The Lifetime Prevention Schedule

Establishing Priorities among Effective Clinical Prevention Services in British Columbia

Summary and Technical Report
September 2022 Update

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

British Columbia

Acknowledgments

This project was completed under the guidance of the Lifetime Prevention Schedule Expert Committee. Current committee members are:

- **Stephen Smith** (chair) - Director, Life Course Prevention, Population and Public Health Division, BC Ministry of Health
- **Lindsay Arscott -** Director, Primary Care Quality, Primary Care, BC Ministry of Health
- **Jane Buxton -** Public Health and Preventive Medicine Specialist, University of British Columbia
- **Heather Davidson -** Manager, Provincial Services, Hospital and Provincial Health Services Division, BC Ministry of Health
- **Martin Dawes** - Professor of Family Practice, Department of Family Practice, Faculty of Medicine, UBC
- **Tijana Fazlagic -** Executive Director, PharmaCare Benefits Branch, Pharmaceutical Services, BC Ministry of Health
- **Jeff Hook -** Policy Analyst, Laboratory Services, Pharmaceutical, Lab and Blood Services, BC Ministry of Health
- **Jillian Hannah** - Policy Analyst, Laboratory Services, Pharmaceutical, Lab and Blood Services, BC Ministry of Health
- **Zahra Hussein -** Provincial Lead, Primary Care, Child Health BC
- **Heather Jackson** - Senior Director, Quality, Research and Integrative Care, Cardiac Services BC
- **Martin Lavoie -** Deputy Provincial Health Officer, Office of the Provincial Health Officer
- **Julie MacFarlane -** Provincial Lead, Screening Programs, Perinatal Services BC
- **Amie Mazza -** Manager, Provincial and Specialized Services, Hospital and Provincial Health Services Division, BC Ministry of Health
- **Megan Oakey -** Provincial Manager, Injury Prevention, Population and Public Health, BCCDC
- **Aciemme (Sam) Ospan** - Manager, Lifetime Prevention Schedule, Population and Public Health, BC Ministry of Health
- **Yang Geng -** Policy Analyst, Lifetime Prevention Schedule, Population and Public Health, BC Ministry of Health
- **Stuart Peacock** - Head of Cancer Control Research, BC Cancer Agency
- **Jonathan Robinson -** Executive Director, Healthy Living and Health Promotion, Population and Public Health, BC Ministry of Health
- **George Watson** - Family Physician, General Practice Services Committee
- **Glenys Webster** - Director, Women's, Maternal and Early Childhood Health, Population and Public Health, BC Ministry of Health
- **Manik Saini** – Director, Health Technology Assessment, Partnership and Innovation Division, BC Ministry of Health

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Establishing Priorities among Effective Clinical Prevention Services in British Columbia: *2020/21 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 30 CPS have been reviewed by the Lifetime Prevention Schedule Expert Committee (LPSEC) for potential inclusion in the LPS. Two updated reviews were concluded in 2021/22; screening for colorectal cancer and screening & treatment for hypertension. A new CPS, screening & interventions to reduce unhealthy drug use, was also modelled in 2021/22.

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.

[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.

CPS Intervention Rate

Table ES-1 provides a one-page summary of the 30 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 using a fecal occult blood test (FIT) (frequency). An estimated 50% of the relevant cohort in BC are currently receiving screening at this frequency (rate of coverage in BC). 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	7.4%
Behavioural Counseling Interventions - Children/Youth (C/Y)				
Interventions to support breastfeeding	During pregnancy and after birth	Multiple sessions	Unknown	46%
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%
Preventing tobacco use (school-aged children & youth)	Ages 6 - 17	Annually	Unknown	53%
Preventive Medication / Devices - Children				
Fluoride varnish	On primary teeth at time of tooth eruption (ages 1 - 5)	Every six months	Unknown	62%
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%	88%
Addition of HPV-based cervical cancer screening	Ages 30 - 65	Every 5 years	0%	88%
Screening for colorectal cancer	Ages 45 - 75	FOBT 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	88%	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 type 2 diabetes mellitus (T2DM)	Ages 18 and older - risk assessment	Every 3-5 years	Unknown	58%
	High risk for T2DM - blood glucose	Every 3-5 years	Unknown	80%
	Very high risk for T2DM - blood glucose	Every year	Unknown	80%
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 osteoporosis	Females age 65	One-time	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 chlamydia and gonorrhea	Sexually active females 24 years of age or younger	When sexual history reveals new or persistent risk factors since the last negative test	Unknown	55%
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 for unhealthy drug use and brief intervention	Ages 18 - 69	Annual screening and brief intervention if required	Unknown	54%
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				
Routine aspirin use for the prevention of cardiovascular disease (CVD) and colorectal cancer	Age 50 - 69 with a 10% or greater 10-year CVD risk & at low risk of bleeding	Screening for CVD risk - At age 50 - 59	Unknown	33%
		Screening for bleeding risk - At age 50 - 59	Unknown	33%
		Management - Low-dose daily aspirin use for 10 years	Unknown	24%
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 were 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 in typical practice 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) is achieved. For example, if coverage for colorectal cancer screening were as high as the BiW (77%), we would expect a CPB of 3,588 QALYs. Since BC's coverage is at 50%, a CPB of 2,330 QALYs is being achieved. This is 1,258 QALYs short of the potential 3,588 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 $14,639, based on a discount rate of 1.5%. If a 0% discount rate is used, then the cost/QALY would be reduced to $9,921.

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.	CPB(2) (0% Discount) 'BiW'(1)	CPB(2) (0% Discount) Gap	CE(3) (% Discount) 1.5%	CE(3) (% Discount) 0%
Screening for Asymptomatic Disease or Risk Factors - Children/Youth (C/Y)					
Vision screening for amblyopia	2	2	0	$5,124,459	$419,106
Screening for depression (ages 12-18)	Unknown	222		$28,215	$27,331
Behavioural Counseling Interventions - Children/Youth (C/Y)					
Interventions to support breastfeeding	Unknown	5,002		($9,021)	($11,966)
Growth monitoring and healthy weight management in children and youth	196	196	0	$29,436	$18,148
Preventing tobacco use (school-aged children & youth)	Unknown	4,123		($7,349)	($9,538)
Preventive Medication / Devices - Children					
Fluoride varnish	Unknown	150		$43,038	$43,038
Dental sealants	Unknown	157		($24,690)	($29,320)
Screening for Asymptomatic Disease or Risk Factors - Adults					
Screening for breast cancer	703	1,189	486	$19,720	$18,326
Screening (cytology-based) for cervical cancer	1,153	1,471	318	$25,542	$26,980
Addition of HPV-based cervical cancer screening	0	655	655	($21,556)	($19,264)
Screening for colorectal cancer	2,330	3,588	1,258	$14,639	$9,921
Screening for lung cancer	Unknown	1,745		$2,240	$2,080
Screening for hypertension	15,995	15,995	-	($350)	$116
Screening for cardiovascular disease risk and treatment (with statins)	Unknown	9,370		$3,223	$1,392
Screening for type 2 diabetes mellitus (T2DM)	Unknown	3,494		($3,121)	($3,453)
Screening for depression in general adult population	Unknown	-8		Dominated	Dominated
Screening for depression in pregnant and postpartum women	Unknown	109		$23,042	$10,140
Screening for osteoporosis	Unknown	91		($29,412)	($34,145)
Screening for abdominal aortic aneurysm	Unknown	340		$11,995	$9,973
Screening for Sexually Transmitted Infections and Blood Borne Pathogens - Adults					
Screening for human immunodeficiency virus	Unknown	360		$16,434	$16,434
Screening for chlamydia and gonorrhea	Unknown	143		$57,174	$53,410
Screening for hepatitis C virus	*	555		$3,170	$1,222
Behavioural Counseling Interventions - Adults					
Prevention of sexually transmitted infections (STIs)	Unknown	3,285		$10,267	$10,267
Counselling and interventions to prevent tobacco use	3,730	5,944	2,214	($3,440)	($2,094)
Screening and behavioural counseling interventions to reduce unhealthy alcohol use	Unknown	5,035		$9,609	$9,258
Screening and brief intervention to reduce unhealthy drug use	Unknown	326		$52,369	$40,371
Screening for and management of obesity	Unknown	2,287		$12,160	$11,140
Preventing falls	Unknown	429		$35,213	$35,213
Preventive Medication / Devices - Adults					
Routine aspirin use for the prevention of cardiovascular disease (CVD) and colorectal cancer	Unknown	1,098		$2,302	$411
Folic acid supplementation for the prevention of neural tube defects	Unknown	95		$195,379	$113,155

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

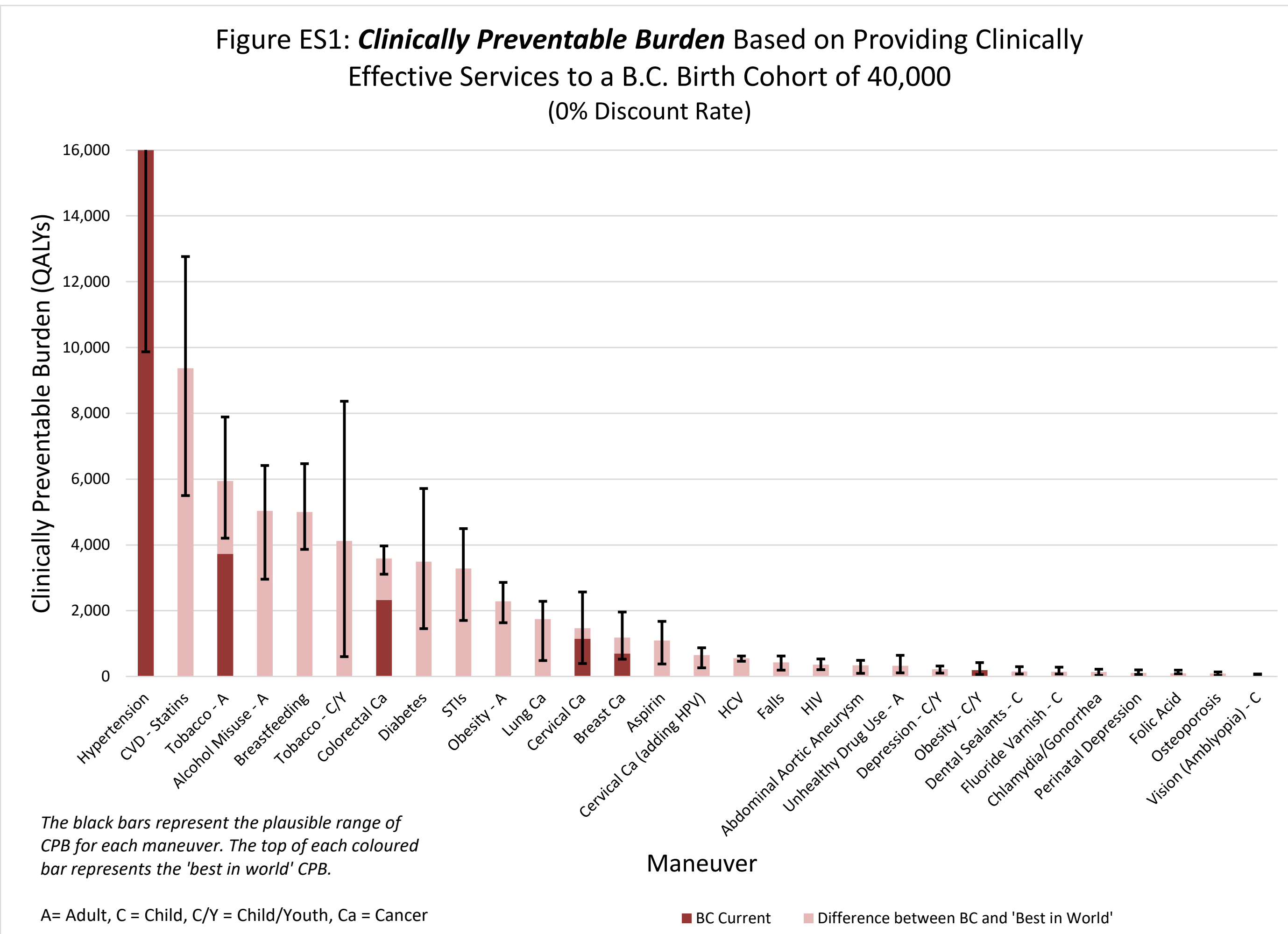
** More than 31% of the 1945-1964 birth cohort in BC has been screened for hepatitis C. The CPB for this CPS is calculated based on the 1945 - 1964 birth cohort that has not yet been screened.*

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 body of the text. Using a 1.5% discount rate tends to reduce the CPB. 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 *hypertension screening and treatment* (Hypertension) (i.e., achieving levels that are comparable to the best in the world) would result in a CPB of 15,995 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.

