[1675] Statistics Canada. *Canadian Community Health Survey Public Use Microdata File 2014*. All computations, use and interpretation of these data are entirely that of H. Krueger & Associates Inc.

- Research for the USPSTF found that behavioral intervention participants lost an average of 6% or 3 kg (6.6 lb) of their baseline weight (95% CI of 4 to 7 kg [8.8 to 15.4 lb]) in the first year with 12 to 26 treatment sessions, compared with little or no weight loss in the control group participants.[1676] Research for the CTFPHC found similar results with an average weight loss of 3.02 kg (95% CI of 2.52 to 3.52).[1677] In addition, waist circumference was reduced by an average of 2.78 cm (95% CI of 2.22 to 3.34) and BMI was reduced by 1.11kg/m^2 (95% CI of 0.84 to 1.39). On average, one out of every five participants (95% CI of 4 to 7) lost at least 5% of their body weight (Table 3, row *c*) and one out of nine (95% CI of 7 to 12) lost more than 10% of their body weight. A weight loss of 5% is considered clinically important.

- Other assumptions used in assessing the clinically preventable burden are detailed in the Reference Document.

Based on these assumptions, the CPB associated with screening for and management of obesity is 2,278 QALYs (Table 3, row *i*).

Table 3: CPB of Screening for and Management of Obesity in Adults in a Birth Cohort of 40,000

Row Label	Variable	Base Case	Data Source
a	Years of life lived with Class I or II obesity	343,441	Tables 1 and 2
b	Adherence with an intensive, multicomponent behavioral intervention	33%	Ref Doc
c	Number needed to treat to achieve a clinically important reduction in weight (≥5% of body weight)	5	√
d	Reduced years of life lived with Class I or II obesity due to intervention	22,667	= (a * b) / c
	Benefits Associated with Screening and Management		
e	Reduction in quality of life - Class I / II obesity vs. overweight	6.96%	Ref Doc
f	QALYs gained	1,578	= d * e
g	Reduction in years of life lived - Class I / II obesity vs. overweight	3.09%	Ref Doc
h	QALYs gained	700	= d * g
i	**Potential QALYs gained, management increasing from 0% to 33%**	**2,278**	= f + h

√ = Estimates from the literature

We also modified a major assumption and recalculated the CPB as follows:

- Assume that one out of every four participants lost at least 5% of their body weight after completing an intensive, multicomponent behavioral intervention, rather than one out of every five participants (Table 3, row *c*): **CPB = 2,848 QALYs**.

- Assume that one out of every seven participants lost at least 5% of their body weight after completing an intensive, multicomponent behavioral intervention, rather than one out of every five participants (Table 3, row *c*): **CPB = 1,627 QALYs**.

[1676] LeBlanc ES, O'Connor E, Whitlock EP et al. Effectiveness of primary care–relevant treatments for obesity in adults: a systematic evidence review for the US Preventive Services Task Force. *Annals of Internal Medicine*. 2011; 155(7): 434-47.
[1677] Peirson L, Douketis J, Ciliska D et al. Treatment for overweight and obesity in adult populations: a systematic review and meta-analysis. *Canadian Medical Association Open Access Journal*. 2014; 2(4): e306-e17.

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with screening for and management of obesity in adults aged 18 or older in a British Columbia birth cohort of 40,000.

In modelling CE, we made the following assumptions:

- **Frequency of screening** - We assumed that a general practitioner would measure a patient's height and weight in order to calculate BMI and discuss physical activity and healthy eating once every two years (Table 4, row *g*).
- **Cost of an intensive, multicomponent behavioral intervention** - The per person costs of such interventions in the literature vary substantially, ranging from $301 to $3,646 (converted to 2022 CAD).[1678,1679,1680,1681] The difference in costs is largely attributable to the ratio of facilitators to clients. The intervention costing $3,646 per person involved case managers teaching a 16-week curriculum on a one-to-one basis.[1682] The intervention costing $301 per person was set up for 16 group sessions of up to 18 persons.[1683] We used the mean cost of three of the four interventions (excluding the $3,646 per person intervention) for an estimated cost of $680 per person per intervention (Table 4, row *m*).
- **Patient time costs for intensive, multicomponent behavioral intervention** - We assumed three hours of patient time would be required (including travel to and from the session) for an average of 18 sessions, the mid-point between 12 and 24 sessions (Table 4, rows *q*).
- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the CE associated with screening for and management of obesity is $14,510 per QALY (Table 4, row *ff*).

[1678] Gustafson A, Khavjou O, Stearns SC et al. Cost-effectiveness of a behavioral weight loss intervention for low-income women: the Weight-Wise Program. *Preventive Medicine*. 2009; 49(5): 390-5.
[1679] Krukowski RA, Tilford JM, Harvey-Berino J et al. Comparing behavioral weight loss modalities: incremental cost-effectiveness of an internet-based versus an in-person condition. *Obesity*. 2011; 19(8): 1629-35.
[1680] Neumann A, Schwarz P and Lindholm L. Estimating the cost-effectiveness of lifestyle intervention programmes to prevent diabetes based on an example from Germany: Markov modelling. *Cost-effectiveness and Resource Allocation*. 2011; 9(1): 17.
[1681] Group DPPR. Costs associated with the primary prevention of type 2 diabetes mellitus in the diabetes prevention program. *Diabetes Care*. 2003; 26(1): 36-47.
[1682] Ibid.
[1683] Gustafson A, Khavjou O, Stearns SC et al. Cost-effectiveness of a behavioral weight loss intervention for low-income women: the Weight-Wise Program. *Preventive Medicine*. 2009; 49(5): 390-5.

Table 4: CE of Screening for and Management of Obesity in Adults in a Birth Cohort of 40,000			
Row Label	**Variable**	**Base Case**	**Data Source**
a	Individuals in birth cohort at age 40	38,847	Tables 1 & 2
b	Total life years between age 18 and 70	1,989,145	Tables 1 & 2
c	Proportion of years with Class I / II obesity without intervention	14.9%	Tables 1 & 2
d	Years with Class I / II obesity without intervention	343,441	Tables 1 & 2
e	Adherence with screening in primary care	73%	Ref Doc
f	Adherence with an intensive, multicomponent behavioral intervention	33%	Ref Doc
	Costs of intervention		
g	Frequency of measuring height and weight and asking about physical activity and diet between age 18 and 70 (every x years)	2	Assumed
h	Total number of screens	726,038	= (b * e) / g
i	Cost of 10-minute office visit	$35.97	Ref Doc
j	Value of patient time and travel for office visit	$74.32	Ref Doc
k	Portion of 10-minute office visit for screen	50%	Ref Doc
l	Cost of screening	$40,037,369	= h * (I + j) * k
m	Costs per person of an intensive, multicomponent behavioral intervention	$680	√
n	Individuals eligible for an intensive, multicomponent behavioral intervention	5,793	= a * c
o	Individuals enrolled in an intensive, multicomponent behavioral intervention	1,912	= n * f
p	Costs of an intensive, multicomponent behavioral intervention	$1,299,238	= o * m
q	# of treatments per intensive, multicomponent behavioral intervention	18	√
r	Value of patient time and travel for per intervention treatment	$111.48	√
s	Value of patient time and travel for intervention	$3,836,362	= o * q * r
	Cost avoided		
t	Number needed to treat to achieve a clinically important reduction in weight (≥5% of body weight)	5	√
u	Individuals achieving a clinically important reduction in weight (≥5% of body weight)	382	= o / t
v	Years with Class I / II obesity avoided with intervention	22,667	= (u / n) * d
w	Excess direct costs per year attributable to obesity	$915	Ref Doc
x	Excess direct costs per year attributable to overweight	$258	Ref Doc
w	Costs avoided	$14,892,280	=(w - x) *v
	CE calculation		
z	Cost of intervention over lifetime of birth cohort	$45,172,970	= l + p + s
aa	Costs avoided	$14,892,280	= w
bb	QALYs saved	2,278	Table 3, row i
cc	Cost of intervention over lifetime of birth cohort (1.5% discount)	$31,318,607	Calculated
dd	Costs avoided (1.5% discount)	$10,324,880	Calculated
ee	QALYs saved (1.5% discount)	1,447	Calculated
ff	**CE ($/QALY saved)**	**$14,510**	= (cc-dd)/ee

√ = Estimates from the literature

We also modified several major assumptions and recalculated the cost per QALY as follows:

- Assume that one out of every four participants lost at least 5% of their body weight after completing an intensive, multicomponent behavioral intervention rather than one out of every five participants (Table 3, row *c*): CE = $10,181 per QALY.
- Assume that one out of every seven participants lost at least 5% of their body weight after completing an intensive, multicomponent behavioral intervention rather than one out of every five participants (Table 3, row *c*): CE = $23,168 per QALY.
- Assume that the frequency of measuring height and weight and asking about physical activity and diet would occur every year rather than once every two years (Table 4, row *g*): CE = **$33,694 per QALY**.
- Assume that the frequency of measuring height and weight and asking about physical activity and diet would occur every three years rather than once every two years (Table 4, row *g*): CE = $8,115 per QALY.
- Assume the proportion of an office visit required for screening/referral is reduced from 50% to 33% (Table 4, row *k)*: **CE = $7,987 per QALY**.
- Assume the proportion of an office visit required for screening/referral is increased from 50% to 67% (Table 4, row *k)*: CE = $21,033 per QALY.
- Assume that the costs per person of an intensive, multicomponent behavioral intervention are reduced from $680 to $301 (Table 4, row *m*): CE = $14,163 per QALY.
- Assume that the costs per person of an intensive, multicomponent behavioral intervention are increased from $680 to $3,646 (Table 4, row *m*): CE = $17,227 per QALY.

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening for and management of obesity is estimated to be 1,447 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to result in cost-savings of $14,510 per QALY (see Table 5).

Table 5: Screening for and Management of Obesity in Adults in a Birth Cohort of 40,000

Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Gap between 0% and Best in the World (33%)			
1.5% Discount Rate	**1,447**	1,033	1,809
3% Discount Rate	955	682	1,194
0% Discount Rate	2,278	1,627	2,848
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$14,510**	$7,987	$33,694
3% Discount Rate	$15,773	$8,682	$36,629
0% Discount Rate	$13,292	$7,317	$30,868
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	Cost-saving	Cost-saving	$6,000
3% Discount Rate	Cost-saving	Cost-saving	$6,523
0% Discount Rate	Cost-saving	Cost-saving	$5,497

United States Preventive Service Task Force Recommendations (2012)

> *Falls are the leading cause of injury in adults aged 65 years or older. Between 30% and 40% of community dwelling adults aged 65 years or older fall at least once per year.*
>
> *The USPSTF recommends exercise or physical therapy and vitamin D supplementation to prevent falls in community-dwelling adults aged 65 years or older who are at increased risk for falls. (Grade B recommendation)*
>
> *The USPSTF does not recommend automatically performing an in-depth multifactorial risk assessment in conjunction with comprehensive management of identified risks to prevent falls in community-dwelling adults aged 65 years or older because the likelihood of benefit is small. In determining whether this service is appropriate in individual cases, patients and clinicians should consider the balance of benefits and harms on the basis of the circumstances of prior falls, comorbid medical conditions, and patient values. (Grade C recommendation)*[1684]

More specifically, the USPSTF suggests annual screening for risk using "a pragmatic, expert-supported approach to identifying high risk persons (based on) a history of falls and mobility problems and the results of a timed Get-Up-and-Go test. The test is performed by observing the time it takes a person to rise from an armchair, walk 3 meters (10 feet), turn, walk back, and sit down again." Exercise should consist of at least 150 minutes of moderate intensity activity per week while Vitamin D supplementation of 800 IU per day should occur for at least one year.[1685]

Note that the 2003 recommendations from the CTFPHC apply only to individuals living in long-term care facilities, rather than the general population of community-dwelling elderly.[1686]

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with preventing falls in the community-dwelling elderly.