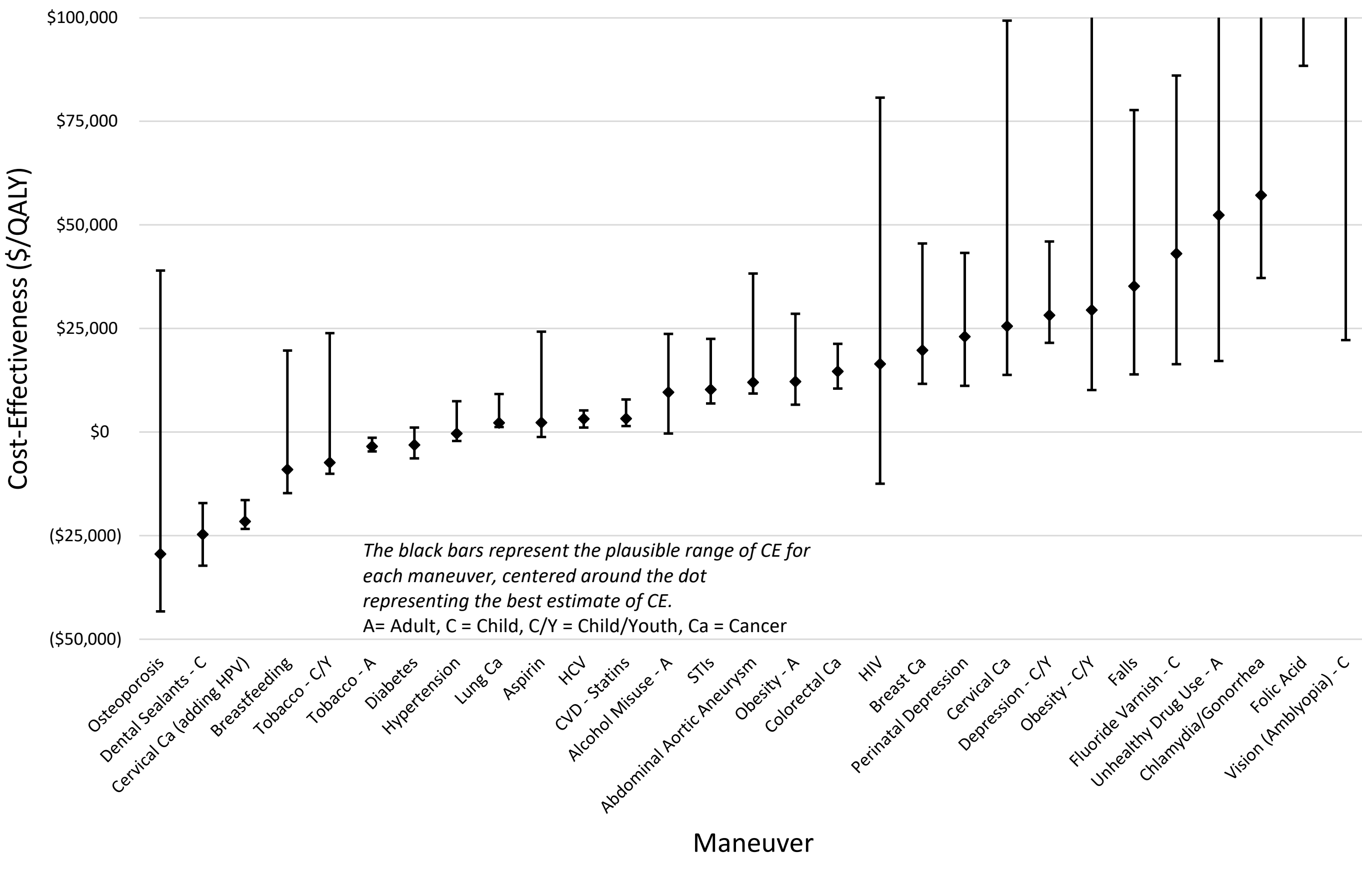


Note that the labels on the horizontal axis in Figures ES-1 and ES-2 refer to the CPS included in Table ES-1. The 'A' refers to adults, the 'C' to children, the 'C/Y' to children/youth and the 'Ca' to cancer.

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. *Screening for osteoporosis in women 65+* has the best CE result of any service reviewed. That is, this service is considered to be cost-saving, with a cost per QALY of -$29,412 (with a potential range from -$43,257 to $38,997). The chart inset shows the results for interventions with plausible ranges extending over $100,000 / QALY.

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



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 $9,609 to -$710 (i.e. becomes cost saving) if patient time costs are excluded.

Combined Comparison Using CPB and CE

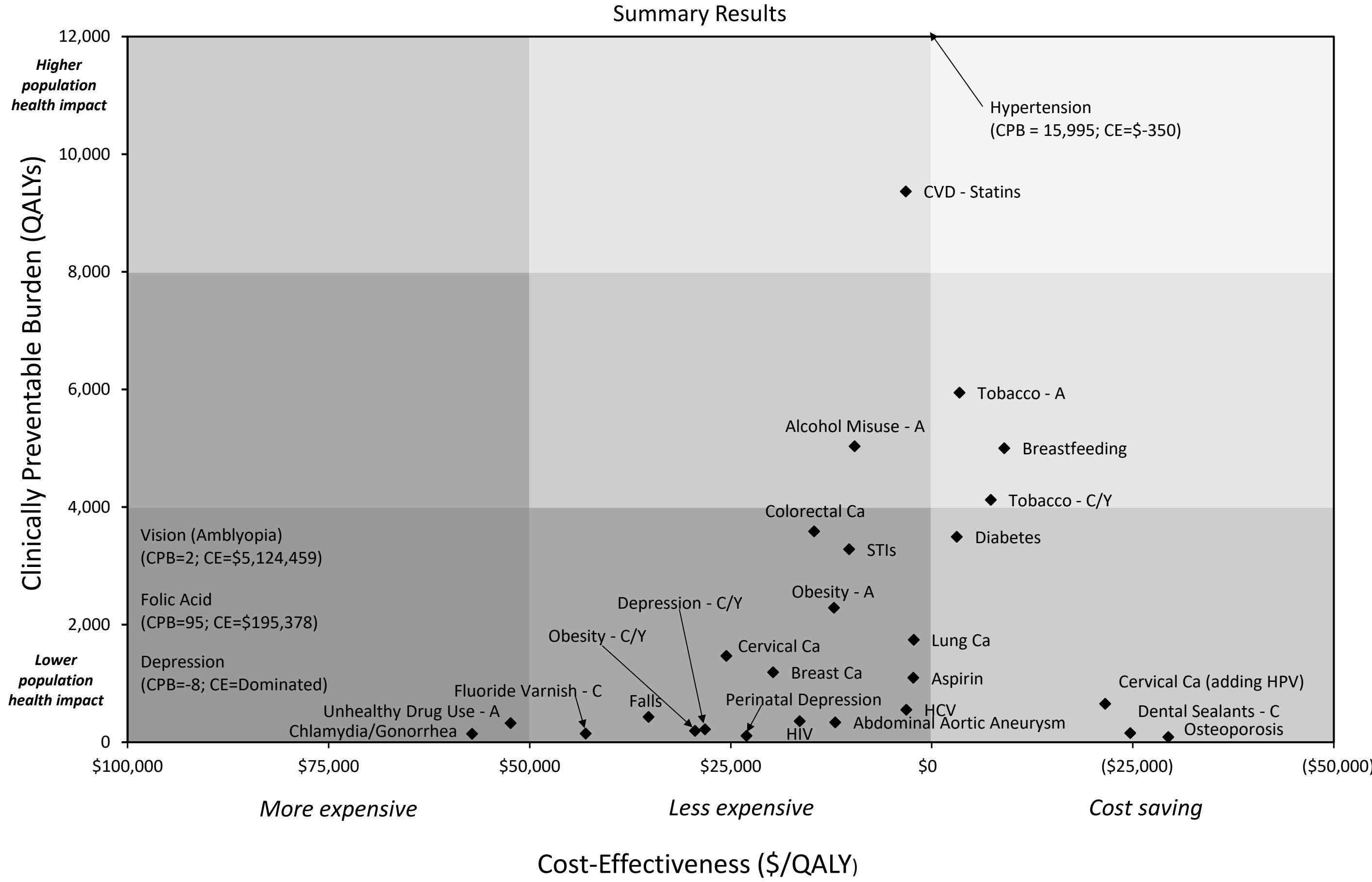
The results for CPB and CE are combined in Figure ES-3. CPB is on the vertical axis, ranging from 0 to 12,000 QALYs. CE is on the horizontal axis, ranging from $100,000/QALY at the intersection of the x- and y-axis to -$50,000 at the far right of the x-axis. By arranging CPB and CE in this manner, the 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 4,000 QALYs, 4,001 to 8,000 QALYs and 8,001 to 12,000 QALYs. CE was also divided into three equal segments as follows: $100,000 to $50,000 per QALY, $50,000 to $0 per QALY and $0 to -$50,000 per QALY.

The resulting nine equivalent 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



In Figures ES-4 to ES-7, we have incorporated visual information on plausible ranges (based on one-way sensitivity analysis) with the point estimates for each service. To avoid overcrowding the above figure (ES-3), we have separated the services into four figures. Figure ES-4 includes services specific to children and youth, Figures ES-5 and ES-6 includes screening services for non-cancer and cancer conditions respectively, and Figure ES-7 includes the remainder of the services reviewed.

Figure ES4: **Establishing Priorites Among Effective Clinical Prevention Services in BC**

Combining Clinically Preventable Burden and Cost-Effectiveness
Summary Results for Children and Youth

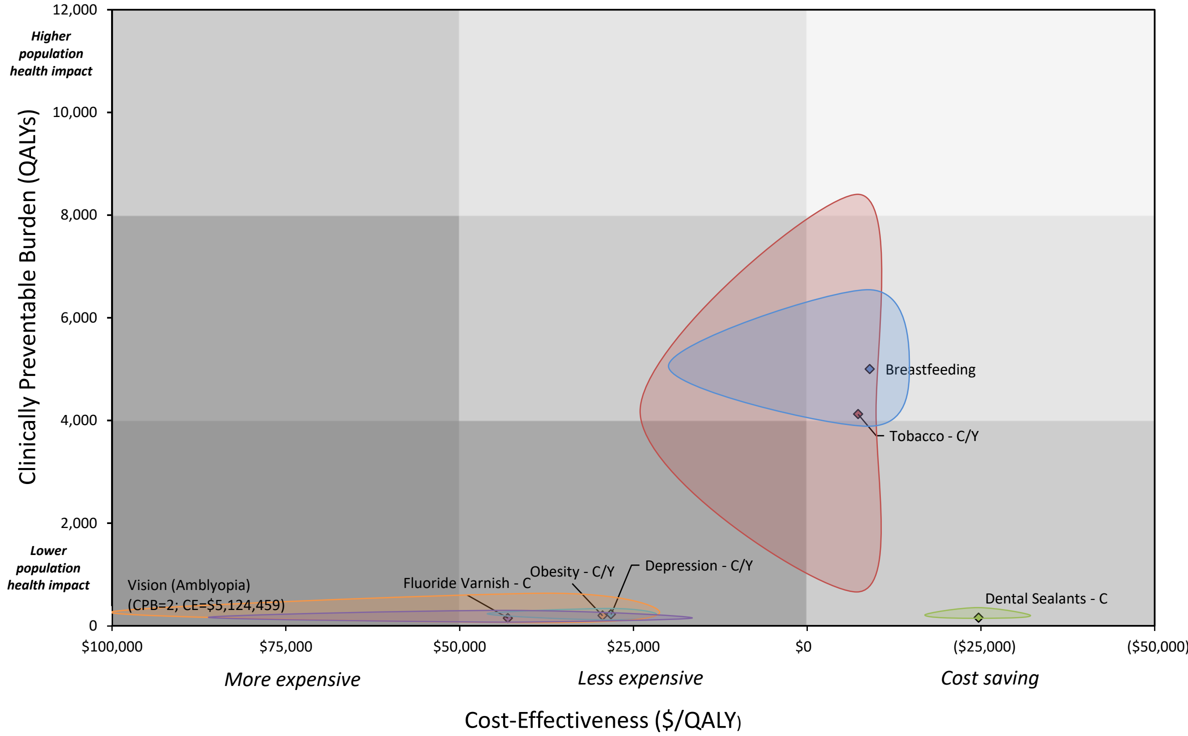


Figure ES5: **Establishing Priorites Among Effective Clinical Prevention Services in BC**

Combining Clinically Preventable Burden and Cost-Effectiveness
Summary Results for Non-Cancer Screening Maneuvers