In estimating CPB, we made the following assumptions:

- We first estimated the number of life years lived in a BC cohort of 40,000 from age 65 to death as well as the average life expectancy for this cohort (see Table 1). The 778,475 life years lived was used to populate row *a* of Table 2 while the average life expectancy of 12.9 years was used to populate row *c* of Table 2.

[1684] Moyer VA. Prevention of falls in community-dwelling older adults: U.S. Preventive Services Task Force recommendation statement. *Annals of Internal Medicine*. 2012; 157(3): 197-204.
[1685] Ibid.
[1686] Canadian Task Force on Preventive Health Care. *Prevention of Falls in Long-Term Care Facilities: Systematic Review and Recommendations* 2003. Available at http://canadiantaskforce.ca/wp-content/uploads/2012/09/CTF_FallsPrevn_TR_Jun03.pdf?0136ff. Accessed November 2013.

Table 1: Deaths and Years of Life Lived Between the Ages of 65 and Death
in a British Columbia Birth Cohort of 40,000

Age Group	*Individuals in Birth Cohort*	*Life Years Lived*	Life Expectancy
60-64	36,435		
65-69	35,035	175,175	19.9
70-74	32,929	164,644	16.0
75-79	29,753	148,766	12.4
80-84	25,060	125,300	9.2
85-89	18,546	92,728	6.5
90+	13,927	71,862	5.2
Total		**778,475**	**12.9**

- An estimated 94.3% of life years in this cohort are lived in the community (Table 1, row *b*).[1687]
- Fall-related hospitalizations occur at a rate of 14.19 per 1,000 elderly in BC (Table 1, row *d*).[1688]
- An estimated 30% of individuals die within one year after a fall-related hospitalization (Table 1, row *f*).[1689]
- Individuals who survive a fall-related hospitalization have a 20% reduced life expectancy (Table 1, row *h*).[1690]
- Individuals who survive a fall-related hospitalization have a .20 reduction in quality of life in year 1 following the hospitalization (Table 1, row *k*) and 0.06 reduction per year thereafter (Table 1, row *m*).[1691]
- Interventions involving exercise or physical therapy in reducing falls in community-dwelling elderly have an effectiveness rate of 13% (RR of 0.87: 95% CI of 0.81 to 0.94) (Table 1, row *p*).[1692]
- Current delivery of screening and counselling regarding exercise interventions is assumed to be 18% (Table 1, row *r*) (see Reference Document).
- Adherence with exercise intervention is assumed to be 30% (Table 1, row *s*).
- Other assumptions used in assessing the clinically preventable burden are detailed in the Reference Document.

[1687] BC Stats. *2006 Census Fast Facts: Living Arrangements of Seniors in British Columbia*. 2008. Available at http://www.bcstats.gov.bc.ca/Files/ac5baf3d-1490-437c-bc2c-7a6dfc7699f7/LivingArrangementofSeniorsinBritishColumbia.pdf. Accessed February 2018.
[1688] Scott V, Wagar L and Elliot S. *Falls & Related Injuries Among Older Canadians: Fall Related Hospitalizations & Prevention Initiatives*. 2010. Available at http://www.hiphealth.ca/media/research_cemfia_phac_epi_and_inventor_20100610.pdf. Accessed February 2018.
[1689] Ibid.
[1690] Frick KD, Kung JY, Parrish JM et al. Evaluating the cost-effectiveness of fall prevention programs that reduce fall-related hip fractures in older adults. *Journal of the American Geriatrics Society*. 2010; 58(1): 136-41.
[1691] Ibid.
[1692] Michael YL, Whitlock EP, Lin JS et al. Primary care-relevant interventions to prevent falling in older adults: a systematic evidence review for the U.S. Preventive Services Task Force. *Annals of Internal Medicine*. 2010; 153(12): 815-25.

The role of vitamin D in fracture prevention is contentious.[1693,1694,1695] The 2012 USPSTF review noted above, for example, has suggested that vitamin D supplementation reduced the risk of falling by 17% (RR of 0.83 [95% CI of 0.77 to 0.89]).[1696] The Cochrane review, on the other hand, found no reduction in the risk of falling associated with vitamin D supplementation ((RR of 0.96 [95% CI of 0.89 to 1.03]) although the reviewers did acknowledge that vitamin D supplementation may lower this risk in "people with lower vitamin D levels before treatment."[1697] Both groups agree, however, that group and home based exercise as well as home safety interventions reduce the rate of falls and the risk of falls.

Since the 2012 USPSTF review and recommendations regarding the prevention of falls in the community-dwelling elderly, the USPSTF has released (in May 2013) an updated assessment of the use of vitamin D and calcium supplementation to prevent fractures in adults. [1698,1699] The updated recommendations include the following:

> *The USPSTF concludes that the current evidence is insufficient to assess the balance of the benefits and harms of combined vitamin D and calcium supplementation for the primary prevention of fractures in premenopausal women or in men. (Grade I recommendation)*
>
> *The USPSTF concludes that the current evidence is insufficient to assess the balance of the benefits and harms of daily supplementation with greater than 400 IU of vitamin D_3 and greater than 1,000 mg of calcium for the primary prevention of fractures in noninstitutionalized postmenopausal women. (Grade I recommendation)*
>
> *The USPSTF recommends against daily supplementation with 400 IU or less of vitamin D_3 and 1,000 mg or less of calcium for the primary prevention of fractures in noninstitutionalized postmenopausal women. (Grade D recommendation).*

We have therefore focused on the role of exercise in the prevention of falls in the community-dwelling elderly.

Based on these assumptions, the CPB associated with screening and interventions to reduce falls in community-dwelling elderly is 450 (see Table 2, row *t*). The CPB of 429 represents the gap between no coverage and the 'best in the world' coverage estimated at 18% for screening for risk and 30% for adherence with recommended exercise regimen.

[1693] Rosen CJ. Vitamin D supplementation: bones of contention. *The Lancet*. 2014; 383(9912): 108-10.
[1694] Reid IR, Bolland MJ and Grey A. Effects of vitamin D supplements on bone mineral density: a systematic review and meta-analysis. *The Lancet*. 2014; 383(9912): 146-55.
[1695] Bischoff-Ferrari HA, Willett WC, Orav EJ et al. A pooled analysis of vitamin D dose requirements for fracture prevention. *New England Journal of Medicine*. 2012; 367: 40-9.
[1696] Michael YL, Whitlock EP, Lin JS et al. Primary care-relevant interventions to prevent falling in older adults: a systematic evidence review for the U.S. Preventive Services Task Force. *Annals of Internal Medicine*. 2010; 153(12): 815-25.
[1697] Gillespie LD, Robertson MC, Gillespie WJ et al. Interventions for preventing falls in older people living in the community. Cochrane Database of Systematic Reviews. 2012
[1698] U.S. Preventive Services Task Force. *Vitamin D and Calcium Supplementation to Prevent Fractures, Topic Page*. 2013. Available at http://www.uspreventiveservicestaskforce.org/uspstf/uspsvitd.htm. Accessed February 2018.
[1699] Moyer VA. Vitamin D and calcium supplementation to prevent fractures in adults: U.S. Preventive Services Task Force Recommendation Statement. *Annals of Internal Medicine*. 2013; 158: 691-6.

Table 2: CPB of Screening and Intervention to Reduce Falls in a Birth Cohort of 40,000 (B.C.)			
Row Label	**Variable**	**Base Case**	**Data Source**
a	Years lived ages 65+	778,475	Table 1
b	Adjusted for community-dwelling elderly	0.943	√
c	Average life expectancy	12.9	Table 1
d	Fall-related hospitalizations /1,000	14.19	√
e	Fall-related hospitalizations	10,417	= (a*b)/1000*d
f	Deaths in year following hospital admission	0.30	√
g	Fall-related hospitalization LYs lost due to deaths	40,433	=e*f*c
h	Reduced life expectancy for survivors of fall-related hospitalization	0.20	√
i	Fall-related hospitalization LYs lost in survivors	18,869	=e*(1-f)*c*h
j	Fall-related hospitalization LYs lived in survivors	75,474	=e*(1-f)*c-i
k	Reduction in QoL associated with surviving a fall-related hospitalization - Year 1	0.20	√
l	QALYs lost associated with surviving a fall-related hospitalization - Year 1	1,458	=e*(1-f)*k
m	Reduction in QoL associated with surviving a fall-related hospitalization - subsequent years	0.06	√
n	QALYs lost associated with surviving a fall-related hospitalization - subsequent years	3,396	=(j-(1-f)-i)*m
o	Total QALYs lost	64,156	=g+i+k+n
p	Effectiveness of exercise at reducing falls	13.0%	√
q	QALYs gained based on 100% adherence	8,340	= o * p
r	Delivery of screening and counseling	18.0%	Ref Doc
s	Adherence with exercise	30.0%	Assumed
t	**QALYs gained, CPB**	**450**	= q * r * s

√ = Estimates from the literature

We also modified a number of major assumptions and recalculated the CPB as follows:

- Assume that the proportion of the elderly who die within one year following their falls-related hospitalization is decreased from 30% to 25% (Table 2, row f): CPB = 415.
- Assume that the proportion of the elderly who die within one year following their falls-related hospitalization is increased from 30% to 35% (Table 2, row f): CPB = 486.
- Assume the effectiveness of exercise interventions is decreased from 13% to 6% (Table 2, row *p*): **CPB = 208**.
- Assume the effectiveness of exercise interventions is increased from 13% to 19% (Table 2, row *p*): **CPB = 658**.

Modelling Cost-Effectiveness

In this section, we will calculate the CPB associated with preventing falls in the community-dwelling elderly.

In estimating CE, we made the following assumptions:

- **Cost per hour of exercise** – This is easily the most significant cost and thus drives the estimate of CE (Table 3, row *m*). We have estimated the cost of $5.00 per hour (e.g., the approximate cost of admission to a community exercise facility), but have also included a sensitivity analysis from $0 (e.g., walking) to $25 (e.g., the estimated cost per hour for a commercially-based group exercise program).[1700]
- **Falls-related hospitalization** – The cost of a falls-related hospitalization is taken from the Canadian Institute of Health Information Patient Cost Estimator.[1701] We used the average cost in British Columbia in 2021/22 associated with a hospitalization for a primary procedure of case-mix group 727 *Fixation/repair hip/femur* of $15,029 (Table 3, row *o*).
- Other costs and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the CE associated with screening and interventions to reduce falls in community-dwelling elderly are estimated at $35,998/QALY (see Table 3, row z).

[1700] This cost is based on a monthly fee of $299 divided by 12 one hour exercise sessions (approximately 3 per week).
[1701] Canadian Institute for Health Information. *Patient Cost Estimator*. 2023. Available at https://apps.cihi.ca/mstrapp/asp/Main.aspx. Accessed December 2023.

Table 3: CE of Screening and Intervention to Reduce Falls in a Birth Cohort of 40,000 (B.C.)			
Row Label	**Variable**	**Base Case**	**Data Source**
a	Years lived ages 65+ as community dwelling elderly	734,102	Table 2, row a * Table 2, row b
	Costs of screening		
b	Cost of 10-minute office visit	$35.97	Ref Doc
c	Value of patient time and travel for office visit	$74.32	Ref Doc
d	Portion of 10-minute office visit for screen	50%	Ref Doc
e	Delivery of screening and counseling	18%	Table 2, row r
f	Cost of screening over lifetime of birth cohort	$7,286,774	= (a * e) * (b + c) * d
	Costs of interventions		
g	Proportion of elderly with falls in previous year	0.30	√
h	Portion of 10-minute office visit for referral to exercise program	50%	Ref Doc
i	Cost of referrals	$2,186,032	= (a * f) * e * ((b + c) * d)
j	Adherence with exercise recommendation	30%	Table 2, row s
k	Life years lived with exercise in at risk individuals	11,892	= a * e * g * j
l	Hours of exercise (3 times per week for 1 hour)	1,855,224	= k * 52 * 3
m	Cost per hour of exercise	$5.00	√
n	Cost of intervention (exercise)	$9,276,118	= l * m
	Costs avoided		
o	Reduction in fall-related hospitalizations	169	= (k / a) * Table 2, row e
p	Cost of a fall-related hospitalization	$15,029	√
q	Cost avoided	$2,536,204	= o * p
	CE calculation		
r	Cost of initial screen	$7,286,774	= f
s	Costs of referral and intervention	$11,462,150	= i + n
t	Costs avoided	$2,536,204	= q
u	QALYs saved	450	Table 2, row t
v	Cost of initial screen (1.5% discount rate)	$6,222,922	Calculated
w	Costs of referral and intervention (1.5% discount rate)	$9,788,703	Calculated
x	Costs avoided (1.5% discount rate)	$2,165,924	Calculated
y	QALYs saved (1.5% discount rate)	385	Calculated
z	**CE ($/QALY saved)**	**$35,998**	= (v + w - x) / y

√ = Estimates from the literature

We also modified a number of major assumptions and recalculated the CE as follows:

- Assume that the proportion of the elderly who die within one year following their falls-related hospitalization is decreased from 30% to 25% (Table 2, row *f*): CE = $35,970 / QALY.
- Assume that the proportion of the elderly who die within one year following their falls-related hospitalization is increased from 30% to 35% (Table 2, row *f*): CE = $33,374 / QALY.
- Assume the effectiveness of exercise interventions is decreased from 13% to 6% (Table 2, row *p*): CE = $77,996 / QALY.
- Assume the effectiveness of exercise interventions is increased from 13% to 19% (Table 2, row *p*): CE = $24,630 / QALY.
- Assume the cost of an hour of exercise is decreased from $5 to $0 (Table 3, row *m*): **CE = $15,402 / QALY**.
- Assume the cost of an hour of exercise is increased from $5 to $25 (Table 3, row *m*): **CE = $118,384 / QALY**.

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening and interventions to reduce falls in community-dwelling elderly is estimated to be 385 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to result in cost-savings of $35,998 per QALY (see Table 4).

Table 4: Screening and Intervention to Reduce Falls in the Community-Dwelling Elderly
Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Gap between 0% and 'Best in the World' (18% screening / 30% exercise adherence)			
1.5% Discount Rate	**385**	178	562
3% Discount Rate	331	153	483
0% Discount Rate	450	208	658
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$35,998**	$15,402	$118,384
3% Discount Rate	$35,998	$15,402	$118,384
0% Discount Rate	$35,998	$15,402	$118,384
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$21,825	$1,228	$104,211
3% Discount Rate	$21,825	$1,228	$104,211
0% Discount Rate	$21,825	$1,228	$104,211

Preventive Medication / Devices

Routine Aspirin Use for the Prevention of Cardiovascular Disease and Colorectal Cancer – Evidence Update

Background

In 2007, the U.S. Preventive Services Task Force (USPSTF) recommended "against the routine use of aspirin… to prevent colorectal cancer in individuals at average risk for colorectal cancer" with a D recommendation.[1702] In 2009, the USPSTF recommended "the use of aspirin for men age 45 to 79 years when the potential benefit due to a reduction in myocardial infarctions outweighs the potential harm due to an increase in gastrointestinal hemorrhage." The USPSTF also recommended "the use of aspirin for women age 55 to 79 years when the potential benefit of a reduction in ischemic strokes outweighs the potential harm of an increase in gastrointestinal hemorrhage." Both of these 2009 recommendations were A recommendations.[1703]

The 2014 LPS Review

In a 2014 update of the BC LPS, members of the Lifetime Prevention Schedule Expert Committee (LPSEC) reviewed key research that had been published since the 2009 USPSTF recommendations[1704,1705,1706] calling into question the clinical effectiveness of low-dose aspirin in primary prevention.[1707,1708,1709] A major concern of this new research was that the evidence used for the 2009 USPSTF recommendations appeared to overestimate the benefits of the use of aspirin in primary prevention (e.g. a reduction in cardiovascular disease) and to underestimate the harms (e.g. gastrointestinal bleeding and hemorrhagic stroke).

More specifically, a 2009 meta-analysis of results from randomised trials by the Antithrombotic Trialists' Collaboration found that the use of aspirin in primary prevention resulted in a 12% reduction in serious vascular events (RR of 0.88, 95% CI of 0.82-0.94), mainly due to a reduction in non-fatal myocardial infarction.[1710] No net effect on stroke was observed (RR of 0.95, 95% CI of 0.85-1.06). In addition, vascular mortality did not differ in those with long-term aspirin use (RR of 0.97, 95% CI of 0.87-1.09). This lack of a mortality effect compares to the LPS assumption at the time (based on the original Health Partners model) of a 30% mortality benefit associated with aspirin chemoprophylaxis. The limited

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[1702] U.S. Preventive Services Task Force. Routine aspirin or nonsteroidal anti-inflammatory drugs for the primary prevention of colorectal cancer. *Annals of Internal Medicine*. 2007; 146(5): 361-4.
[1703] U.S. Preventive Services Task Force. Aspirin for the prevention of cardiovascular disease: U.S. Preventive Services Task Force recommendation statement. *Annals of Internal Medicine*. 2009; 150(6): 396-404.
[1704] Baigent C, Blackwell L, Collins R et al. Aspirin in the primary and secondary prevention of vascular disease: collaborative meta-analysis of individual participant data from randomised trials. *The Lancet*. 2009; 373(9678): 1849-60.
[1705] Seshasai SR, Wijesuriya S, Sivakumaran R et al. Effect of aspirin on vascular and nonvascular outcomes: meta-analysis of randomized controlled trials. *Archives of Internal Medicine*. 2012; 172(3): 209-16.
[1706] Sutcliffe P, Connock M, Gurung T et al. Aspirin for prophylactic use in the primary prevention of cardiovascular disease and cancer: a systematic review and overview of reviews. *Health Technology Assessment*. 2013; 17(43): 1-253.
[1707] Selak V, Elley CR, Wells S et al. Aspirin for primary prevention: yes or no? *Journal of Primary Health Care*. 2010; 2(2): 92-9.
[1708] Raju NC and Eikelboom JW. The aspirin controversy in primary prevention. *Current Opinion in Cardiology*. 2012; 27(5): 499-507.
[1709] Patrono C. Low-dose aspirin in primary prevention: cardioprotection, chemoprevention, both, or neither? *European Heart Journal*. 2013; 34(44): 3403-11.
[1710] Baigent C, Blackwell L, Collins R et al. Aspirin in the primary and secondary prevention of vascular disease: collaborative meta-analysis of individual participant data from randomised trials. *The Lancet*. 2009; 373(9678): 1849-60.

benefits of long-term aspirin use are offset by a significant 54% *increase* in major gastrointestinal and other extracranial bleeds (RR of 1.54, 95% CI of 1.30-1.82).

A 2012 meta-analysis of randomized controlled trials by Seshasai et al. came to similar conclusions.[1711] Aspirin treatment reduced total cardiovascular disease (CVD) events by 10% (OR of 0.90; 95% CI of 0.85-0.96), driven primarily by a reduction in nonfatal myocardial infarction (OR of 0.80; 95% CI of 0.67-0.96). They also found no significant reduction in CVD death (OR of 0.99; 95% CI of 0.85-1.15) or cancer mortality (OR of 0.93; 95% CI of 0.84-1.03). On the other hand, there was an increased risk of nontrivial bleeding events (OR of 1.31; 95% CI of 1.14-1.50). The authors conclude that "despite important reductions in nonfatal MI, aspirin prophylaxis in people without prior CVD does not lead to reductions in either cardiovascular death or cancer mortality. Because the benefits are further offset by clinically important bleeding events, routine use of aspirin for primary prevention is not warranted and treatment decisions need to be considered on a case-by-case basis." (p. 209)

A 2013 health technology assessment by the U.K. National Institute for Health Research came to the following conclusions:[1712]

- The benefits of aspirin use in primary prevention include a possible 6% reduction in relative risk (RR) for all-cause mortality (RR of 0.94, 95% CI of 0.88-1.00)
- The benefits of aspirin use in primary prevention include a 10% reduction in major cardiovascular events (RR of 0.90, 95% CI of 0.85-0.96)
- The benefits of aspirin use in primary prevention with respect to a reduction in cancer incidence and mortality are inconclusive
- The harms of aspirin use in primary prevention include a 37% increased risk of gastrointestinal bleeding (RR of 1.37, 95% CI of 1.15-1.62)
- The harms of aspirin use in primary prevention include an overall risk of major bleeds of between 54% (RR of 1.54, 95% CI of 1.30-1.82) and 62% (RR of 1.62, 95% CI of 1.31-2.00)
- The harms of aspirin use in primary prevention include an increased risk for haemorrhagic stroke of between 32% (RR of 1.32, 95% CI of 1.00-1.74) and 38% (RR of 1.38, 95% CI of 1.01-1.82)

The authors conclude that the

> *benefits of aspirin for primary prevention of cancer or CVD are relatively modest, remain statistically uncertain, and are an order of magnitude less than that observed in secondary prevention for CVD. In contrast, harms (especially bleeding) occur at relatively higher frequency (apparently very high frequency in some populations) and are statistically based on strong evidence […].There are several guidelines that propose the widespread employment of aspirin for individuals at increased risk for CVD, based on an assessment of the balance between CV benefits (e.g. reduced MI and stroke) and various harms (especially bleeding). Definitions of 'high' risk vary according to country and guideline. However, as we have indicated in this short report, opinion and evidence have shifted over time. At a population level, aspirin for primary prevention of CVD is associated with net harm due to increased potential for bleeding, while the results for benefits are not persuasive.* (pg. 74-5)

[1711] Seshasai SR, Wijesuriya S, Sivakumaran R et al. Effect of aspirin on vascular and nonvascular outcomes: meta-analysis of randomized controlled trials. *Archives of Internal Medicine*. 2012; 172(3): 209-16.
[1712] Sutcliffe P, Connock M, Gurung T et al. Aspirin for prophylactic use in the primary prevention of cardiovascular disease and cancer: a systematic review and overview of reviews. *Health Technology Assessment*. 2013; 17(43): 1-253.