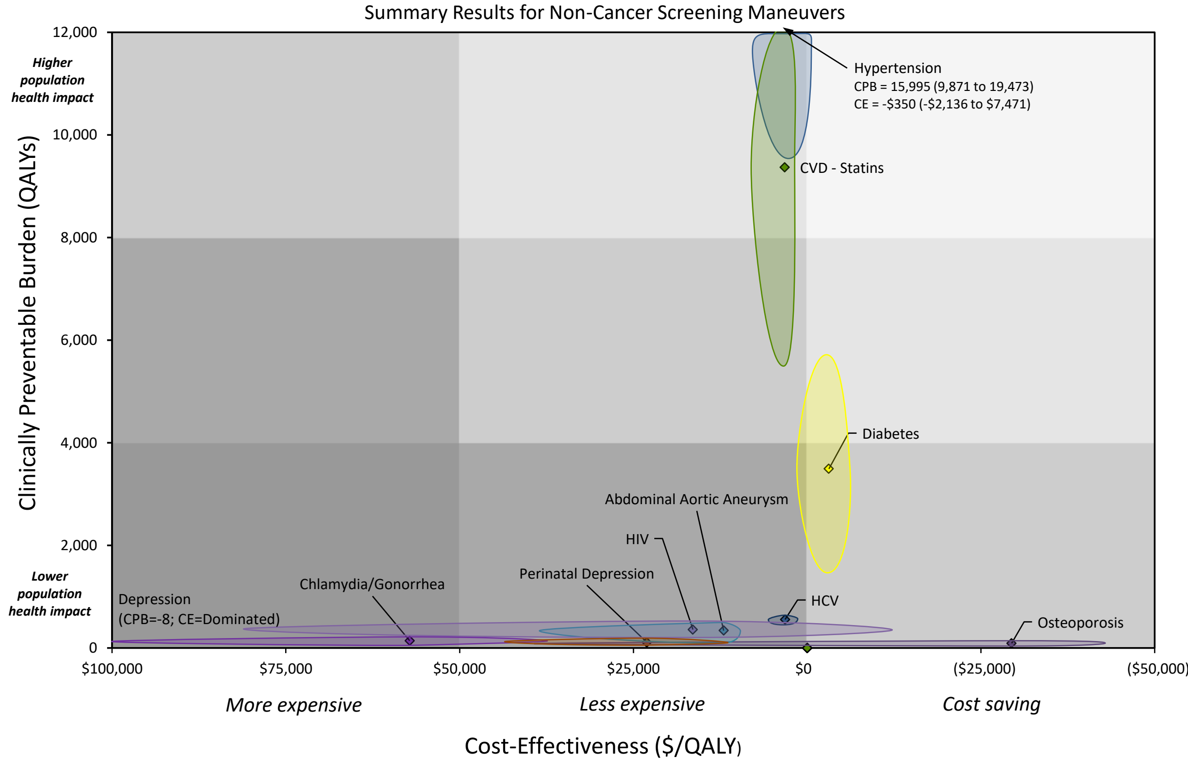


Figure ES6: **Establishing Priorites Among Effective Clinical Prevention Services in BC**

Combining Clinically Preventable Burden and Cost-Effectiveness
Summary Results for Cancer Screening

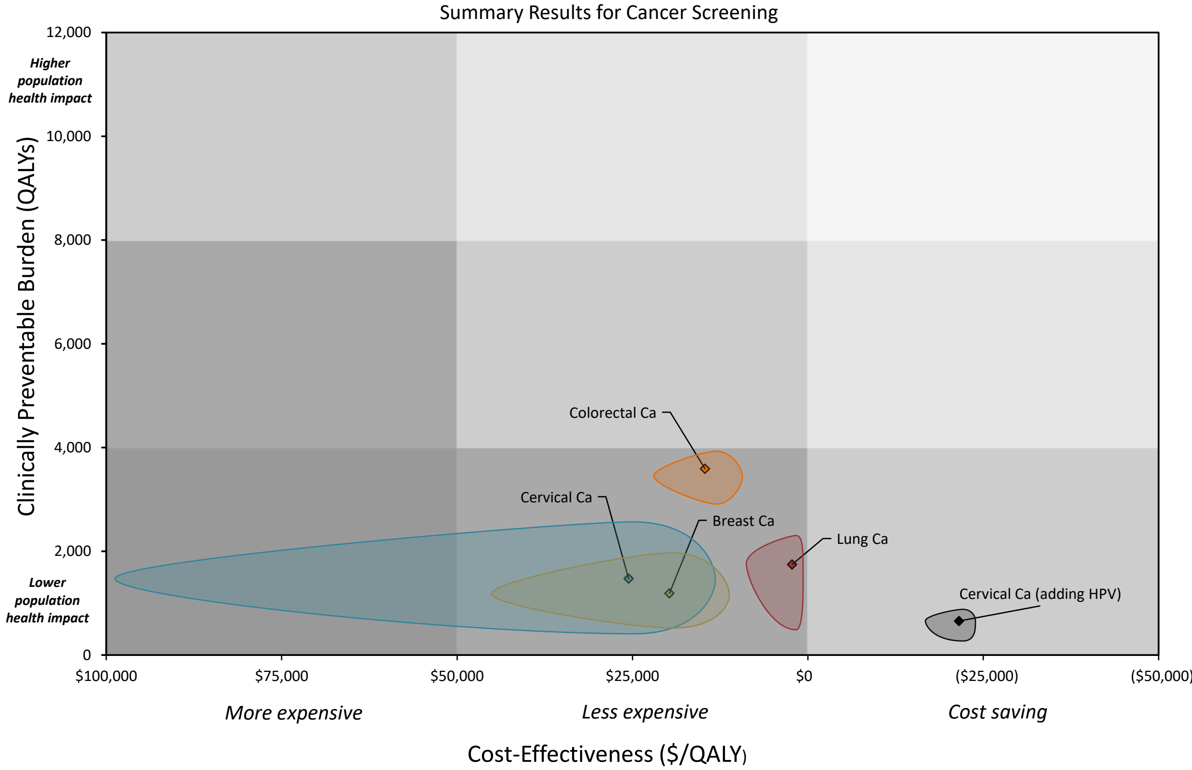
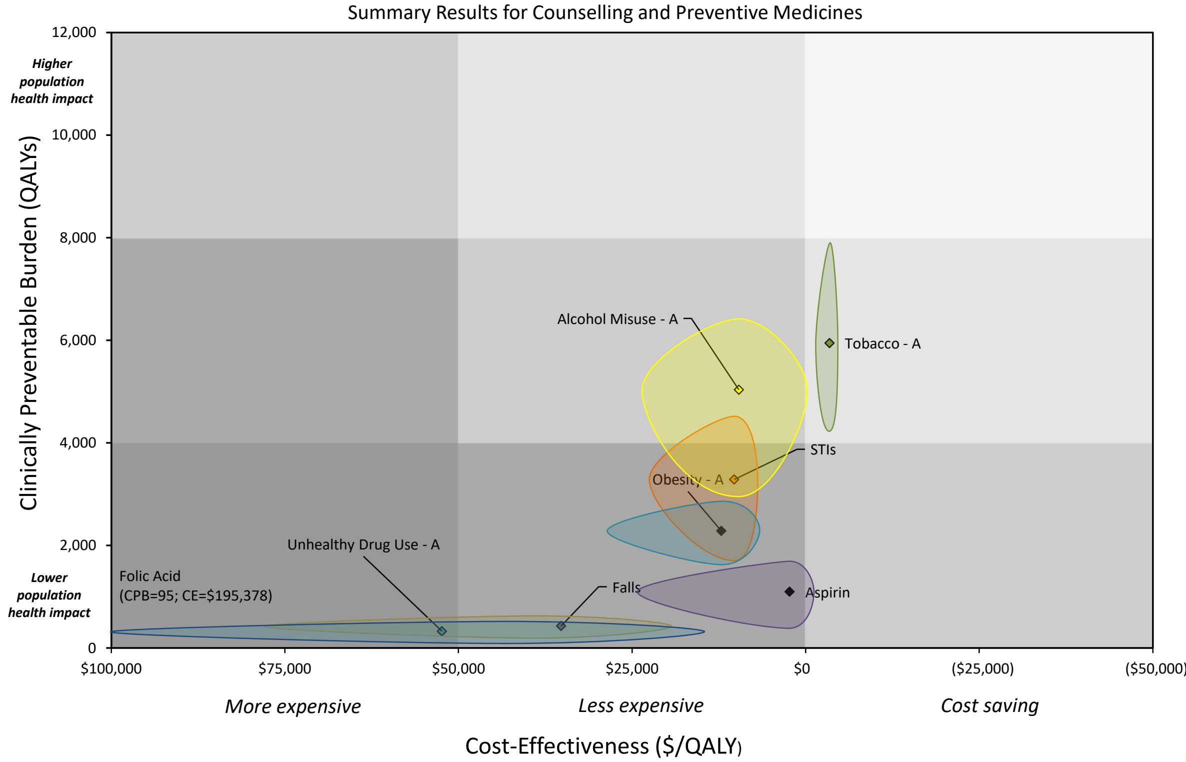


Figure ES7: **Establishing Priorites Among Effective Clinical Prevention Services in BC**

Combining Clinically Preventable Burden and Cost-Effectiveness
Summary Results for Counselling and Preventive Medicines



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

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

CHD – Coronary Heart Disease

CHEP - Canadian Hypertension Education Program

CI – Confidence Interval

CIN – Cervical Intraepithelial Neoplasia

CISUR – Canadian Institute for Substance Use Research

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

DSM - Diagnostic and Statistical Manual of Mental Disorders

DXA - Dual-Energy X-ray Absorptiometry

ECG – Electrocardiogram

eGFR - Estimated Glomerular Filtration Rate

ES – Executive Summary

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)

FIT – Fecal Immunochemical Test

FOBT – Fecal Occult Blood Test

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

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

HR – Hazard Ratio

ICD – International Classification of Diseases

ID – Intellectual Disability

ICBP - International Cancer Benchmarking Partnership

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!

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

SCID – Severe Combined Immune Deficiency

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

SG – Standard Gamble

SIDS – Sudden Infant Death Syndrome

SUD – Substance Use Disorder

SVR – Sustained Virologic Response

TC – Total Cholesterol

TEOAE –Transient Evoked Otoacoustic Emissions

TG – Triglycerides

TREC – T-cell Receptor Excision Circles

TTO – Time Trade-Off

UK – United Kingdom

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

Clinical Prevention in Children and Youth

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).*[2]

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.[3] Based on this information, vision screening was included in the BC Lifetime Prevention Schedule.[4]

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[2] 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.

[3] 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.

[4] 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.

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).*[5]

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 current Canadian Task Force on Preventive Health Care. It may not reflect current evidence or current standards of practice."[6]

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).[7] 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.[8]

What is Amblyopia

Amblyopia is a "functional reduction in visual acuity characterized by abnormal processing of visual images by the brain".[9] 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

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[5] 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.

[6] 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.

[7] 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.

[8] 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.

[9] 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.

(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.[10]

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 39,824, Table 2, row *a*) would survive to age 5, based on data from the BC life tables for 2010 to 2012.
- 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.[11]
- 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.[12]
- 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.[13,14] We use the range of completed screens in our sensitivity analysis.

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[10] 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.

[11] 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.

[12] 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.

[13] 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.

[14] Keren Massey, Manager, Early Childhood Health, Public Health Services Branch, BC Ministry of Health. September 25, 2019. Personal communication.

- 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%.[15]
- 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 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.[16]

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.[17] 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*).[18]

[15] 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.
[16] 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.
[17] Campbell LR and Charney E. Factors associated with delay in diagnosis of childhood amblyopia. *Pediatrics*. 1991; 87(2): 178-85.
[18] Human Early Learning Partnership. Screening Research and Evaluation Unit. *BC Early Childhood*

- 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.[19]

- 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*).

- The reported incidence of recurrence in successfully treated cases of amblyopia varies substantially.[20,21] McConachie and Gottlieb suggest a range in recurrence rates of between 13 – 24% for two or more logMAR lines at one year.[22]

- 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 77.6 years (Table 2, row *q*), based on data from the BC life tables for 2010 to 2012.

- 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+[23] (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:[24]

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.

[19] Tailor V, Bossi M, Greenwood JA et al. Childhood amblyopia: current management and new trends. *British Medical Bulletin.* 2016; 119(1): 75-86.

[20] 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.

[21] Gunton KB. Advances in amblyopia: what have we learned from PEDIG trials? *Pediatrics*. 2013; 131(3): 540-7.

[22] Maconachie GD and Gottlob I. The challenges of amblyopia treatment. *Biomedical Journal*. 2015; 38(6): 510-6.

[23] 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.

[24] 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.

- 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)
- 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.[25]
- 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.[26] They assumed a reduction in QoL of 4.0% associated with living with amblyopia (yielding a cost per QALY of $14,323[27]) 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.[28] 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 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.

[25] Membreno JH, Brown MM, Brown GC et al. A cost-utility analysis of therapy for amblyopia. *Ophthalmology*. 2002; 109(12): 2265-71.
[26] 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.
[27] All costs in the following sections have been converted to 2017 Canadian dollars.
[28] 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.

- 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.[29] 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".

- 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.[30,31,32]

- 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[33] (3.5%) and van de Graaf et al[34] (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.[35] 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).[36]

- 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).[37] 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

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29 Carlton J and Kaltenthaler E. Amblyopia and quality of life: a systematic review. *Eye*. 2011; 25(4): 403.
30 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.
31 Bokhary K. Impact of amblyopia treatment on vision-related quality of life. *Optometry: Open Access*. 2016; 1(2):
32 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.
33 Membreno JH, Brown MM, Brown GC et al. A cost-utility analysis of therapy for amblyopia. *Ophthalmology*. 2002; 109(12): 2265-71.
34 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.
35 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.
36 Kulp MT, Cotter SA, Connor AJ et al. Should amblyopia be treated? *Ophthalmic and Physiological Optics*. 2014; 34(2): 226-32.
37 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.

is not considered to be clinically significant.[38,39,40] Indeed, the most recent evidence review for the USPSTF concluded that “studies directly evaluating the effectiveness of screening were limited and do not establish whether vision screening in preschool children is better than no screening.”[41]

- 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 2.3 QALYs (Table 2, row *w*).

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[38] Gibson R and Sanderson H. Observer variation in ophthalmology. *British Journal of Ophthalmology*. 1980; 64(6): 457-60.

[39] 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.

[40] 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.

[41] 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.

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	39,824	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	329	= 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	77.6	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**	**2.3**	= 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 = 12.9
- Assume the disutility associated with living with amblyopia is changed from 0.0 to 0.003: CPB = 34.1
- 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 3.2 (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 = 4.0

- 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 = 2.4
- 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 = 2.6
- Assume treatment compliance increases from 50% to 80% (Table 2, row j): CPB = 3.7
- 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 = 0.9
- Assume the incidence of permanent visual impairment or blindness is at the high end of the range (Table 2, rows r, s, t): CPB = 4.0
- Assume the disutility associated with permanent visual impairment or blindness is reduced from -0.187 to -0.124 (Table 2, row u): CPB = 0.5
- Assume the disutility associated with permanent visual impairment or blindness is increased from -0.187 to -0.260 (Table 2, row u): CPB = 4.4

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 $19.63 and $27.35 in 2017 CAD.[42] They 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 to screen approximately 43,771 kindergarten age children.[43] This represents a cost of $15.81 per screen (Table 3, row *d*).
- Visits to the optometrist cost $47.08 for a full eye exam (Table 3, row i).[44]

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[42] 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.
[43] Khalilah Alwani, Policy Analyst, Women's, Maternal and Early Childhood Health, Public Health Services Branch, BC Ministry of Health. February 24, 2021. Personal Communication.
[44] BC Doctors of Optometry. *MSP and Your Eye Health.* 2019. Available at https://bc.doctorsofoptometry.ca/patients/msp/. Accessed August 2019.

- 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.[45] The cost of an intervention is estimated at 1,015 (95% CI of 907 to 1,122) in 2006 British Pounds Sterling (£) or $2,168 (95% CI of $1,938 to $2,397) in 2017 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 $5,124,459 per QALY (Table 3, row *r*).

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	39,824	Table 1 row b
b	Screening rate	93%	Table 1, row d
c	# of screens	37,076	= a * b
	Costs of screening		
d	Screening cost per child in BC	$15.81	√
e	Cost of screening over lifetime of birth cohort	$586,174	= 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	329	= f * g
i	Cost of full eye exam	$47.08	√
j	Value of patient time and travel for office visit	$59.38	Ref Doc
k	Costs of follow-up visits to Optometrist	$35,073	= h * (i + j)
	Costs of interventions		
l	Estimated intervention cost	$2,168	√
m	# of interventions	165	Table 1, row m
n	Total cost over lifetime of birth cohort	$357,187	= l * m
	CE calculation		
o	Lifetime cost of screening and interventions	$978,433	= e + k + n
p	QALYs saved (0% discount rate)	2.3	Table 1, row y
q	QALYs saved (1.5% discount rate)	0.2	Calculated
r	**CE ($/QALY saved)**	**$5,124,459**	= 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 = $310,030

[45] 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.

- Assume the disutility associated with living with amblyopia is changed from 0.0 to 0.001: CE = $151,445
- Assume the disutility associated with living with amblyopia is changed from 0.0 to 0.003: CE = $51,496
- Assume the disutility associated with living with amblyopia is changed from 0.0 to 0.007: CE = $22,197
- Threshold disutility for living with amblyopia required to produce a CE of $50,000 / QALY: 0.0031
- Threshold disutility for living with amblyopia required to produce a CE of $25,000 / QALY: 0.0062
- 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 = $20,798

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 $5.1 million to $0.15 million. If the disutility is changed to 0.62%, 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 = $12,799,545
- Assume the prevalence of amblyopia is increased from 3.5% to 6.0% (Table 2, row b): CE = $3,845,278
- Assume joint testing sensitivity decreases from 69.5% to 60%. (Table 2, row e): CE = $5,610,548
- Assume joint testing sensitivity increases from 69.5% to 78%. (Table 2, row e): CE = $4,789,904
- Assume treatment compliance increases from 50% to 80% (Table 2, row j): CE = $3,904,313
- Assume the recurrence of amblyopia decreases from 18.5% to 13.0% (Table 2, row l): CE = $2,422,398
- Assume the recurrence of amblyopia increases from 18.5% to 24.0% (Table 2, row l): CE = n/a (intervention is <u>harmful</u> [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 <u>harmful</u> [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 = $733,572
- 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 <u>harmful</u> [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 = $687,619
- Assume the cost per intervention is reduced from $2,168 to $1,938 (Table 3, row l): CE = $4,925,408

- Assume the cost per intervention is increased from $2,168 to $2,397 (Table 3, row l): CE = $5,321,666

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 2.3 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated at $5,124,459 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
3% Discount Rate	-0.8	-1.6	28
0% Discount Rate	2.3	0.5	76
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$5,124,459**	$22,197	$12,799,545
3% Discount Rate	-*	$34,628	-*
0% Discount Rate	$419,106	$12,812	$1,046,816
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$5,022,003	$21,754	$12,697,089
3% Discount Rate	-*	$33,936	-*
0% Discount Rate	$410,727	$12,555	$1,038,437

* 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."[46] 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" [47] 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 $5.1 million. However, adding just a 0.1% disutility changes the cost / QALY from $5.1 million to $0.15 million. If the disutility is changed to 0.7%, the cost / QALY would be $22,197.

[46] 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.
[47] 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.

Screening for Major Depressive Disorder in Youth

United States Preventive Services Task Force Recommendations[48]

> *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.[49]

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."[50] For adolescents with risk factors for MDD, "repeated screening may be most productive."[51]
- 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.[52] 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.[53]

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[48] 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.
[49] Joffres M, Jaramillo A, Dickinson J et al. Recommendations on screening for depression in adults. *Canadian Medical Association Journal*. 2013; 185(9): 775-82.
[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] 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.
[52] 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.
[53] 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[54] 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

[54] 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 7.4% (10.6%[55] times 70.0%) and that screening for this 7.4% of adolescents (Table 6, row *ah*) is completed at each well-care visit, or 2.07 times per year (Table 6, row *ag)*,[56] 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 6.9% (10.6%[57] times 65.4%) and that screening for this 6.9% of male adolescents (Table 6a, row *ah*) is completed at each well-care visit, or 1.75 times per year (Table 6a, row *ag)*,[58] 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 8.0% (10.6%[59] times 75.0%) and that screening for this 8.0% of female adolescents (Table 6b, row *ah*) is completed at each well-care visit, or 2.42 times per year (Table 6b, row *ag)*,[60] 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%).[61]
- 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.[62]
- 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.[63]
- Vasiliadis and colleagues found that there was no significant difference between Canadian and US rates of depression and subsequent use of mental health services.[64]
- 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

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[55] Lewandowski RE, O'Connor B, Bertagnolli A et al. Screening for and diagnosis of depression among adolescents in a large health maintenance organization. *Psychiatric Services*. 2016; 67(6): 636-41.
[56] 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.
[57] Lewandowski RE, O'Connor B, Bertagnolli A et al. Screening for and diagnosis of depression among adolescents in a large health maintenance organization. *Psychiatric Services*. 2016; 67(6): 636-41.
[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] Lewandowski RE, O'Connor B, Bertagnolli A et al. Screening for and diagnosis of depression among adolescents in a large health maintenance organization. *Psychiatric Services*. 2016; 67(6): 636-41.
[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] 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.
[62] 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.
[63] 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.
[64] 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[65] (containing data for 2014 and 2015) and 2017[66] (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.[67]

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[65] 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.

[66] 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.

[67] 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.[68]
- 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.[69]
- Suicide mortality among youth ages 15 – 19 in BC between 2011 and 2013 is 4.7 / 100,000 population.[70]
- The ratio of attempted suicides to completed suicides among adolescents is estimated to be 50:1 to 100:1.[71]
- 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.[72]

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[68] Kann L, McManus T, Harris WA et al. Youth risk behavior surveillance—United States, 2017. *MMWR Surveillance Summaries*. 2018; 67(8): 1.
[69] 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.
[70] 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.
[71] Shain BN. Suicide and suicide attempts in adolescents. *Pediatrics*. 2007; 120(3): 669-76.
[72] 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).[73]

- Based on the evidence from Rohde et al [74] and Johnson et al[75] noted above, we have assumed that the effect of adolescent depression on suicide would continue until age 34.

- Based on data from the 2013[76], 2014[77] and 2015[78] 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.

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73 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.
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.
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 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.
77 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.
78 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 males, 45 of the 267 (17.0%) deaths between the ages of 12 and 34 are due to ISH, resulting in 2,159 life-years lost due to ISH (see Table 4). In the birth cohort of 20,000 females, 17 of 131 (13.2%) deaths between the ages of 12 and 34 are due to ISH, resulting in 1,030 life-years lost due to ISH (see Table 5).

Table 4: Deaths and Life Years Lost Attributable to Intentional Self-Harm (ISH)
in a British Columbia Male 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	19,898					
12	19,896	2	11.8%	0.2	68.6	13
13	19,894	2	11.8%	0.3	67.6	17
14	19,892	3	11.8%	0.3	66.6	20
15	19,888	3	24.3%	0.8	65.7	54
16	19,884	4	24.3%	1.0	64.7	66
17	19,878	6	24.3%	1.4	63.7	87
18	19,871	7	24.3%	1.8	62.7	110
19	19,862	9	24.3%	2.2	61.7	138
20	19,850	12	18.3%	2.1	60.8	129
21	19,837	14	18.3%	2.5	59.8	149
22	19,821	16	18.3%	2.9	58.9	168
23	19,805	17	18.3%	3.0	57.9	176
24	19,788	17	18.3%	3.1	57.0	175
25	19,772	16	15.2%	2.5	56.0	138
26	19,756	15	15.2%	2.3	55.1	127
27	19,742	15	15.2%	2.2	54.1	120
28	19,727	15	15.2%	2.2	53.1	118
29	19,713	14	15.2%	2.2	52.2	114
30	19,698	15	15.2%	2.2	51.2	115
31	19,683	15	15.2%	2.3	50.2	117
32	19,666	16	15.2%	2.5	49.3	121
33	19,649	17	15.2%	2.6	48.3	125
34	19,631	18	15.2%	2.7	47.4	129
Total		**267**	**17.0%**	**45**		**2,159**

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	19,912					
12	19,911	1	0.0%	0.0	72.6	0
13	19,910	1	0.0%	0.0	71.6	0
14	19,909	1	0.0%	0.0	70.6	0
15	19,907	2	15.5%	0.3	69.6	22
16	19,904	3	15.5%	0.4	68.6	30
17	19,900	4	15.5%	0.7	67.6	46
18	19,894	6	15.5%	0.9	66.6	62
19	19,887	6	15.5%	1.0	65.7	65
20	19,881	6	24.4%	1.6	64.7	101
21	19,874	7	24.4%	1.6	63.7	103
22	19,868	7	24.4%	1.6	62.7	101
23	19,861	6	24.4%	1.6	61.7	97
24	19,855	7	24.4%	1.6	60.8	98
25	19,848	6	24.4%	1.6	59.8	94
26	19,842	6	10.1%	0.6	58.8	37
27	19,836	6	10.1%	0.6	57.8	37
28	19,829	7	10.1%	0.7	56.8	38
29	19,822	7	10.1%	0.7	55.9	38
30	19,815	7	10.1%	0.7	54.9	39
31	19,808	8	10.1%	0.8	53.9	41
32	19,799	8	10.1%	0.8	52.9	45
33	19,791	9	10.1%	0.9	51.9	46
34	19,781	10	10.1%	1.0	51.0	50
Total		**131**	**15.0%**	**20**		**1,030**

- 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.[79,80] 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."[81] 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

[79] 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.
[80] 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.
[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.

antidepressant maintenance therapy = 0.72 to 0.83.[82] Whiteford and colleagues[83] 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.[84,85,86]

- 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.[87]

- 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%.[88] 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.