Based on this updated evidence on clinical effectiveness, the LPSEC found that the routine use of low-dose aspirin in primary prevention no longer passed the initial test for inclusion on the BC LPS, namely that the maneuver is not clinically effective (i.e. benefits do not significantly outweigh harms).[1713]

The 2016 USPSTF Recommendations

In the process of updating both their 2007 and 2009 recommendation on the routine use of aspirin to prevent colorectal cancer and cardiovascular diseases, the USPSTF commissioned three systematic evidence reviews[1714,1715,1716] and one decision analysis using simulation modelling.[1717]

The systematic review by Guirguis-Blake and colleagues noted that very-low dose aspirin use (≤100mg daily) for primary prevention reduced the risk of nonfatal myocardial infarction by 17% (RR of 0.83, 95% CI of 0.74 – 0.94) and nonfatal stroke by 14% (RR of 0.86, 95% CI of 0.76 – 0.98) but they found no reduction in all-cause or cardiovascular mortality.[1718]

The systematic review by Chubak and co-authors noted that using aspirin (in dosages ranging from 50 to 500mg daily) for primary prevention reduced the incidence of colorectal cancer by 40% (RR of 0.60, 95% CI of 0.47 – 0.76) but only in secondary studies which followed individuals for at least 10 years. In addition, the use of aspirin for approximately 5 years reduced the risk of death from CRC about 20 years later by 33% (RR of 0.67, 95% CI of 0.52 – 0.86). Aspirin's effect on ***total cancer*** mortality and incidence was not clearly established.[1719]

The systematic review by Whitlock et al. found that very-low dose aspirin use (≤100mg daily or every other day) increased the risk of major gastrointestinal bleeding by 58% (RR of 1.58, 95% CI of 1.29 – 1.95) and the risk of haemorrhagic stroke by a non-significant 27% (RR of 1.27, 95% CI of 0.96 – 1.68).[1720]

To help disentangle the "uncertain relationship between the benefits and harms of long-term aspirin use", the USPSTF commissioned the decision analysis by Dehmer and colleagues.[1721]

[1713] H. Krueger & Associates Inc. *Establishing Priorities among Effective Clinical Prevention Services in British Columbia: Summary and Technical Report*. July 16, 2014.

[1714] Guirguis-Blake J, Evans C, Senger C et al. Aspirin for the primary prevention of cardiovascular events: a systematic evidence review for the U.S. Preventive Services Task Force. *Annals of Internal Medicine*. 2016; 164(12): 804-13.

[1715] Chubak J, Whitlock E, Williams S et al. Aspirin for the prevention of cancer incidence and mortality: systematic evidence reviews for the U.S. Preventive Services Task Force. *Annals of Internal Medicine*. 2016; 164(12): 814-25.

[1716] Whitlock E, Burda B, Williams S et al. Bleeding risks with aspirin use for primary prevention in adults: a systematic review for the U.S. Preventive Services Task Force. *Annals of Internal Medicine*. 2016; 164(12): 826-35.

[1717] Dehmer S, Maciosek M, Flottemesch T et al. Aspirin for the primary prevention of cardiovascular disease and colorectal cancer: a decision analysis for the US Preventive Services Task Force. *Annals of Internal Medicine*. 2016; 164(12): 777-86.

[1718] Guirguis-Blake J, Evans C, Senger C et al. Aspirin for the primary prevention of cardiovascular events: a systematic evidence review for the U.S. Preventive Services Task Force. *Annals of Internal Medicine*. 2016; 164(12): 804-13.

[1719] Chubak J, Whitlock E, Williams S et al. Aspirin for the prevention of cancer incidence and mortality: systematic evidence reviews for the U.S. Preventive Services Task Force. *Annals of Internal Medicine*. 2016; 164(12): 814-25.

[1720] Whitlock E, Burda B, Williams S et al. Bleeding risks with aspirin use for primary prevention in adults: a systematic review for the U.S. Preventive Services Task Force. *Annals of Internal Medicine*. 2016; 164(12): 826-35.

[1721] Dehmer S, Maciosek M, Flottemesch T et al. Aspirin for the primary prevention of cardiovascular disease and colorectal cancer: a decision analysis for the US Preventive Services Task Force. *Annals of Internal Medicine*. 2016; 164(12): 777-86.

The decision analysis found that the results of net gains (as measured by QALYs) were quite sensitive to all assumptions about the relative risks of both benefits and harms, including baseline risks for GI bleeding. In addition, the results are highly sensitive to assumptions made about the potential disutility associated with regular aspirin use. Their base-case scenario assumed no disutility associated with regular aspirin use.

The collation of this evidence resulted in the following recommendations by the USPSTF.[1722]

> *The USPSTF recommends initiating low dose aspirin use for the primary prevention of cardiovascular disease (CVD) and colorectal cancer (CRC) in adults aged 50 to 59 years who have a 10% or greater 10-year CVD risk, are not at increased risk for bleeding, have a life expectancy of at least 10 years, and are willing to take low-dose aspirin daily for at least 10 years. (B recommendation)*
>
> *The decision to initiate low-dose aspirin use for the primary prevention of CVD and CRC in adults aged 60 to 69 years who have a 10% or greater 10-year CVD risk should be an individual one. Persons who are not at increased risk for bleeding, have a life expectancy of at least 10 years, and are willing to take low-dose aspirin daily for at least 10 years are more likely to benefit. Persons who place a higher value on the potential benefits than the potential harms may choose to initiate low-dose aspirin. (C recommendation)*
>
> *Risk factors for gastrointestinal (GI) bleeding with aspirin use include higher dose and longer duration of use, history of GI ulcers or upper GI pain, bleeding disorders, renal failure, severe liver disease, and thrombocytopenia. Other factors that increase risk for GI or intracranial bleeding with low-dose aspirin use include concurrent anticoagulation or nonsteroidal anti-inflammatory drug (NSAID) use, uncontrolled hypertension, male sex, and older age.*

The current LPS modelling for *Routine Aspirin Use for the Prevention of Cardiovascular Disease and Colorectal Cancer* is based on this 2016 USPSTF recommendation.

The 2022 USPSTF Recommendations

To update its 2016 recommendation,[1723] the USPSTF commissioned a systematic review on the effectiveness of aspirin to reduce the risk of CVD events (myocardial infarction and stroke), cardiovascular mortality, and all-cause mortality in persons without a history of CVD. The systematic review also investigated the effect of aspirin use on CRC incidence and mortality in primary CVD prevention populations, as well as the harms (particularly bleeding) associated with aspirin use.[1724] The USPSTF also commissioned an update of the previous microsimulation modeling study to assess the net balance of benefits and harms from aspirin use for primary prevention of CVD and CRC, stratified by age, sex, and CVD risk level.[1725]

The systematic review found that low dose aspirin use was associated with a 12% decreased risk of nonfatal myocardial infarction (OR of 0.88 [95% CI, 0.80-0.96]) and a 12% decreased risk of nonfatal ischemic stroke (OR of 0.88 [95% CI, 0.78-1.00]). They note that fatal

[1722] Bibbins-Domingo K. Aspirin use for the primary prevention of cardiovascular disease and colorectal cancer: US Preventive Services Task Force recommendation statement. *Annals of Internal Medicine*. 2016; 164(12): 836-45.
[1723] U.S. Preventive Services Task Force. Aspirin use to prevent cardiovascular disease: US Preventive Services Task Force recommendation statement. *JAMA*. 2022; 327(16): 1577-84.
[1724] Guirguis-Blake J, Evans C, Perdue L et al. Aspirin use to prevent cardiovascular disease and colorectal cancer. Updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2022; 327(16): 1585-97.
[1725] Dehmer S, O'Keefe l, Evans C et al. Aspirin use to prevent cardiovascular disease and colorectal cancer. Updated modeling study for the US Preventive Services Task Force. *JAMA*. 2022; 327(16):1598-1607.

cardiovascular events are less common, so pooled analyses showed that low-dose aspirin use was not associated with a statistically significant effect on fatal myocardial infarction, fatal stroke, cardiovascular mortality, or all-cause mortality.[1726] The 12% decreased risk is marginally (but not significantly) lower than the 17% (RR of 0.83, 95% CI of 0.74 – 0.94) observed for nonfatal myocardial infarction and the 14% (RR of 0.86, 95% CI of 0.76 – 0.98) observed for nonfatal stroke in the 2016 evidence review.[1727]

The previous (2016) USPSTF evidence review assessing aspirin's effect on the risk of CRC incidence and mortality leaned heavily on results from the Women's Health Study (WHS), an RCT involving 33,682 females aged 45 and over with 17.5 years of follow-up.[1728] This study observed an 18% reduction in the ***incidence*** of CRC (OR of 0.82, 95% CI of 0.69-0.98) with this effect emerging only after 10 years of follow-up. The authors of the 2022 USPSTF evidence review requested an additional follow-up analysis, with 26 years of follow-up now available. WHS follow-up data from 17.5 to 26 years showed no significant difference in CRC incidence between the group initially randomized to aspirin for 10 years of usage and the control group (OR of 1.16, 95% CI of 0.78-1.72]). The updated analysis also indicated no statistically significant reduction in the incidence of CRC at 26 years of follow-up (OR of 0.87, 95% CI of 0.74-1.02).[1729]

The combined results from four other RCTs included in the 2022 evidence review indicated no statistically significant association with CRC incidence at 5 to 10 years of follow-up (OR of 1.07 [(95% CI, 0.92-1.24]).[1730]

Results for CRC ***mortality*** were highly variable with longer term observational studies suggesting a benefit (OR of 0.77, 95% CI of 0.61-0.98]).[1731] Two RCTs, however, suggested either no benefit or perhaps even an increased risk associated with aspirin use. The WHS found no statically significant association at 10 years (OR of 1.14, 95% CI of 0.73-1.78) [1732] while a more recent RCT (**Asp**irin in **R**educing **E**vents in the **E**lderly or ASPREE) reported that aspirin use was associated with statistically significantly higher CRC mortality at 4.7 years follow-up (OR of 1.77, 95% CI of 1.02-3.07) in adults ages 70 and older.[1733]

Based on the available evidence on the association between aspirin use and CRC, the authors of the 2022 USPSTF evidence review conclude that "there was limited trial evidence on benefits for colorectal cancer, with the findings highly variable by length of follow-up and statistically significant only when considering long-term observational follow-up beyond randomized trial periods."[1734]

[1726] Guirguis-Blake J, Evans C, Perdue L et al. Aspirin use to prevent cardiovascular disease and colorectal cancer. Updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2022; 327(16): 1585-97.
[1727] Guirguis-Blake J, Evans C, Senger C et al. Aspirin for the primary prevention of cardiovascular events: a systematic evidence review for the U.S. Preventive Services Task Force. *Annals of Internal Medicine*. 2016; 164(12): 804-13.
[1728] Cook N, Lee I, Zhang S et al. Alternate-day, low-dose aspirin and cancer risk: Long-term observational follow-up of a randomized trial. *Annals of Internal Medicine*. 2013; 159(2): 77-85.
[1729] Guirguis-Blake J, Evans C, Perdue L et al. Aspirin use to prevent cardiovascular disease and colorectal cancer. Updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2022; 327(16): 1585-97.
[1730] Ibid.
[1731] Ibid.
[1732] Ibid.
[1733] McNeil J, Nelson M, Woods R et al; ASPREE Investigator Group. Effect of aspirin on all-cause mortality in the healthy elderly. *New England Journal of Medicine*. 2018; 379(16): 1519-28.
[1734] Guirguis-Blake et al. *JAMA*. 2022.