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[82] 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.
[83] 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.
[84] 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.
[85] 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.
[86] 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.
[87] 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.
[88] 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%.[89]
- 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.[90]

- 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.[91]
- 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.[92]
- 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.[93] 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.[94]
- 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%

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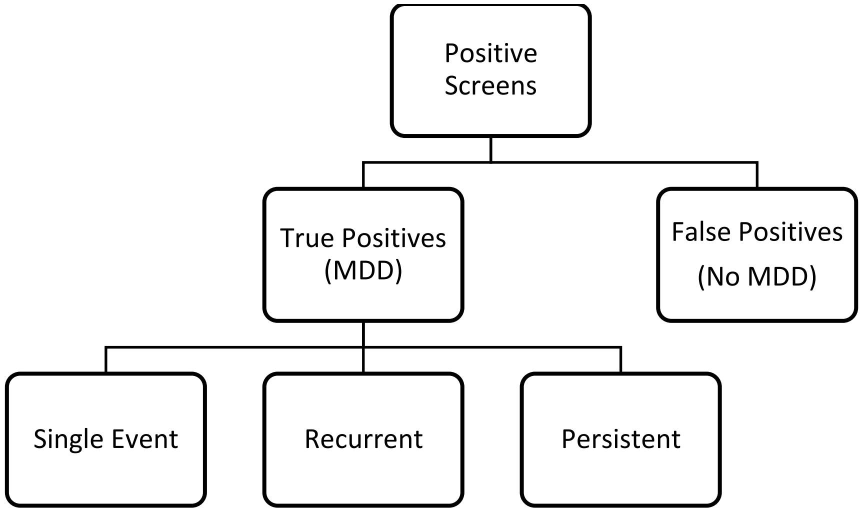
[89] Canals J, Blade J, Carbajo G et al. The Beck Depression Inventory: Psychometric characteristics and usefulness in nonclinical adolescents. *European Journal of Psychological Assessment*. 2001; 17(1): 63.
[90] Roberts RE, Lewinsohn PM and Seeley JR. Screening for adolescent depression: A comparison of depression scales. *Journal of the American Academy of Child & Adolescent Psychiatry*. 1991; 30(1): 58-66.
[91] 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.
[92] 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.
[93] 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:
[94] 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.[95] 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.[96]

- 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."[97] 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).[98]
- 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.[99]
- 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.[100]
- 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:

[95] 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.
[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.
[97] 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.
[98] 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.
[99] Aciemme (Sam) Ospan, Senior Manager, Lifetime Prevention Schedule, Healthy Living and Health Promotion Branch, BC Ministry of Health. April 18, 2019. Personal communication.
[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.



- 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%[101] and 79%[102]) 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%[103] and 75.2%[104]) and vary this from 21.8% to 65.2% in our sensitivity analysis (Table 6a, rows *be, bu & co*).

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[101] 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.
[102] 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:
[103] 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.
[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:

- 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%[105] and 80.7%[106]) 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 6, 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 6, row *cj*)

- Cognitive behavioural therapy (CBT) is considered to be a "well-established intervention" for depression in adolescents.[107]
- 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 *au*) of adolescents receiving this therapy compared to a placebo.[108]

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[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:
[107] 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.
[108] 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."[109]
- 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.[110]
- 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.
- 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%) (Table 6, row *av*).
- The Canadian Network for Mood and Anxiety Treatments (CANMAT) 2016 Clinical Guidelines recommend two treatment phases for depression:[111]
    - 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.[112] On average, half of individuals experiencing at least one MDE during their lifetime will experience between 5-9 recurrent episodes during their lifetime.[113,114,115]
- 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.[116]

- 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*).

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109 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.
110 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.
111 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.
112 Burcusa SL and Iacono WG. Risk for recurrence in depression. *Clinical Psychology Review*. 2007; 27(8): 959-85.
113 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.
114 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.
115 Colman I, Naicker K, Zeng Y et al. Predictors of long-term prognosis of depression. *Canadian Medical Association Journal*. 2011; 183(17): 1969-76.
116 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 6, 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 6, 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 6, 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 6, 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.[117,118] 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. [119] On average, anti-depressants are taken on 226 days each year.[120]
- The average length of an adolescent depressive episode has been reported to range between 24.4 and 27 weeks.[121,122]
- 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.[123]

- 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.

117 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.
118 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.
119 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.
120 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.
121 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.
122 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.
123 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.[124,125] 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 6a 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).

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[124] 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.

[125] 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><th colspan="2" rowspan="2"></th><th colspan="3">True Positive Screens</th><th rowspan="2">False Positive Screens</th></tr>
<tr><th>Single Event</th><th>Recurrent</th><th>Persistent</th></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).[126] 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 *bg*).

[126] 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 222 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	39,804	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	37,735	= a - c
e	Number of life years, 13 year olds	39,801	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	36,100	= e - g
i	Number of life years, 14 year olds	39,797	BC Life Table
j	Annual rate of MDD, 14 year olds	11.7%	√
k	Life years with MDD, 14 year olds	4,656	= i * j
l	Life years without MDD, 14 year olds	35,141	= i - k
m	Number of life years, 15 year olds	39,792	BC Life Table
n	Annual rate of MDD, 15 year olds	15.0%	√
o	Life years with MDD, 15 year olds	5,969	= m * n
p	Life years without MDD, 15 year olds	33,823	= m - o
q	Number of life years, 16 year olds	39,784	BC Life Table
r	Annual rate of MDD, 16 year olds	16.0%	√
s	Life years with MDD, 16 year olds	6,365	= q * r
t	Life years without MDD, 16 year olds	33,419	= q - s
u	Number of life years, 17 and 18 year olds	79,534	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	13,123	= u * v
x	Life years without MDD, 17 and 18 year olds	66,411	= u - w
y	**Life years with MDD between 12 and 18**	**35,885**	= c + g + k + o + s + w
z	QoL decrement due to depression	0.31	√
aa	QALYs lost during adolescence due to depression	11,124	= y * z
ab	Deaths attributable to ISH between the ages of 12 and 34	65	Tables 4 & 5
ac	QALYS lost due to deaths attributable to ISH between the ages of 12 and 34	3,189	Tables 4 & 5
ad	**Total QALYs lost due to depression in adolescence**	**14,313**	= aa + ac
ae	% MDD undetected in lifetime	25.0%	√
af	Life years with undetected MDD in cohort between 12 - 18 years of age	8,971	= y * ae
ag	Number of well care visits per year	2.07	√
ah	Depression screening rate	7.4%	√
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	1,003	= af * ag * ah * ai
al	Number of MDD cases diagnosed incorrectly, initial test	2,230	= (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	2,230	= al * (1 - an)
ap	Rate of anti-depressants, months 0 - 3	19.7%	√
aq	Number taking anti-depressants months 0 - 3	439	= ao * ap
ar	Rate of anti-depressants, months 4 - 6	22.2%	√
as	Number taking anti-depressants months 4 - 6	495	= ao * ar
at	Life years on anti-depressants	234	= (aq * 0.25) + (as * 0.25)
au	QoL decrement due to anti-depressant therapy	0.08	√
av	**QALYs Gained (or Lost), Incorrectly Diagnosed MDD**	**-18.7**	= - (at * au)

Table 6: 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	1,003	= ak * am
ax	Rate of single event MDD in correct diagnoses	50.0%	√
ay	Number of single event MDD cases	502	= aw * ax
az	Rate of 6-month anti-depressant use	22.2%	√
ba	Number on anti-depressants	111	= 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**	**14.3**	= 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	128	= 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**	**3.9**	= bh * bi * bj
	Recurrent MDD		
bl	Number of MDD cases correctly identified, overall	1,003	= ak * am
bm	Rate of recurrent MDD in correct diagnoses	44.7%	√
bn	Number of recurrent MDD cases	448	= bl * bm
bo	Rate of 12-month anti-depressant use	22.2%	√
bp	Number on anti-depressants	99	= 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**	**205**	= 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	115	= 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**	**83**	= bx * by * bz *bs
	Persistent MDD		
cb	Number of MDD cases correctly identified, overall	1,003	= ak * am
cc	Rate of persistent MDD in correct diagnoses	5.3%	√
cd	Number of persistent MDD cases	53	= cb * cc
ce	Rate of first year anti-depressant use	22.2%	√
cf	Number on anti-depressants	12	= 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**	**3.0**	= cf * cg * ch
cj	Rate of anti-depressant use years 2 - 20	100.0%	√
ck	Number on anti-depressants	53	= 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**	**261**	= 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	14	= 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**	**33**	= cr * cs * ct
	Summary of QALYs Gained with Screening		
cv	Individuals with MDD helped by treatment	88	= aw * ((az * bb) + (bg * bi))
cw	Depression free life years due to screening, correctly diagnosed MDD	603	= (bd + bk) + (bt + ca) + (ci + cn + cu)
cx	Reduction in % of total life years with MDD due to screening	1.68%	= cw / y
cy	QALYs gained due to screening, correctly diagnosed MDD	241	= cx * ad
cz	QALYs due to treating incorrectly diagnosed MDD	-19	= av
da	**Net QALYs as a result of screening (CPB)**	**222**	= 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 = 126
- Assume the rate of undetected MDD increases from 25% to 35% (Table 6, row *ae*): CPB = 318
- 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 = 206
- Assume the rate of treatment seeking increases from 50.5% to 69% (Table 6, row *aq*): CPB = 239
- Assume the rate of treatment seeking decreases from 50.5% to 32% (Table 6, row *aq*): CPB = 204
- 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*): CPB = 144
- 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 *bg*): CPB = 264
- Assume that the screening rate is only applied to one visit per year per patient, rather than 2.07 (Table 6, row *ag*): CPB = 107

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 83 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	19,896	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	18,862	= a - c
e	Number of life years, 13 year olds	19,894	BC Life Table
f	Annual rate of MDD, 13 year olds	9.3%	√
g	Life years with MDD, 13 year olds	1,850	= e * f
h	Life years without MDD, 13 year olds	18,044	= e - g
i	Number of life years, 14 year olds	19,892	BC Life Table
j	Annual rate of MDD, 14 year olds	11.7%	√
k	Life years with MDD, 14 year olds	2,327	= i * j
l	Life years without MDD, 14 year olds	17,564	= i - k
m	Number of life years, 15 year olds	19,888	BC Life Table
n	Annual rate of MDD, 15 year olds	15.0%	√
o	Life years with MDD, 15 year olds	2,983	= m * n
p	Life years without MDD, 15 year olds	16,905	= m - o
q	Number of life years, 16 year olds	19,884	BC Life Table
r	Annual rate of MDD, 16 year olds	16.0%	√
s	Life years with MDD, 16 year olds	3,181	= q * r
t	Life years without MDD, 16 year olds	16,703	= q - s
u	Number of life years, 17 and 18 year olds	39,750	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	6,559	= u * v
x	Life years without MDD, 17 and 18 year olds	33,191	= u - w
y	**Life years with MDD between 12 and 18**	**17,935**	= c + g + k + o + s + w
z	QoL decrement due to depression	0.31	√
aa	QALYs lost during adolescence due to depression	5,560	= y * z
ab	Deaths attributable to ISH between the ages of 12 and 34	45	Table 4
ac	QALYS lost due to deaths attributable to ISH between the ages of 12 and 34	2,159	Table 4
ad	**Total QALYs lost due to depression in adolescence**	**7,719**	= aa + ac
ae	% MDD undetected in lifetime	25.0%	√
af	Life years with undetected MDD in cohort between 12 - 18 years of age	4,484	= y * ae
ag	Number of well care visits per year	1.75	√
ah	Depression screening rate	6.9%	√
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	395	= af * ag * ah * ai
al	Number of MDD cases diagnosed incorrectly, initial test	879	= (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	879	= al * (1 - an)
ap	Rate of anti-depressants, months 0 - 3	17.5%	√
aq	Number taking anti-depressants months 0 - 3	154	= ao * ap
ar	Rate of anti-depressants, months 4 - 6	19.5%	√
as	Number taking anti-depressants months 4 - 6	171	= ao * ar
at	Life years on anti-depressants	81	= (aq * 0.25) + (as * 0.25)
au	QoL decrement due to antidepressant therapy	0.08	√
av	**QALYs Gained (or Lost), Incorrectly Diagnosed MDD**	**-6.5**	= - (at * au)

Table 6a: 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	395	= ak * am
ax	Rate of single event MDD in correct diagnoses	50.0%	√
ay	Number of single event MDD cases	198	= aw * ax
az	Rate of 6-month anti-depressant use	19.5%	√
ba	Number on anti-depressants	39	= 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**	**5.0**	= 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	44	= 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**	**1.3**	= bh * bi * bj
	Recurrent MDD		
bl	Number of MDD cases correctly identified, overall	395	= ak * am
bm	Rate of recurrent MDD in correct diagnoses	45.3%	√
bn	Number of recurrent MDD cases	179	= bl * bm
bo	Rate of 12-month anti-depressant use	19.5%	√
bp	Number on anti-depressants	35	= 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**	**72**	= 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	39	= 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**	**29**	= bx * by * bz *bs
	Persistent MDD		
cb	Number of MDD cases correctly identified, overall	395	= ak * am
cc	Rate of persistent MDD in correct diagnoses	4.7%	√
cd	Number of persistent MDD cases	19	= cb * cc
ce	Rate of first year anti-depressant use	19.5%	√
cf	Number on anti-depressants	4	= 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**	**0.9**	= cf * cg * ch
cj	Rate of anti-depressant use years 2 - 20	100.0%	√
ck	Number on anti-depressants	19	= 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**	**91**	= 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	4	= 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**	**10**	= cr * cs * ct
	Summary of QALYs Gained with Screening		
cv	Individuals with MDD helped by treatment	30	= aw * ((az * bb) + (bg * bi))
cw	Depression free life years due to screening, correctly diagnosed MDD	208	= (bd + bk) + (bt + ca) + (ci + cn + cu)
cx	Reduction in % of total life years with MDD due to screening	1.16%	= cw / y
cy	QALYs gained due to screening, correctly diagnosed MDD	90	= cx * ad
cz	QALYs due to treating incorrectly diagnosed MDD	-7	= av
da	**Net QALYs as a result of screening (CPB)**	**83**	= 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 = 47
- Assume the rate of undetected MDD increases from 25% to 35% (Table 6a, row *ae*): CPB = 119
- 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 = 77
- Assume the rate of treatment seeking increases from 43.5% to 65.2% (Table 6a, row *aq*): CPB = 92
- Assume the rate of treatment seeking decreases from 43.5% to 21.8% (Table 6a, row *aq*): CPB = 75
- 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*): CPB = 56
- 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 *bg*): CPB = 98
- Assume that the screening rate is only applied to one visit per year per patient, rather than 1.75 (Table 6a, row *ag*): CPB = 48

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 135 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	19,911	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	18,876	= a - c
e	Number of life years, 13 year olds	19,910	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	18,059	= e - g
i	Number of life years, 14 year olds	19,909	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	16,720	= 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	5,565	= y * z
ab	Deaths attributable to ISH between the ages of 12 and 34	20	Table 5
ac	QALYS lost due to deaths attributable to ISH between the ages of 12 and 34	1,030	Table 5
ad	**Total QALYs lost due to depression in adolescence**	**6,596**	= 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	8.0%	√
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	630	= af * ag * ah * ai
al	Number of MDD cases diagnosed incorrectly, initial test	1,401	= (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	1,401	= al * (1 - an)
ap	Rate of anti-depressants, months 0 - 3	20.9%	√
aq	Number taking anti-depressants months 0 - 3	293	= ao * ap
ar	Rate of anti-depressants, months 4 - 6	23.6%	√
as	Number taking anti-depressants months 4 - 6	331	= ao * ar
at	Life years on anti-depressants	156	= (aq * 0.25) + (as * 0.25)
au	QoL decrement due to antidepressant therapy	0.08	√
av	**QALYs Gained (or Lost), Incorrectly Diagnosed MDD**	**-12.5**	= - (at * au)

Table 6b: 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	630	= ak * am
ax	Rate of single event MDD in correct diagnoses	50.0%	√
ay	Number of single event MDD cases	315	= aw * ax
az	Rate of 6-month anti-depressant use	23.6%	√
ba	Number on anti-depressants	74	= 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**	**9.6**	= 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	83	= 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**	**2.5**	= bh * bi * bj
	Recurrent MDD		
bl	Number of MDD cases correctly identified, overall	630	= ak * am
bm	Rate of recurrent MDD in correct diagnoses	44.3%	√
bn	Number of recurrent MDD cases	279	= bl * bm
bo	Rate of 12-month anti-depressant use	23.6%	√
bp	Number on anti-depressants	66	= 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**	**135**	= 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	74	= 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**	**53**	= bx * by * bz *bs
	Persistent MDD		
cb	Number of MDD cases correctly identified, overall	630	= ak * am
cc	Rate of persistent MDD in correct diagnoses	5.7%	√
cd	Number of persistent MDD cases	36	= cb * cc
ce	Rate of first year anti-depressant use	23.6%	√
cf	Number on anti-depressants	8	= 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**	**2.2**	= cf * cg * ch
cj	Rate of anti-depressant use years 2 - 20	100.0%	√
ck	Number on anti-depressants	36	= 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**	**175**	= 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	9	= 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**	**23**	= cr * cs * ct
	Summary of QALYs Gained with Screening		
cv	Individuals with MDD helped by treatment	58	= aw * ((az * bb) + (bg * bi))
cw	Depression free life years due to screening, correctly diagnosed MDD	402	= (bd + bk) + (bt + ca) + (ci + cn + cu)
cx	Reduction in % of total life years with MDD due to screening	2.24%	= cw / y
cy	QALYs gained due to screening, correctly diagnosed MDD	148	= cx * ad
cz	QALYs due to treating incorrectly diagnosed MDD	-12	= av
da	**Net QALYs as a result of screening (CPB)**	**135**	= 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 = 76
- Assume the rate of undetected MDD increases from 25% to 35% (Table 6b, row *ae*): CPB = 194
- 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 = 126
- Assume the rate of treatment seeking increases from 52.0% to 70.7% (Table 6b, row *aq*): CPB = 145
- Assume the rate of treatment seeking decreases from 52.0% to 33.3% (Table 6b, row *aq*): CPB = 125
- 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*): CPB = 83
- 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 *bg*): CPB = 163
- Assume that the screening rate is only applied to one visit per year per patient, rather than 2.42 (Table 6b, row *ag*): CPB = 56

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)*,[127] 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 $34.85 (see Reference Document) (Table 7, row *e)*.
- The value of patient time for each visit to a primary care office is $59.38 (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[128] 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 $4.40 per use (Table 7, row *n*).[129]
- 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*), with half of the therapy group in individual sessions and half in group sessions.

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[127] 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.
[128] 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.
[129] Pearson Clinical Assessment Canada. *Beck Depression Inventory®—II*. 2018. Available at https://www.pearsonclinical.ca/en/products/product-master/item-139.html. Accessed January 2019.

- 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="6">Treatment Modeling for Positive MDD Screens</th></tr>
<tr><th colspan="2" rowspan="2"></th><th colspan="3">True Positive Screens</th><th rowspan="2">False Positive Screens</th></tr>
<tr><th>Single Event</th><th>Recurrent</th><th>Persistent</th></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>

- 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.[130,131] (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*).[132]
- 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 VI clinical social worker, Level 16 with 6 years of experience. We assume 25% benefits and 40% non-worked hours and a wage rate of $48.65 / hr[133] for a total cost per *worked* hour of $80.27 ($48.65 + ($48.65 * 0.25) + ($48.65 * 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 $240.82 (3 hours * $80.27) 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.[134]

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130 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.
131 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.
132 Dr. Kelly Price, Senior Psychologist, Child and Youth Mental Health Branch, B.C. Ministry of Children and Families. January 8, 2019. Personal communication.
133 Health Employers Association of BC. *Provincial Agreement between the Health Science Professionals Bargaining Association and Health Employers Association of BC April 1, 2012 – March 31, 2019.* Available at http://www.heabc.bc.ca/public/CAs/HSP/HSP2012-2019_FINAL_3.pdf. Accessed January 2019.
134 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.[135] We model daily treatment with 20mg fluoxetine (or generic equivalent). The cost ranges between $0.35 – 0.88 per 20mg pill for the "BC, Canada" and "Vancouver, BC" geographies. The dispensing fee ranges from $10 – 13.99.[136] 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 $368.48 (($0.615 * 365) + (12 * $12.00)) (Table 7, row *aj*). Using the high and low numbers of the ranges above, we use a high of $489 and low of $248 / year in our sensitivity analysis.
- Clayton and Barcelo estimated the direct costs associated with a completed suicide in the province of New Brunswick to be $5,693 (in 1996 CAD) or $8,129 in 2017 CAD, including ambulance, hospital, physician, autopsy, and funeral services plus the cost of police investigations.[137]
- Kinchin and Doran estimated the direct costs per youth suicide in Australia to be $9,721 (in 2014 AUD) or $8,336 in 2017 CAD.[138]
- 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.[139]
- For modelling purposes, we have assumed the direct costs per completed suicide in BC to be $8,233 ($8,129 + $8,336 / 2) (Table 7, row *db*) and the direct cost per suicide attempt to be $9,056 ($8,233 * 1.1) (Table 7, row *dc*).
- The ratio of attempted suicides to completed suicides among adolescents is estimated to be 50:1 to 100:1.[140] One-third (33%) of suicide attempts in adolescents require medical attention.[141] For modelling purposes, we assumed that there would be 25 attempted suicides requiring medical attention per completed 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.[142] 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 $5,251 (2017) CAD (Table 7, row *di*).

[135] Pacific Blue Cross. *Pharmacy Compass*. 2018. Available at https://www.pac.bluecross.ca/pharmacycompass. Accessed January 2019.
[136] Pacific Blue Cross. *Pharmacy Compass*. 2018. Available at https://www.pac.bluecross.ca/pharmacycompass. Accessed January 2019.
[137] Clayton D and Barcel A. The cost of suicide mortality in New Brunswick, 1996. *Chronic Diseases in Canada.* 1999; 20(2): 89-95.
[138] Kinchin I and Doran CM. The cost of youth suicide in Australia. *International Journal of Environmental Research and Public Health.* 2018; 15(4): 672-82.
[139] Shepard DS, Gurewich D, Lwin AK et al. Suicide and suicidal attempts in the United States: costs and policy implications. *Suicide and Life-Threatening Behavior*. 2016; 46(3): 352-62.
[140] Shain BN. Suicide and suicide attempts in adolescents. *Pediatrics.* 2007; 120(3): 669-76.
[141] Kann L, McManus T, Harris WA et al. Youth risk behavior surveillance—United States, 2017. *MMWR Surveillance Summaries*. 2018; 67(8): 1.
[142] Wright DR, Katon WJ, Ludman E et al. Association of adolescent depressive symptoms with health care utilization and payer-incurred expenditures. *Academic Pediatrics.* 2016; 16(1): 82-9.