The systematic review also found that low dose aspirin use increased the risk of major gastrointestinal bleeding by 58% (OR of 1.58, 95% CI of 1.38 – 1.80) and the risk of a non-fatal haemorrhagic stroke by 38% (OR of 1.38, 95% CI of 1.01 – 1.85).[1735]

The microsimulation modeling study estimated that lifetime net QALYs were positive for both men and women at 5% or greater 10-year CVD risk when starting between ages 40 and 59 years. For persons starting aspirin between ages 60 and 79 years, however, lifetime net life-years were negative in most cases.[1736]

The 2022 USPSTF evidence review and updated microsimulation modeling study led to the following USPSTF recommendations:[1737]

> *The decision to initiate low-dose aspirin use for the primary prevention of CVD in adults aged 40 to 59 years who have a 10% or greater 10-year CVD risk should be an individual one. Evidence indicates that the net benefit of aspirin use in this group is small. Persons who are not at increased risk for bleeding and are willing to take low-dose aspirin daily are more likely to benefit. (C recommendation)*
>
> *The USPSTF recommends against initiating low-dose aspirin use for the primary prevention of CVD in adults 60 years or older. (D recommendation)*

The 2022 USPSTF recommendations exclude a reference to CRC as "the evidence is unclear whether aspirin use reduces the risk of colorectal cancer incidence or mortality."[1738]

Summary

Based on the information summarized above, current evidence no longer supports routine aspirin use for the prevention of CVD and CRC. Therefore, this maneuver will no longer be included on the LPS, as it does not meet the LPS criteria for clinical effectiveness (the first step of the LPS process).

[1735] Ibid.
[1736] Dehmer S, O'Keefe l, Evans C et al. Aspirin use to prevent cardiovascular disease and colorectal cancer. Updated modeling study for the US Preventive Services Task Force. *JAMA*. 2022; 327(16):1598-1607.
[1737] U.S. Preventive Services Task Force. Aspirin use to prevent cardiovascular disease: US Preventive Services Task Force recommendation statement. *JAMA*. 2022; 327(16): 1577-84.
[1738] Ibid.

United States Preventive Services Task Force Recommendations (2017)[1739]

The USPSTF recommends that all women who are planning or capable of pregnancy take a daily supplement containing 0.4 to 0.8 mg (400-800µg) of folic acid (Grade A recommendation).

The critical period of supplementation starts at least 1 month before conception and continues through the first 2 to 3 months.

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with advising all women of reproductive age to take a daily supplement containing 0.4 to 0.8 mg (400-800µg) of folic acid.

In estimating CPB, we made the following assumptions:

What are Neural Tube Defects?

- "NTDs are major birth defects of the brain and spine that occur early in pregnancy as a result of improper closure of the embryonic neural tube, which can lead to death or varying degrees of disability. The two most common NTDs are anencephaly and spina bifida." [1740]
- Anencephaly is a serious birth defect in which a baby is born without parts of the brain and skull.
- "Spina bifida is a congenital malformation in which the spinal column is split (bifid) as a result of failed closure of the embryonic neural tube, during the fourth week post-fertilization."[1741]
- NTDs are caused by a variety of genetic and non-genetic factors, although the contributing role of each is not fully known. Between 10% and 60% of NTDs have a genetic component. Lack of folic acid is perhaps the best known risk factor but there are a number of potential behavioural and environmental risk factors, such as alcohol use, smoking, poor nutrition, valproic acid use and indoor air pollution. Consequently, some women who take folic acid supplements in the periconceptional period still experience NTD-affected pregnancies.[1742]
- The WHO has wrestled with determining what proportion of NTDs are preventable given optimal (<906 nmol/L) red blood cell folate concentrations in the population. If

[1739] Bibbins-Domingo K, Grossman D, Curry S et al. Folic acid supplementation for the prevention of neural tube defects: US Preventive Services Task Force recommendation statement. *Journal of American Medical Association*. 2017; 317(2): 183-9.
[1740] Williams J, Mai C, Mulinare J et al. Updated estimates of neural tube defects prevented by mandatory folic acid fortification - United States, 1995–2011. *Morbidity and Mortality Weekly Report*. 2015; 64(1): 1-5.
[1741] Copp A, Adzick N, Chitty L et al. Spina bifida. *Nature Reviews Disease Primers*. 2015; 1: 1-45.
[1742] Ibid.

these levels are uniformly achieved, the rate of NTDs could fall somewhere within the range of 4 to 9 per 10,000 live births.[1743, 1744]

Prevalence of Neural Tube Defects

- Between 1993 and 2002, a total of 2,446 NTDs were among live births, still births and terminations of pregnancies in seven Canadian Provinces.[1745] Of the 2,446 neural tube defects identified in seven Canadian provinces between 1993 and 2002, 1,466 (60%) were terminations of pregnancy, 112 (5%) were stillbirth and 868 (35%) were live birth. The majority of NTDs were either spina bifida (53%) or anencephaly (34%) (see Table 1).[1746]

Table 1: NTDS by Diagnostic Category and Pregnancy Outcome In Seven Canadian Provinces, 1993 to 2002.

	Pregnancy Outcome				
Diagnostic Category	Induced Abortion	Stillbirth	Live Birth	Total	% of Total
Spina bifida	595	35	656	1,286	53%
Anencephaly	668	67	95	830	34%
Encephalocele	160	8	115	283	12%
Unspecified NTD	24	0	0	24	1%
Iniencephaly	19	2	2	23	1%
All NTDs	**1,466**	**112**	**868**	**2,446**	
% of Total	60%	5%	35%		

- Based on data from these seven provinces between January 1, 1993 and September 30, 1997, the prevalence of NTDs among live births, still births and terminations of pregnancies was 15.8 per 10,000 live births.[1747] BC's rate, at 9.6 per 10,000, was the lowest of the seven provinces (see Table 2).

Table 2: Prevalance of NTDS / 10,000 Births In Seven Canadian Provinces January 1, 1993 to September 30, 1997

Province	**Rate**
N/L	45.6
NS	27.2
PEI	20.8
PQ	17.7
MB	15.4
AB	11.2
BC	9.6
Combined	**15.8**

[1743] World Health Organization. *Guideline: Optimal Serum and Red Blood Cell Folate Concentrations in Women of Reproductive Age for Prevention of Neural Tube Defects*. 2015. World Health Organization. Available at http://www.who.int/iris/handle/10665/161988. Accessed February 2017.

[1744] Tinker S, Hamner H, Qi Y et al. US women of childbearing age who are at possible increased risk of a neural tube defect-affected pregnancy due to suboptimal red blood cell folate concentrations, National Health and Nutrition Examination Survey 2007 to 2012. *Birth Defects Research Part A: Clinical and Molecular Teratology*. 2015; 103(6): 517-26.

[1745] The seven provinces include Newfoundland & Labrador, Prince Edward Island, Nova Scotia, Quebec, Manitoba, Alberta and British Columbia.

[1746] De Wals P, Tairou F, Van Allen M et al. Reduction in neural-tube defects after folic acid fortification in Canada. *New England Journal of Medicine*. 2007; 357(2): 135-42.

[1747] Ibid.

Evidence of the Effectiveness of Folic Acid Supplementation in Reducing the Prevalence of NTDs

- In Hungary in the mid-1980s, 7,540 women planning to conceive were randomly assigned to receive a prenatal vitamin supplement (including 0.8 mg of folic acid) or a trace element supplement, starting one month prior to conception and for three months after conception. In the evaluation of 4,704 pregnancies and 4,122 live births, 28 congenital malformations were observed in the experimental group vs. 47 in the control group. Six of the congenital malformations in the control group were neural-tube defects (NTDs) vs. none in the experimental group.[1748] Given the results of this trial, RCTs are no longer considered ethically possible because of the clear benefits of folic acid supplementation.[1749]

- Other cohort and case control studies completed between 1976 and 1998 consistently found evidence of a protective effect associated with folic acid supplementation.[1750]

- Case control studies since 1998 have not consistently demonstrated a protective association with folic acid supplementation, but these studies tend to be weakened by misclassification and recall bias.[1751]

Fortification of Grain Products with Synthetic Folic Acids

- The evidence of the effectiveness of folic acid supplementation in reducing the prevalence of NTDs noted above led to a 1992 recommendation by the US Public Health Service that all women of childbearing age consume 400µg (0.4 mg) of folic acid daily, followed by the US Food and Drug Administration authorization to add synthetic folic acid to grain products in March of 1996 with mandatory compliance by January of 1998.[1752]

- In Canada, the milling industry began fortification early in 1997 to meet US requirements for imported flour. On November 11, 1998, fortification of all types of white flour, enriched pasta and cornmeal became mandatory in Canada.[1753, 1754]

- The prevalence of NTDs among live births, still births and terminations of pregnancies declined from 10.7 cases per 10,000 live births before the implementation of food fortification in the US (1995 to 1996) to 7.0 cases per 10,000 live births after fortification.[1755]

- In Canada, the prevalence of neural tube defects among live births, still births and terminations of pregnancies decreased from 15.8 to 8.6 per 10,000 live births between January 1, 1993 and December 31, 2002 (see Table 3).[1756] The time period was divided into three 'fortification' periods. The pre-fortification period ran from January 1, 1993 to September 30, 1997 to coincide with the beginning of flour

[1748] Czeizel A and Dudás I. Prevention of the first occurrence of neural-tube defects by periconceptional vitamin supplementation. *New England Journal of Medicine*. 1992; 327(26): 1832-5.
[1749] Viswanathan M, Treiman K, Kish-Doto J et al. Folic acid supplementation for the prevention of neural tube defects: an updated evidence report and systematic review for the US Preventive Services Task Force. *Journal of American Medical Association*. 2017; 317(2): 190-203.
[1750] Ibid.
[1751] Ibid.
[1752] Williams L, Mai C, Edmonds L et al. Prevalence of spina bifida and anencephaly during the transition to mandatory folic acid fortification in the United States. *Teratology*. 2002; 66(1): 33-9.
[1753] De Wals P, Tairou F, Van Allen M et al. Reduction in neural-tube defects after folic acid fortification in Canada. *New England Journal of Medicine*. 2007; 357(2): 135-42.
[1754] Ray J. Efficacy of Canadian folic acid food fortification. *Food and Nutrition Bulletin*. 2008; 29(2): S225-30.
[1755] Williams J, Mai C, Mulinare J et al. Updated estimates of neural tube defects prevented by mandatory folic acid fortification - United States, 1995–2011. *Morbidity and Mortality Weekly Report*. 2015; 64(1): 1-5.
[1756] De Wals P, Tairou F, Van Allen M et al. Reduction in neural-tube defects after folic acid fortification in Canada. *New England Journal of Medicine*. 2007; 357(2): 135-42.

fortification in Canada. The partial fortification period ran from October 1, 1997 to March 31, 2000 based on evidence from Ontario that red-cell folate levels in the population started to increase in April 1997 and reached a plateau in February 1999.[1757] The full fortification period ran from April 1, 2000 to December 31, 2002. The biggest reduction between the pre-fortification and full fortification periods was observed in Newfoundland and Labrador (from 45.6 to 7.6 per 10,000) while the smallest reduction was observed in BC (from 9.6 to 7.5 per 10,000). BC already had the lowest prevalence of NTDs (at 9.6 per 10,000) in the country before fortification (see Table 3).