CE for Both Sexes

Based on these assumptions, the CE associated with screening for major depressive disorder in adolescents ages 12 to 18 is $28,215 / 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	278,512	Table 6, rows a + e + l + m + q + u
b	Number of well care visits per year	2.07	√
c	Depression screening rate	7.4%	√
d	Number of screens conducted, cohort total	42,662	= a * b * c
e	Cost of 10 minute office visit	$34.85	Ref Doc
f	Value of patient time and travel for office visit	$59.38	Ref Doc
g	Portion of 10-minute visit for screening	50%	Ref Doc
h	Initial screening cost	$2,010,042	= d * (e + f) * g
i	Number of MDD cases correctly identified, initial test	1,003	Table 6, row ak
j	Number of MDD cases diagnosed incorrectly, initial test	2,230	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	$4.40	√
n	Cost of second screening	$0	= l * (((e + f) * g) + m)
o	Number of MDD cases correctly identified, overall	1,003	Table 6, row ao
p	Number of MDD cases diagnosed incorrectly, overall	2,230	Table 6, row ap
q	Total number of MDD cases diagnosed	3,233	= o + p
r	Follow up visits, each diagnosed depression	1	Assumed
s	Follow up visit cost	$304,656	= 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	637	= q * t
v	Cost of medication, per year	$368	√
w	Cost of medication, 0 - 3 months	$58,673	= 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	718	= q * x
z	Cost of medication, per year	$368	√
aa	Cost of medication, 4 - 6 months	$66,118	= y * z * 0.25
ab	Follow up visits for medication review, per patient	1	√
ac	Cost of medication follow-up	$67,634	= y * ab * (e + f)
ad	Counselling rate	25.6%	Table 6
ae	Number receiving counselling	828	= q * ad
af	Rate of individual counselling	50.0%	√
ag	Number receiving individual counselling	414	= ae * af
ah	Number of CBT sessions	12	√
ai	Cost of clinical social worker per session	$240.82	√
aj	Cost of offering individual CBT (social worker)	$1,196,090	= ag * ah * ai
ak	Session length, in hours	1.5	√
al	Travel time, in hours	1.0	√
am	Patient time, cost per hour	$29.69	Ref Doc
an	Patient time cost, individual CBT treatment sessions	$368,656	= ag * ah * (ak + al) * am
ao	Rate of group counselling	50.0%	√
ap	Number receiving individual counselling	414	= ae * ao
aq	Number of CBT sessions	12	√
ar	Number of individuals in each session	10	√
as	Cost of offering group CBT (social worker)	$119,609	= (ap / ar) * aq * ai
at	Session length, in hours	1.5	√
au	Travel time, in hours	1.0	√
av	Patient time cost per hour	$29.69	Ref Doc
aw	Patient time cost, group CBT treatment sessions	$368,656	= 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	111	= o * ax * ay
ba	Cost of medication, per year	$368	√
bb	Cost of medication, 7 - 12 months	$20,515	= az * ba * 0.5
bc	Counselling costs	$0	Included in 4 - 6 month counselling costs

Table 7: 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	53	= o * be * bf
bh	Cost of medication, per year	$368	√
bi	Additional years of medication	19	√
bj	Cost of medication, 2 - 20 years	$374,198	= 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	$240.82	√
bn	Cost of offering individual CBT (social worker), years 2 - 20	$250,464	= 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	$29.69	Ref Doc
br	Patient time cost, first CBT treatment sessions	$301,512	= 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	$191,387	= 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	448	= 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	99	= bv * by
ca	Cost of medication, per year	$368	√
cb	Cost of medication, recurrent MDD	$256,608	= bz * ca * bw * bx
cc	Counselling rate, for recurrent MDD	25.6%	√
cd	Number individuals in therapy, per recurrent MDD event	115	= bv * cc
ce	Rate of individual counselling	50.0%	√
cf	Number receiving individual counselling	57	= cd * ce
cg	Number of CBT sessions	5	√
ch	Cost of clinical social worker per session	$240.82	√
ci	Cost of offering individual CBT (social worker)	$483,550	= cf * cg * ch * bw
cj	Session length, in hours	1.5	√
ck	Travel time, in hours	1.0	√
cl	Patient time cost per hour	$29.69	Ref Doc
cm	Patient time cost, individual CBT sessions, recurrent MDD	$149,039	= cf * cg * (cj + ck) * cl * bw
cn	Rate of group counselling	50.0%	√
co	Number receiving group counselling	57	= cd * cn
cp	Number of CBT sessions	5	√
cq	Number of individuals in each session	10	√
cr	Cost of offering group CBT (social worker)	$48,355	= (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	$29.69	Ref Doc
cv	Patient time cost, group CBT, recurrent MDD	$149,039	= co * cp * (cs + ct) * cu * bw
cw	Sub-total, Screening & Screening Follow-up Cost	$2,314,698	= h + n + s
cx	Sub-total, Medication and Medication Follow-up Cost	$1,035,133	= w + aa + ac + bb + bj + bt + cb
cy	Sub-total, Individual Counselling Cost	$2,749,310	= aj + an + bn + br + ci + cm
cz	Sub-total, Group Counselling Cost	$685,659	= as + aw + cr + cv
da	**Total Cost of Intervention**	**$6,784,800**	= cw + cx + cy + cz
	Potential Costs Avoided		
db	Direct costs per completed suicide	$8,233	√
dc	Direct cost per attempted suicide	$9,056	√
dd	Completed suicides avoided due to screening	1.09	Table 6, row ab * Table 6, row cx
de	Costs avoided due to suicides avoided	$8,988	= db * dd
df	Attempted suicides requiring medical attention per completed suicide	25	√
dg	Costs avoided due to suicide attempts avoided	$247,171	= dc * dd * df
dh	Number of people for whom treatment is effective	88.3	Table 6, row cv
di	Health care cost avoided in first 12 months after screening due to effective treatment	$5,251	√
dj	Health care cost avoided, total	$463,735	= dh * di
dk	**Net Costs of Intervention**	**$6,064,907**	= da - de - dg - dj
dl	Net QALYs Gained	221.9	Table 6, row da
dm	Cost Effectiveness (CE) of Intervention, $/QALY	$27,331	= dk / dl
dn	Net Cost of Intervention (1.5% Discount)	$5,375,723	Calculated
do	Net QALYs Gained (1.5% Discount)	190.5	Calculated
dp	Cost Effectiveness (CE) of Intervention, $/QALY (1.5% Discount)	**$28,215**	= 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 = $43,932
- Assume the rate of undetected MDD increases from 25% to 35% (Table 6, row *ae*): CE = $22,091
- 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 = $21,555
- Assume the rate of treatment seeking increases from 50.5% to 69% (Table 6, row *aq*): CE = $30,645
- Assume the rate of treatment seeking decreases from 50.5% to 32% (Table 6, row *aq*): CE = $25,361
- 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 = $45,994
- 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 = $23,446
- Assume number of visits after depression diagnosis increases from 1 to 2 (Table 7, row *r*): CE = $29,745
- Assume the cost of medication increases from $368/year to $489/year (Table 7, rows *v, z, ba, bh & ca*): CE = $29,251
- Assume the cost of medication decreases from $368/year to $248/year (Table 7, rows *v, z, ba, bh & ca*): CE = $27,177
- Assume the number of suicide attempts per completed suicide is increased from 25 to 33 (Table 7, row *df*): CE = $27,869
- Assume the number of suicide attempts per completed suicide is reduced from 25 to 17 (Table 7, row *df*): CE = $28,561
- Assume the direct cost of completed suicide doubles from $8,233 to $16,466 (Table 7, row *db*) and the direct cost of attempted suicide doubles from $9,056 to $18,112 (Table 7, row *dc*): CE = $27,094
- Assume that the screening rate is only applied to one visit per year per patient, rather than 2.07 (Table 6, row *ag*): CE = $28,215 (i.e. no change)

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 $27,595 (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	139,204	Table 6, rows a + e + l + m + q + u
b	Number of well care visits per year	1.75	√
c	Depression screening rate	6.9%	√
d	Number of screens conducted, cohort total	16,809	= a * b * c
e	Cost of 10 minute office visit	$34.85	Ref Doc
f	Value of patient time and travel for office visit	$59.38	Ref Doc
g	Portion of 10-minute visit for screening	50%	Ref Doc
h	Initial screening cost	$791,951	= d * (e + f) * g
i	Number of MDD cases correctly identified, initial test	395	Table 6, row ak
j	Number of MDD cases diagnosed incorrectly, initial test	879	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	$4.40	√
n	Cost of second screening	$0	= l * (((e + f) * g) + m)
o	Number of MDD cases correctly identified, overall	395	Table 6, row ao
p	Number of MDD cases diagnosed incorrectly, overall	879	Table 6, row ap
q	Total number of MDD cases diagnosed	1,274	= o + p
r	Follow up visits, each diagnosed depression	1	Assumed
s	Follow up visit cost	$120,033	= 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	223	= q * t
v	Cost of medication, per year	$368	√
w	Cost of medication, 0 - 3 months	$20,535	= 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	248	= q * x
z	Cost of medication, per year	$368	√
aa	Cost of medication, 4 - 6 months	$22,882	= y * z * 0.25
ab	Follow up visits for medication review, per patient	1	√
ac	Cost of medication follow-up	$23,406	= y * ab * (e + f)
ad	Counselling rate	22.1%	Table 6
ae	Number receiving counselling	281	= q * ad
af	Rate of individual counselling	50.0%	√
ag	Number receiving individual counselling	140	= ae * af
ah	Number of CBT sessions	12	√
ai	Cost of clinical social worker per session	$240.82	√
aj	Cost of offering individual CBT (social worker)	$405,932	= ag * ah * ai
ak	Session length, in hours	1.5	√
al	Travel time, in hours	1.0	√
am	Patient time, cost per hour	$29.69	Ref Doc
an	Patient time cost, individual CBT treatment sessions	$125,115	= ag * ah * (ak + al) * am
ao	Rate of group counselling	50.0%	√
ap	Number receiving individual counselling	140	= ae * ao
aq	Number of CBT sessions	12	√
ar	Number of individuals in each session	10	√
as	Cost of offering group CBT (social worker)	$40,593	= (ap / ar) * aq * ai
at	Session length, in hours	1.5	√
au	Travel time, in hours	1.0	√
av	Patient time cost per hour	$29.69	Ref Doc
aw	Patient time cost, group CBT treatment sessions	$125,115	= 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	39	= o * ax * ay
ba	Cost of medication, per year	$368	√
bb	Cost of medication, 7 - 12 months	$7,100	= az * ba * 0.5
bc	Counselling costs	$0	Included in 4 - 6 month counselling costs

Table 7a: 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	19	= o * be * bf
bh	Cost of medication, per year	$368	√
bi	Additional years of medication	19	√
bj	Cost of medication, 2 - 20 years	$130,053	= 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	$240.82	√
bn	Cost of offering individual CBT (social worker), years 2 - 20	$74,983	= 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	$29.69	Ref Doc
br	Patient time cost, first CBT treatment sessions	$104,791	= 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	$66,517	= 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	179	= 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	35	= bv * by
ca	Cost of medication, per year	$368	√
cb	Cost of medication, recurrent MDD	$90,054	= bz * ca * bw * bx
cc	Counselling rate, for recurrent MDD	22.1%	√
cd	Number individuals in therapy, per recurrent MDD event	39	= bv * cc
ce	Rate of individual counselling	50.0%	√
cf	Number receiving individual counselling	20	= cd * ce
cg	Number of CBT sessions	5	√
ch	Cost of clinical social worker per session	$240.82	√
ci	Cost of offering individual CBT (social worker)	$166,413	= cf * cg * ch * bw
cj	Session length, in hours	1.5	√
ck	Travel time, in hours	1.0	√
cl	Patient time cost per hour	$29.69	Ref Doc
cm	Patient time cost, individual CBT sessions, recurrent MDD	$51,292	= cf * cg * (cj + ck) * cl * bw
cn	Rate of group counselling	50.0%	√
co	Number receiving group counselling	20	= cd * cn
cp	Number of CBT sessions	5	√
cq	Number of individuals in each session	10	√
cr	Cost of offering group CBT (social worker)	$16,641	= (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	$29.69	Ref Doc
cv	Patient time cost, group CBT, recurrent MDD	$51,292	= co * cp * (cs + ct) * cu * bw
cw	Sub-total, Screening & Screening Follow-up Cost	$911,984	= h + n + s
cx	Sub-total, Medication and Medication Follow-up Cost	$360,547	= w + aa + ac + bb + bj + bt + cb
cy	Sub-total, Individual Counselling Cost	$928,526	= aj + an + bn + br + ci + cm
cz	Sub-total, Group Counselling Cost	$233,641	= as + aw + cr + cv
da	**Total Cost of Intervention**	**$2,434,699**	= cw + cx + cy + cz
	Potential Costs Avoided		
db	Direct costs per completed suicide	$8,233	√
dc	Direct cost per attempted suicide	$9,056	√
dd	Completed suicides avoided due to screening	0.53	Table 6, row ab * Table 6, row cx
de	Costs avoided due to suicides avoided	$4,326	= db * dd
df	Attempted suicides requiring medical attention per completed suicide	25	√
dg	Costs avoided due to suicide attempts avoided	$118,972	= dc * dd * df
dh	Number of people for whom treatment is effective	30.4	Table 6, row cv
di	Health care cost avoided in first 12 months after screening due to effective treatment	$5,251	√
dj	Health care cost avoided, total	$159,394	= dh * di
dk	**Net Costs of Intervention**	**$2,152,006**	= da - de - dg - dj
dl	Net QALYs Gained	83.1	Table 6, row da
dm	Cost Effectiveness (CE) of Intervention, $/QALY	$25,887	= dk / dl
dn	Net Cost of Intervention (1.5% Discount)	$1,916,383	Calculated
do	Net QALYs Gained (1.5% Discount)	69.4	Calculated
dp	Cost Effectiveness (CE) of Intervention, $/QALY (1.5% Discount)	**$27,595**	= 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 = $43,386
- Assume the rate of undetected MDD increases from 25% to 35% (Table 6a, row *ae*): CE = $21,415
- 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 = $21,583
- Assume the rate of treatment seeking increases from 43.5% to 65.2% (Table 6a, row *aq*): CE = $30,523
- Assume the rate of treatment seeking decreases from 43.5% to 21.8% (Table 6a, row *aq*): CE = $23,984
- 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 = $43,489
- 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 = $23,168
- Assume number of visits after depression diagnosis increases from 1 to 2 (Table 7a, row *r*): CE = $29,249
- Assume the cost of medication increases from $368/year to $489/year (Table 7a, rows *v, z, ba, bh & ca*): CE = $28,586
- Assume the cost of medication decreases from $368/year to $248/year (Table 7a, rows *v, z, ba, bh & ca*): CE = $26,603
- Assume the number of suicide attempts per completed suicide is increased from 25 to 33 (Table 7a, row *df*): CE = $27,138
- Assume the number of suicide attempts per completed suicide is reduced from 25 to 17 (Table 7a, row *df*): CE = $28,052
- Assume the direct cost of completed suicide doubles from $8,233 to $16,466 (Table 7a, row *db*) and the direct cost of attempted suicide doubles from $9,056 to $18,112 (Table 7a, row *dc*): CE = $26,116
- Assume that the screening rate is only applied to one visit per year per patient, rather than 1.75 (Table 6a, row *ag*): CE = $27,595 (i.e. no change)