Table 3: Prevalance of NTDS / 10,000 Births In Seven Canadian Provinces According to Fortification Period

	Fortification Period		
Province	Prefortification	Partial Fortification	Full Fortification
N/L	45.6	14.2	7.6
NS	27.2	13.2	12.6
PEI	20.8	10.6	0.0
PQ	17.7	12.7	9.7
MB	15.4	8.8	9.3
AB	11.2	7.3	6.7
BC	9.6	10.8	7.5
Combined	**15.8**	**10.9**	**8.6**

- The prevalence of neural tube defects among live births, still births and terminations of pregnancies declined from 11.3 cases per 10,000 live births before the implementation of food fortification in Ontario (1994 to 1997) to 5.8 cases per 10,000 live births after fortification (1998 to 2000).[1758] Ontario's data was not included in Tables 1 to 3 because the review by De Wals et al. focussed on seven provinces rather than all of Canada.

Modelling in a BC Birth Cohort of 40,000

- Based on BC life tables for 2018 to 2020, an estimated 19,624 females would survive through to age 44 in a BC birth cohort of 40,000 (see Table 4). Note that the birth cohort includes both males and females. Our analysis focusses on just the females of reproductive age in this cohort. Based on age specific fertility rates,[1759] an estimated 21,958 live births would occur between the ages of 15 and 44 in this cohort of females (see Table 4).

- For modelling purposes, we have assumed that the pre-fortification rate of NTDs in BC would be approximately 11 / 10,000 live births, followed by a rate of 7.5 / 10,000 live births post-fortification (see Table 3). We have chosen the higher rate of 10.8 (rounded to 11) seen during the partial fortification period in BC (see Table 3) rather than the 9.6 seen during prefortification as a conservative approach (recognizing that the lower 9.6 seen during prefortification in BC may be an anomaly as the rate was reduced from prefortification to partial fortification in all provinces except BC). Furthermore, we have assumed that this could be further reduced to 5.8 / 10,000 live

[1757] Ray J, Vermeulen M, Boss S et al. Declining rate of folate insufficiency among adults following increased folic acid food fortification in Canada. *Canadian Journal of Public Health*. 2002; 93(4): 249-53.
[1758] Ray J, Meier C, Vermeulen M et al. Association of neural tube defects and folic acid food fortification in Canada. *The Lancet*. 2002; 360(9350): 2047-8.
[1759] Statistics Canada. *Fertility indicators, provinces and territories: Interactive dashboard*. See https://www150.statcan.gc.ca/n1/pub/71-607-x/71-607-x2022003-eng.htm. Accessed December 2023.

births based on Ontario's full fortification rate noted above.[1760] In the sensitivity analysis, we modelled the effect of reducing this rate to 4.0 / 10,000, the lowest range considered achievable by the WHO given optimal red blood cell folate concentrations in the population.[1761]

- We have also assumed that 39% (830 of 2,116) of pregnancies with NTD would be anencephaly and 61% (1,286 of 2,116) spina bifida (see Table 1). Furthermore, 11.4% of pregnancies with anencephaly and 51% of pregnancies with spina bifida would result in a live birth (see Table 1). Based on these assumptions, an estimated 7.5 live births with spina bifida would have occurred in the birth cohort pre-fortification. The estimated post-fortification status would be 5.1 live births with spina bifida with the potential to be further reduced to 3.9 live births with spina bifida if Ontario's rate of 5.8 / 10,000 were achieved (see Table 4). Likewise, an estimated 0.74 live births with anencephaly would occur post-fortification with the potential to reduce this to 0.57 live births with anencephaly if Ontario's rate of 5.8 / 10,000 were achieved (see Table 4).

Table 4: Females Ages 15-44, Live Births and Pregnancies with Neural Tube Defects
in a British Columbia Birth Cohort of 40,000

Age Group	*Females in Birth Cohort*	*Life Years Lived*	# of Live Births	***Estimated Prefortification Status***					***Estimated Current Status***					***Estimated Potential Status***				
				Est. # of NTDs	Anen-cephaly	Spina Bifida	*Live Birth with* Anen-cephaly	Spina Bifida	Est. # of NTDs	Anen-cephaly	Spina Bifida	*Live Birth with* Anen-cephaly	Spina Bifida	Est. # of NTDs	Anen-cephaly	Spina Bifida	*Live Birth with* Anen-cephaly	Spina Bifida
15-19	19,899	99,493	270	0.3	0.1	0.2	0.0	0.1	0.2	0.1	0.1	0.0	0.1	0.2	0.1	0.1	0.0	0.0
20-24	19,867	99,333	1,576	1.7	0.7	1.1	0.1	0.5	1.2	0.5	0.7	0.1	0.4	0.9	0.4	0.6	0.0	0.3
25-29	19,825	99,124	4,978	5.5	2.1	3.3	0.2	1.7	3.7	1.5	2.3	0.2	1.2	2.9	1.1	1.8	0.1	0.9
30-34	19,773	98,864	8,281	9.1	3.6	5.5	0.4	2.8	6.2	2.4	3.8	0.3	1.9	4.8	1.9	2.9	0.2	1.5
35-39	19,707	98,536	5,503	6.1	2.4	3.7	0.3	1.9	4.1	1.6	2.5	0.2	1.3	3.2	1.3	1.9	0.1	1.0
40-44	19,624	98,118	1,350	1.5	0.6	0.9	0.1	0.5	1.0	0.4	0.6	0.0	0.3	0.8	0.3	0.5	0.0	0.2
Total		**593,469**	**21,958**	**24.2**	**9.5**	**14.7**	**1.08**	**7.5**	**16.5**	**6.5**	**10.0**	**0.74**	**5.1**	**12.7**	**5.0**	**7.7**	**0.57**	**3.9**

- A 2015 Cochrane Review found that there is high quality evidence that daily folic acid supplementation (alone or in combination with other vitamins and minerals) prevents NTDs when compared with no intervention/placebo or vitamins and minerals without folic acid (RR of 0.31, 95% CI of 0.17 to 0.58). The review also found no evidence of an increase in cleft palate, cleft lip, congenital cardiovascular defects, miscarriages or any other birth defects associated with daily folic acid supplementation.[1762]
- The 2017 USPSTF review found no significant evidence of potential harms associated with folic acid supplementation.[1763]

[1760] Ray J, Meier C, Vermeulen M et al. Association of neural tube defects and folic acid food fortification in Canada. *The Lancet*. 2002; 360(9350): 2047-8.
[1761] World Health Organization. *Guideline: Optimal Serum and Red Blood Cell Folate Concentrations in Women of Reproductive Age for Prevention of Neural Tube Defects*. 2015. World Health Organization. Available at http://www.who.int/iris/handle/10665/161988. Accessed February 2017.
[1762] De-Regil L, Peña-Rosas J, Fernández-Gaxiola A et al. Effects and safety of periconceptional oral folate supplementation for preventing birth defects. *Cochrane Database of Systematic Reviews.* 2015.
[1763] Bibbins-Domingo K, Grossman D, Curry S et al. Folic acid supplementation for the prevention of neural tube defects: US Preventive Services Task Force recommendation statement. *Journal of American Medical Association*. 2017; 317(2): 183-9.

- "Spina bifida results from the incomplete closure of the tissue and bone surrounding the spinal cord. Children born with spina bifida can have mild to severe disabilities depending on the location of the lesion along the spinal cord."[1764]
- The mortality rate is substantially higher for individuals with moderate to severe spina bifida than for less severe cases. Oakeshott and colleagues have followed a cohort of individuals with spina bifida for 50 years and found that just 12% with moderate to severe spina bifida survived to age 50, while 54% of those with less severe spina bifida survived to age 50.[1765, 1766]
- We used this survival data to compare life expectancy in the general population vs. a population with a sacral lesion (least severe) or a lumbar lesion (moderate to severe) (see Table 5). If we use 100% to represent the normal life-span of the general population, a person with a sacral lesion will have a life expectancy of 61.1% (or a loss of 38.9% of a normal life expectancy, Table 6, row *m*) and a person with a lumbar lesion will have a life expectancy of 25.1% (or a loss of 74.9% of a normal life expectancy, Table 6, row *n*).

Table 5: Survival and Year of Life in a Birth Cohort of 40,000
The General Population Compared to Individuals with Spina Bifida

				Individuals with Spina Bifida					
	General Population			**Lower Lesion (less severe)**			*Higher Lesion (more severe)*		
Age Group	Mean Survival Rate	Individuals in Birth Cohort	Years of Life in Birth	Mean Survival Rate	Individuals in Birth Cohort	Years of Life in Birth	Mean Survival Rate	Individuals in Birth Cohort	Years of Life in Birth
0-4	0.997	39,875	199,377	0.818	32,727	163,636	0.649	25,965	129,825
5-9	0.996	39,826	199,132	0.764	30,545	152,727	0.526	21,053	105,263
10-14	0.995	39,813	199,065	0.745	29,818	149,091	0.491	19,649	98,246
15-19	0.994	39,779	198,894	0.691	27,636	138,182	0.456	18,246	91,228
20-24	0.992	39,677	198,385	0.673	26,909	134,545	0.368	14,737	73,684
25-29	0.988	39,518	197,592	0.655	26,182	130,909	0.333	13,333	66,667
30-34	0.983	39,327	196,633	0.618	24,727	123,636	0.298	11,930	59,649
35-39	0.978	39,103	195,517	0.600	24,000	120,000	0.211	8,421	42,105
40-44	0.971	38,835	194,174	0.545	21,818	109,091	0.175	7,018	35,088
45-49	0.962	38,492	192,462	0.545	21,818	109,091	0.123	4,912	24,561
50-54	0.951	38,031	190,154	0.534	21,356	106,782	0.111	4,451	22,253
55-59	0.934	37,379	186,897	0.518	20,705	103,526	0.095	3,799	18,996
60-64	0.911	36,435	182,174	0.494	19,761	98,803	0.071	2,855	14,273
65-69	0.876	35,035	175,175	0.459	18,361	91,803	0.036	1,455	7,274
70-74	0.823	32,929	164,644	0.406	16,255	81,273		0	0
75-79	0.744	29,753	148,766	0.327	13,079	65,395		0	0
80+	0.627	25,060	125,300	0.210	8,386	41,929		0	0
Total			**3,144,342**			**1,920,419**			**789,112**
% Compared to General Population						61.1%			25.1%

[1764] Tilford J, Grosse S, Robbins J et al. Health state preference scores of children with spina bifida and their caregivers. *Quality of Life Research*. 2005; 14(4): 1087-98.
[1765] Oakeshott P, Hunt G, Poulton A et al. Expectation of life and unexpected death in open spina bifida: a 40-year complete, non-selective, longitudinal cohort study. *Developmental Medicine & Child Neurology*. 2009; 52(8): 749-53.
[1766] Oakeshott P, Reid F, Poulton A et al. Neurological level at birth predicts survival to the mid-40s and urological deaths in open spina bifida: a complete prospective cohort study. *Developmental Medicine & Child Neurology*. 2015; 57(7): 634-8.

- The research by Oakeshott and colleagues was based on 117 consecutive infants born with spina bifida between 1963 and 1971 in the UK who have been followed until 2013. Of these 117 infants, 40 (34%) died before the age of 5.[1767] The 1-year survival of infants born with spina bifida in the US has improved from 87.1% during 1983 to 1987 to 93.6% during 1998 to 2002.[1768] To take into account the possibility of better long-term survival of infants currently born with spina bifida, we increased the calculated life expectancy of infants with both a sacral (Table 6, row *m*) and lumbar lesion (Table 6, row *n*) by 25% in the sensitivity analysis.
- Based on a consecutive cohort of 117 children with spina bifida in the UK, the distribution of children were 33.9% (Table 6, row *g*) with a sacral lesion, 28.6% (Table 6, row *h*) with a lower lumbar lesion and 37.5% (Table 6, row *i*) with a higher lumbar lesion.[1769]
- Based on a study of 98 children with spina bifida in Arkansas, the average loss in QoL associated with spina bifida was 41%, ranging from 34% (6% to 62%) for the sacral lesion (Table 6, row *j*), 42% (22% to 62%) for the lower lumbar lesion (Table 6, row *k*) and 52% (25% to 78%) for the upper lumbar lesion (Table 6, row *l*). We used plus or minus one standard deviation provided by Tilford et al. in the sensitivity analysis.[1770] There was also a modest 5% reduction in the QoL of caregivers. This reduction, however, was only significantly different from control caregivers for the group of parents caring for the most severe children (10% reduction in QoL). A subsequent, more in depth analysis of these caregivers identified less sleep and less frequent engagement in leisure and social activities as key differences compared with a sample of control caregivers.[1771]
- Verhoef and colleagues used the SF-36 to compare the QoL in 164 young adults (ages 16 to 25) with spina bifida in Holland. Compared to the average Dutch population ages 16-25, young adults with spina bifida experienced a significant decrement in physical functioning (51%), role limitations due to physical health problems (22%), bodily pain (9%) and general health (17%). No significant differences were observed in vitality, social functioning and role limitations due to emotional health problems or mental health.[1772]
- The life expectancy of an infant born in BC of 82.4 years (Table 6, row *o*) is based on life tables for 2018 to 2020 for BC.
- De Wals and colleagues found that there were 656 live births with spina bifida in seven Canadian provinces between 1993 and 2002. At the same time, 1,466 pregnancies with a diagnosed NTD resulted in an induced abortion (see Table 1).[1773]

[1767] Oakeshott P, Reid F, Poulton A et al. Neurological level at birth predicts survival to the mid-40s and urological deaths in open spina bifida: a complete prospective cohort study. *Developmental Medicine & Child Neurology*. 2015; 57(7): 634-8.
[1768] Shin M, Kucik J, Siffel C et al. Improved survival among children with spina bifida in the United States. *Journal of Pediatrics*. 2012; 161(6): 1132-7.e3.
[1769] Oakeshott P, Hunt G, Poulton A et al. Expectation of life and unexpected death in open spina bifida: a 40-year complete, non-selective, longitudinal cohort study. *Developmental Medicine & Child Neurology*. 2009; 52(8): 749-53.
[1770] Tilford J, Grosse S, Robbins J et al. Health state preference scores of children with spina bifida and their caregivers. *Quality of Life Research*. 2005; 14(4): 1087-98.
[1771] Grosse S, Flores A, Ouyang L et al. Impact of spina bifida on parental caregivers: findings from a survey of Arkansas families. *Journal of Child and Family Studies*. 2009; 18(5): 574-81.
[1772] Verhoef M, Post M, Barf H et al. Perceived health in young adults with spina bifida. *Developmental Medicine & Child Neurology*. 2007; 49(3): 192-7.
[1773] De Wals P, Tairou F, Van Allen M et al. Reduction in neural-tube defects after folic acid fortification in Canada. *New England Journal of Medicine*. 2007; 357(2): 135-42.

We have assumed that for every live birth with spina bifida avoided, an estimated 2.23 abortions (1,466 / 656) would be avoided.

- Other assumptions used in assessing the clinically preventable burden are detailed in the Reference Document.

Based on these assumptions, the CPB associated with advising all women who are planning or capable of pregnancy to take a daily supplement containing 0.4 to 0.8 mg (400-800µg) of folic acid is 74 QALYs (see Table 6, row *ac*). The 74 QALYs is based on moving from the current NTD rate in BC of 7.5 per 10,000 births to 5.8 per 10,000 births, the post fortification rate observed in Ontario.

Table 6: CPB Associated with Advising Women Ages 15 to 44 to Take a Daily Supplement Containing 0.4 to 0.8 mg of Folic Acid in a Birth Cohort of 40,000

Row Label	Variable	Base Case	Data Source
a	Average # of females ages 15-44 in birth cohort	19,782	Table 4
b	Life years lived between the ages of 15 and 44	593,469	Table 4
c	Live births between the ages of 15 and 44	21,958	Table 4
d	Estimated live births with spina bifida prefortification	7.5	Table 4
e	Estimated live births with spina bifida currently	5.1	Table 4
f	Estimated potential live births with spina bifida post fortification	3.9	Table 4
g	Proportion of children with spina bifida with a sacral lesion (least severe)	33.9%	√
h	Proportion of children with spina bifida with a lower lumbar lesion	28.6%	√
i	Proportion of children with spina bifida with a higher lumbar lesion (most severe)	37.5%	√
j	Loss in QoL with a sacral lesion	34.0%	√
k	Loss in QoL with a lower lumbar lesion	42.0%	√
l	Loss in QoL with a upper lumbar lesion	52.0%	√
m	Reduction in life expectancy with a sacral lesion	39.4%	√
n	Reduction in life expectancy with a lumbar lesion	74.9%	√
o	Average life expectancy in BC at birth (in years)	82.4	√
p	Births with sacral lesion spina bifida avoided (7.5 to 3.9)	1.2	= (d - f) * g
q	Births with lumbar lesion spina bifida avoided (7.5 to 3.9)	2.3	= (d - f) - p
r	Life years gained due to sacral lesion spina bifida avoided	39.0	= m * o * p
s	Life years gained due to lumbar lesion spina bifida avoided	144.4	= n * o * q
t	QALYs gained due to sacral lesion spina bifida avoided	20.4	= p * (1 - m) * o * j
u	QALYs gained due to lumbar lesion spina bifida avoided	22.7	= q * (1 -n) * o * (k + l) / 2
v	**Total QALYs gained due to spina bifida avoided (7.5 to 3.9)**	**226**	= r + s + t + u
w	Births with sacral lesion spina bifida avoided (5.1 to 3.9)	0.4	= (e - f) * g
x	Births with lumbar lesion spina bifida avoided (5.1 to 3.9)	0.8	= (e - f) - w
y	Life years gained due to sacral lesion spina bifida avoided	12.7	= m * o * w
z	Life years gained due to lumbar lesion spina bifida avoided	47.2	= n * o * x
aa	QALYs gained due to sacral lesion spina bifida avoided	6.7	= w * (1 - m) * o * j
ab	QALYs gained due to lumbar lesion spina bifida avoided	7.4	= x * (1 -n) * o * (k + l) / 2
ac	**Total QALYs gained due to spina bifida avoided (5.1 to 3.9)**	**74**	= y + z + aa + ab

√ = Estimates from the literature

For our sensitivity analysis, we modified a number of major assumptions and recalculated the CPB as follows:

- Assume that the loss in QoL associated with a sacral lesion is reduced from 34% to 6% (Table 6, row *j*), the loss in QoL associated with a lower lumbar lesion is reduced from 42% to 22% (Table 6, row *k*) and the loss in QoL associated with an upper lumbar lesion is reduced from 52% to 25% (Table 6, row *l*): **CPB = 65**.
- Assume that the loss in QoL associated with a sacral lesion is increased from 34% to 62% (Table 6, row *j*), the loss in QoL associated with a lower lumbar lesion is increased from 42% to 62% (Table 6, row *k*) and the loss in QoL associated with an upper lumbar lesion is increased from 52% to 78% (Table 6, row *l*): CPB = 83.
- Assume that the reduction in life expectancy with either a sacral and lumbar lesion is increased by 25%, giving people with spina bifida a longer lifespan. (Table 6, rows *m* & *n*): CPB = 82.
- Reduce the incidence of NTDs from 5.8 to 4.0 / 10,000 live births: **CPB = 152**.

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with advising all women of reproductive age to take a daily supplement containing 0.4 to 0.8 mg (400-800µg) of folic acid.

In estimating CE, we made the following assumptions:

- Approximately half of all pregnancies are unplanned. Therefore clinicians should advise all women who are capable of pregnancy to take daily folic acid supplements.[1774]
- In a survey of 499 women, the majority (95%) indicated that they prefer to receive information about preconception health from their primary care physician. Only 39% of these women, however, could recall their physician ever discussing this topic.[1775]
- Mazza and colleagues in Australia found that low levels of engagement between primary care providers and women regarding preconception care are due to a number of perceived barriers, including "time constraints, the lack of women presenting at the preconception stage, the numerous competing preventive priorities within the general practice setting, issues relating to the cost of and access to preconception care, and the lack of resources for assisting in the delivery of preconception care guidelines."[1776]
- Does a clinician's advice increase the uptake of daily folic acid supplements during the periconceptional period? In a study of 1,173 women with a median age of 32 in the UK, 51% reported receiving advice on issues such as smoking, alcohol use, healthy diet and folic acid intake from a health professional prior to becoming

[1774] Bibbins-Domingo K, Grossman D, Curry S et al. Folic acid supplementation for the prevention of neural tube defects: US Preventive Services Task Force recommendation statement. *Journal of American Medical Association*. 2017; 317(2): 183-9.
[1775] Frey K and Files J. Preconception healthcare: what women know and believe. *Maternal and Child Health Journal*. 2006; 10(1): 73-7.
[1776] Mazza D, Chapman A and Michie S. Barriers to the implementation of preconception care guidelines as perceived by general practitioners: a qualitative study. *BioMed Central Health Services Research*. 2013; 13(36): 1-8.

pregnant. Women who received this advice were significantly more likely to take folic acid supplements (76%) than women who did not receive this advice (37%).[1777]

- For modelling purposes, we assumed that 70% (ranging from 60% to 80% in the sensitivity analysis) (Table 7, row *b*) of clinicians would advise women ages 15 to 44 to take a daily supplement containing 0.4 to 0.8 mg of folic acid and that 76% (ranging from 66% to 86%) (Table 7, row *e*) of women would follow this advice.
- For modelling purposes, we assumed this advice would need to be given every three years (Table 7, row *c*) and modified this from every one to five years in the sensitivity analysis.
- **Cost of folic acid supplements** – The cost of folic acid supplements averages $0.044 per tablet at London Drugs.[1778] We assumed an annual cost of $16.06 (Table 7, row g).
- **Costs avoided** – Average incremental medical expenditures comparing patients with spina bifida and those without are $41,460 (in 2003 USD) in the first year of life, $14,070 per year from ages 1 -17, $13,339 per year from ages 18-44 and $10,134 per year from ages 45-64.[1779]
- Based on a study of the same 98 children and their caregivers, the caregivers worked an average of 7.5 to 11.3 hours less per week (depending on their children's disability severity) than matched control caregivers.[1780]
- Grosse and co-authors estimated the lifetime costs associated with spina bifida to be $791,900 (in 2014 USD). This includes $513,500 in medical costs, $63,500 in special education and developmental service costs and $214,900 in parental time costs.[1781] We converted the medical costs to equivalent 2022 Canadian costs; $507,186 in medical costs (Table 7, row *r*), $88,337 in special education and developmental service costs (Table 7, row *s*) and $298,955 in parental time costs (Table 7, row *t*).[1782]
- Parental time costs are excluded from the base model (Table 7, row *t*) but included in the sensitivity analysis. The literature on 'spillover effects' (e.g. when the illness of a child or family member has an economic or quality of life impact on the broader family or caregiver(s) is nascent and further work is required before these effects can be relied upon with confidence.[1783,1784]

[1777] Stephenson J, Patel D, Barrett G et al. How do women prepare for pregnancy? Preconception experiences of women attending antenatal services and views of health professionals. *Plos One*. 2014; 9(7): e103085.
[1778] See https://www.londondrugs.com/wellness-by-london-drugs-folic-acid---1mg---180s/L0904156.html. Accessed December 2023.
[1779] Ouyang L, Grosse S, Armour B et al. Health care expenditures of children and adults with spina bifida in a privately insured US population. *Birth Defects Research Part A: Clinical and Molecular Teratology*. 2007; 79(7): 552-8.
[1780] Tilford J, Grosse S, Goodman A et al. Labor market productivity costs for caregivers of children with spina bifida: a population-based analysis. *Medical Decision Making*. 2009; 29(1): 23-32.
[1781] Grosse S, Berry R, Tilford J et al. Retrospective assessment of cost savings from prevention: folic acid fortification and spina bifida in the US. *American Journal of Preventive Medicine*. 2016; 50(5S1): S74-S80.
[1782] Campbell and Cochrane Economics Methods Group. *CCEMG – EPPI-Centre Cost Converter*. 2016. Available at https://eppi.ioe.ac.uk/costconversion/. Accessed December 2016.
[1783] Wittenberg E and Prosser L. Disutility of illness for caregivers and families: a systematic review of the literature. *Pharmacoeconomics*. 2013; 31(6): 489-500.
[1784] Wittenberg E, Ritter G and Prosser L. Evidence of spillover of illness among household members EQ-5D scores from a US sample. *Medical Decision Making*. 2013; 33(2): 235-43.

- For every live birth with spina bifida avoided, an estimated 2.23 abortions would be avoided (Table 7, row *v*). The cost of an abortion is estimated at $609 (in 2010 CAD or $744 in 2022 CAD) (Table 7, row *w*).[1785]
- Anencephaly is uniformly fatal. However, an estimated 11.4% of pregnancies with anencephaly result in live births (Table 1). These infants survive an average of 2.11 days.[1786] According to the Canadian Institute for Health Information's *Patient Cost Estimator*, the average cost per day in BC in 2022 for CMG 599 (Neonate 2500+ grams, ages 0-28 days, other major problem) was $1,413.[1787] We therefore calculated an avoided cost of $2,981 (2.11 * $1,413) per anencephaly live birth avoided (Table 7, row *p*).
- Other costs incurred or avoided and assumptions used in assessing cost-effectiveness are detailed in the Reference Document.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the CE associated with advising all women of reproductive age to take a daily supplement containing 0.4 to 0.8 mg (400-800µg) of folic acid is $398,537 / QALY (Table 7, row *ad*).

[1785] Black A, Guilbert E, Hassan F et al. The cost of unintended pregnancies in Canada: estimating direct cost, role of imperfect adherence, and the potential impact of increased use of long-acting reversible contraceptives. *Journal of Obstetrics and Gynaecology Canada*. 2015; 37(12): 1086-97.
[1786] Jaquier M, Klein A and Boltshauser E. Spontaneous pregnancy outcome after prenatal diagnosis of anencephaly. *British Journal of Obstetric and Gynaecology: An International Journal of Obstetrics & Gynaecology*. 2006; 113(8): 951-3.
[1787] Canadian Institute for Health Information. *Patient Cost Estimator.* Available online at https://www.cihi.ca/en/spending-and-health-workforce/spending/patient-cost-estimator. Accessed January 2017

Table 7: CE Associated with Advising Women Ages 15 to 44 to Take a Daily Supplement Containing 0.4 to 0.8 mg of Folic Acid in a Birth Cohort of 40,000			
Row Label	**Variable**	**Base Case**	**Data Source**
a	Life years lived between the ages of 15 and 44	593,469	Table 6, row b
b	Clinician adherence in offering advice re: folic acid supplementation	70%	Assumed
c	Frequency of offering advice re: folic acid supplementation (every x years)	3	Assumed
d	Life years covered by advice re: folic acid supplementation	415,428	= a * b
e	Proportion of women taking folic acid supplementation after receiving advice	76%	√
f	Life years covered by folic acid supplementation	315,725	= d * e
g	Annual cost of folic acid supplementation	$16.06	√
h	Cost of folic acid supplementation	$5,070,548	= f * g
i	Cost of 10-minute office visit	$35.97	√
j	Portion of 10-minute office visit for offering advice	50%	Assumed
k	Costs of office visits	$2,490,491	= (d / c) * i * j
l	Patient time required per office visit (hours)	2	Assumed
m	Value of patient time (per hour)	$74.32	√
n	Value of patient time and travel for intervention	$10,291,537	= (d / c) * l * m * j
o	**Estimated cost of the intervention**	**$17,852,576**	= h + k + n
p	Medical care costs avoided per anencephaly live birth avoided	-$2,981	√
q	Cases of anencephaly live births avoided with intervention	0.17	Table 4
r	Medical care costs avoided per case of spina bifida avoided	-$507,186	√
s	Special education and developmental service costs avoided per case of spina bifida avoided	-$88,337	√
t	Parental time costs avoided per case of spina bifida avoided	$0	√
u	Cases of spina bifida avoided with intervention	1.16	Table 6, row w + x
v	Abortions avoided per spina bifida live birth	2.23	√
w	Costs avoided per abortion avoided	-$744	√
	CE Calculation		
x	Cost of intervention over lifetime of birth cohort	$17,852,576	= o
y	Costs avoided over lifetime of birth cohort	-$691,604	= ((r + s + t) * u)+(u * v * w)+(p * q)
z	QALYs saved	74	Table 6, row ac
aa	Cost of intervention over lifetime of birth cohort (1.5% discount)	$17,852,576	Calculated
ab	Costs avoided over lifetime of birth cohort (1.5% discount)	-$607,271	Calculated
ac	QALYs saved (1.5% discount)	43	Calculated
ad	**CE ($/QALY saved)**	**$398,537**	= (aa + ab) / ac

√ = Estimates from the literature

For our sensitivity analysis, we modified a number of major assumptions and recalculated the CE as follows:

- Assume that the loss in QoL associated with a sacral lesion is reduced from 34% to 6% (Table 6, row *j*), the loss in QoL associated with a lower lumbar lesion is reduced from 42% to 22% (Table 6, row *k*) and the loss in QoL associated with an upper lumbar lesion is reduced from 52% to 25% (Table 6, row *l*): CE = $455,133.
- Assume that the loss in QoL associated with a sacral lesion is increased from 34% to 62% (Table 6, row *j*), the loss in QoL associated with a lower lumbar lesion is increased from 42% to 62% (Table 76 row *k*) and the loss in QoL associated with an upper lumbar lesion is increased from 52% to 78% (Table 6, row *l*): CE = $354,815.

- Assume that the reduction in life expectancy with either a sacral and lumbar lesion is increased by 25% (Table 6, rows *m* & *n*): CE = $358,118.
- Reduce the incidence of NTDs from 5.8 to 4.0 / 10,000 live births: CE = $186,358.
- Assume that clinician adherence in offering advice re: folic acid supplementation is reduced from 70% to 60% (Table 7, row *b*): CE = $339,598.
- Assume that clinician adherence in offering advice re: folic acid supplementation is increased from 70% to 80% (Table 7, row *b*): CE = $457,475.
- Assume that the frequency of offering advice re: folic acid supplementation is increased from every 3 years to every year (Table 7, row *c*): **CE = $989,319**.
- Assume that the frequency of offering advice re: folic acid supplementation is decreased from every 3 years to every 5 years (Table 7, row *c*): **CE = $280,380**.
- Assume the proportion of women taking folic acid supplementation after receiving advice is decreased from 76% to 66% (Table 7, row *e*): CE = $383,118.
- Assume the proportion of women taking folic acid supplementation after receiving advice is increased from 76% to 86% (Table 7, row *e*): CE = $413,955.
- Assume that the portion of a 10-minute office visit required for offering advice is reduced from 50% to 33% (Table 7, row *j*): CE = $298,104.
- Assume that the portion of a 10-minute office visit required for offering advice is increased from 50% to 66% (Table 7, row *j*): CE = $493,062.
- Include parental time costs avoided per case of spina bifida avoided (Table 7, row *t*): CE = $391,516.

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with advising all women of reproductive age to take a daily supplement containing 0.4 to 0.8 mg (400-800µg) of folic acid is estimated to be 43 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is $398,537 per QALY (see Table 8).

Table 8: Advising Women Ages 15 to 44 to Take a Daily Supplement Containing 0.4 to 0.8 mg of Folic Acid in a Birth Cohort of 40,000

Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
1.5% Discount Rate	**43**	38	89
3% Discount Rate	27	24	56
0% Discount Rate	74	65	152
CE ($/QALY) **including** patient* time costs			
1.5% Discount Rate	**$398,537**	$280,380	$989,319
3% Discount Rate	$631,236	$444,864	$1,563,094
0% Discount Rate	$231,765	$162,715	$577,016
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$160,701	$137,679	$275,811
3% Discount Rate	$256,090	$219,776	$437,656
0% Discount Rate	$92,774	$79,320	$160,044

** Patient time costs do not normally include caregiver time costs (spillover effects). In this model, however, we have included caregiver time costs but only in the sensitivity analysis and not in the base case analysis.*

While the approach modelled above involving regular clinic-based reminders for women ages 15 to 44 to take a daily supplement containing folic acid is not cost-effective, folic acid supplementation is still highly recommended before conception and throughout pregnancy. The BC Perinatal Health Program's *Maternity Care Pathway*, for example, recommends "supplementation with folic acid before conception and throughout pregnancy. Folic acid supplementation as per patient risk (0.4 mg – 5 mg per day per pregnancy)."[1788]

[1788] BC Perinatal Health Program, *Maternity Care Pathway*, February 2010. Available online at http://www.perinatalservicesbc.ca/Documents/Guidelines-Standards/Maternal/MaternityCarePathway.pdf. Accessed July 2017.