CE for Females

Based on the above assumptions for males, the CE associated with screening for major depressive disorder in male adolescents' ages 12 to 18 is $29,368 (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	139,335	Table 6, rows a + e + l + m + q + u
b	Number of well care visits per year	2.42	√
c	Depression screening rate	8.0%	√
d	Number of screens conducted, cohort total	26,807	= a * b * c
e	Cost of 10 minute office visit	$34.85	Ref Doc
f	Value of patient time and travel for office visit	$59.38	Ref Doc
g	Portion of 10-minute visit for screening	50%	Ref Doc
h	Initial screening cost	$1,262,998	= d * (e + f) * g
i	Number of MDD cases correctly identified, initial test	630	Table 6, row ak
j	Number of MDD cases diagnosed incorrectly, initial test	1,401	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	$4.40	√
n	Cost of second screening	$0	= l * (((e + f) * g) + m)
o	Number of MDD cases correctly identified, overall	630	Table 6, row ao
p	Number of MDD cases diagnosed incorrectly, overall	1,401	Table 6, row ap
q	Total number of MDD cases diagnosed	2,032	= o + p
r	Follow up visits, each diagnosed depression	1	Assumed
s	Follow up visit cost	$191,430	= 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	425	= q * t
v	Cost of medication, per year	$368	√
w	Cost of medication, 0 - 3 months	$39,112	= 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	479	= q * x
z	Cost of medication, per year	$368	√
aa	Cost of medication, 4 - 6 months	$44,165	= y * z * 0.25
ab	Follow up visits for medication review, per patient	1	√
ac	Cost of medication follow-up	$45,177	= y * ab * (e + f)
ad	Counselling rate	26.4%	Table 6
ae	Number receiving counselling	536	= q * ad
af	Rate of individual counselling	50.0%	√
ag	Number receiving individual counselling	268	= ae * af
ah	Number of CBT sessions	12	√
ai	Cost of clinical social worker per session	$240.82	√
aj	Cost of offering individual CBT (social worker)	$773,883	= ag * ah * ai
ak	Session length, in hours	1.5	√
al	Travel time, in hours	1.0	√
am	Patient time, cost per hour	$29.69	Ref Doc
an	Patient time cost, individual CBT treatment sessions	$238,524	= ag * ah * (ak + al) * am
ao	Rate of group counselling	50.0%	√
ap	Number receiving individual counselling	268	= ae * ao
aq	Number of CBT sessions	12	√
ar	Number of individuals in each session	10	√
as	Cost of offering group CBT (social worker)	$77,388	= (ap / ar) * aq * ai
at	Session length, in hours	1.5	√
au	Travel time, in hours	1.0	√
av	Patient time cost per hour	$29.69	Ref Doc
aw	Patient time cost, group CBT treatment sessions	$238,524	= 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	74	= o * ax * ay
ba	Cost of medication, per year	$368	√
bb	Cost of medication, 7 - 12 months	$13,704	= az * ba * 0.5
bc	Counselling costs	$0	Included in 4 - 6 month counselling costs

Table 7b: 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	36	= o * be * bf
bh	Cost of medication, per year	$368	√
bi	Additional years of medication	19	√
bj	Cost of medication, 2 - 20 years	$251,548	= 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	$240.82	√
bn	Cost of offering individual CBT (social worker), years 2 - 20	$173,371	= 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	$29.69	Ref Doc
br	Patient time cost, first CBT treatment sessions	$202,685	= 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	$128,656	= 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	279	= 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	66	= bv * by
ca	Cost of medication, per year	$368	√
cb	Cost of medication, recurrent MDD	$169,983	= bz * ca * bw * bx
cc	Counselling rate, for recurrent MDD	26.4%	√
cd	Number individuals in therapy, per recurrent MDD event	74	= bv * cc
ce	Rate of individual counselling	50.0%	√
cf	Number receiving individual counselling	37	= cd * ce
cg	Number of CBT sessions	5	√
ch	Cost of clinical social worker per session	$240.82	√
ci	Cost of offering individual CBT (social worker)	$310,262	= cf * cg * ch * bw
cj	Session length, in hours	1.5	√
ck	Travel time, in hours	1.0	√
cl	Patient time cost per hour	$29.69	Ref Doc
cm	Patient time cost, individual CBT sessions, recurrent MDD	$95,628	= cf * cg * (cj + ck) * cl * bw
cn	Rate of group counselling	50.0%	√
co	Number receiving group counselling	37	= cd * cn
cp	Number of CBT sessions	5	√
cq	Number of individuals in each session	10	√
cr	Cost of offering group CBT (social worker)	$31,026	= (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	$29.69	Ref Doc
cv	Patient time cost, group CBT, recurrent MDD	$95,628	= co * cp * (cs + ct) * cu * bw
cw	Sub-total, Screening & Screening Follow-up Cost	$1,454,427	= h + n + s
cx	Sub-total, Medication and Medication Follow-up Cost	$692,346	= w + aa + ac + bb + bj + bt + cb
cy	Sub-total, Individual Counselling Cost	$1,794,354	= aj + an + bn + br + ci + cm
cz	Sub-total, Group Counselling Cost	$442,567	= as + aw + cr + cv
da	**Total Cost of Intervention**	**$4,383,695**	= cw + cx + cy + cz
	Potential Costs Avoided		
db	Direct costs per completed suicide	$8,233	√
dc	Direct cost per attempted suicide	$9,056	√
dd	Completed suicides avoided due to screening	0.44	Table 6, row ab * Table 6, row cx
de	Costs avoided due to suicides avoided	$3,627	= db * dd
df	Attempted suicides requiring medical attention per completed suicide	25	√
dg	Costs avoided due to suicide attempts avoided	$99,741	= dc * dd * df
dh	Number of people for whom treatment is effective	58.3	Table 6, row cv
di	Health care cost avoided in first 12 months after screening due to effective treatment	$5,251	√
dj	Health care cost avoided, total	$306,347	= dh * di
dk	**Net Costs of Intervention**	**$3,973,980**	= da - de - dg - dj
dl	Net QALYs Gained	135.1	Table 6, row da
dm	Cost Effectiveness (CE) of Intervention, $/QALY	$29,425	= dk / dl
dn	Net Cost of Intervention (1.5% Discount)	$3,514,247	Calculated
do	Net QALYs Gained (1.5% Discount)	119.7	Calculated
dp	Cost Effectiveness (CE) of Intervention, $/QALY (1.5% Discount)	**$29,368**	= 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 = $45,560
- Assume the rate of undetected MDD increases from 25% to 35% (Table 6b, row *ae*): CE = $23,098
- 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 = $22,321
- Assume the rate of treatment seeking increases from 52.0% to 70.7% (Table 6b, row *aq*): CE = $31,878
- Assume the rate of treatment seeking decreases from 52.0% to 33.3% (Table 6b, row *aq*): CE = $26,434
- 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 = $49,734
- 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 = $24,171
- Assume number of visits after depression diagnosis increases from 1 to 2 (Table 7b, row *r*): CE = $30,899
- Assume the cost of medication increases from $368/year to $489/year (Table 7b, row *aj*): CE = $30,472
- Assume the cost of medication decreases from $368/year to $248/year (Table 7b, row *aj*): CE = $28,264
- Assume the number of suicide attempts per completed suicide is increased from 25 to 33 (Table 7b, row *df*): CE = $29,146
- Assume the number of suicide attempts per completed suicide is reduced from 25 to 17 (Table 7b, row *df*): CE = $29,591
- Assume the direct cost of completed suicide doubles from $8,233 to $16,466 (Table 7b, row *db*) and the direct cost of attempted suicide doubles from $9,056 to $18,112 (Table 7b, row *dc*): CE = $28,649
- Assume that the screening rate is only applied to one visit per year per patient, rather than 2.42 (Table 6b, row *ag*): CE = $29,368 (i.e. no change)

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 191 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated at $28,215 per QALY (see Table 8).

In male adolescents ages 12-18, the CPB with screening for, and treatment of, MDD is estimated to be 69 QALYs while the CE is estimated at $27,595 per QALY (see Table 8a).

In female adolescents ages 12-18, the CPB with screening for, and treatment of, MDD is estimated to be 120 QALYs while the CE is estimated at $29,368 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	**191**	92	274
3% Discount Rate	171	83	247
0% Discount Rate	222	107	318
CE ($/QALY) ***including*** patient time costs			
1.5% Discount Rate	**$28,215**	$21,555	$45,994
3% Discount Rate	$28,892	$21,422	$48,789
0% Discount Rate	$27,331	$21,661	$42,094
CE ($/QALY) ***excluding*** patient time costs			
1.5% Discount Rate	$14,063	$9,656	$22,925
3% Discount Rate	$14,201	$9,298	$23,981
0% Discount Rate	$13,998	$10,199	$21,558

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	**69**	39	100
3% Discount Rate	61	34	88
0% Discount Rate	83	47	119
CE ($/QALY) ***including*** patient time costs			
1.5% Discount Rate	**$27,595**	$21,415	$43,489
3% Discount Rate	$28,858	$22,004	$47,491
0% Discount Rate	$25,887	$2,061	$38,218
CE ($/QALY) ***excluding*** patient time costs			
1.5% Discount Rate	$13,264	$10,301	$20,904
3% Discount Rate	$13,693	$10,395	$22,535
0% Discount Rate	$12,788	$10,264	$18,879

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	**120**	49	173
3% Discount Rate	110	45	158
0% Discount Rate	135	56	194
CE ($/QALY) ***including*** patient time costs			
1.5% Discount Rate	**$29,368**	$22,321	$49,734
3% Discount Rate	$29,432	$21,724	$51,078
0% Discount Rate	$29,425	$23,174	$47,720
CE ($/QALY) ***excluding*** patient time costs			
1.5% Discount Rate	$14,934	$10,282	$25,291
3% Discount Rate	$14,742	$9,689	$25,585
0% Discount Rate	$15,378	$11,210	$24,940

Behavioural Counselling Interventions

Promotion of Breastfeeding

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)*[143]

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.*[144]

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[143] 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.
[144] 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.

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) exclusive breastfeeding and a 44% increase (OR = 1.44, 95% CI of 1.13 – 1.84) in long-term (6–8 months) exclusive breastfeeding.[145]

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." [146]

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*). [147] The overall incidence of OM is 1.9 episodes in the first year of life (Table 2, row *j*).[148]

- 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*). [149] AD has a cumulative incidence of 0.165 in the first two years of life (Table 2, row *m*). [150]

- 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*). [151] GI is associated with 0.222 ambulatory visits (Table 2, row *p*) and 0.00298 hospitalizations per infant < 1 year old. [152]

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[145] 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.
[146] Ibid.
[147] Ibid.
[148] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.
[149] 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.
[150] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.
[151] 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.
[152] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.

- 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*).[153] 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*).[154]

- 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 without a history of asthma (Table 2, row *aa*).[155] 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*).[156]

- 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.[157] The 2010 rate of overweight and obesity by age group in BC is detailed in Figure 1.[158] Based on this rate and mean survival rates by age group, a birth cohort of 40,000 in BC would be expected to include 878,446 years in a 'state' of overweight and 348,584 years in a 'state' of obesity (see Table 1). Overweight/obesity is associated with a reduced life expectancy of approximately 0.6 and 2.6 years, respectively (see Reference Document). Given the average life expectancy in BC of 82.2 years, this represents a reduction in life expectancy of 0.73% (0.6 / 82.2) associated with overweight (Table 2, row *jj*) and 3.16% (2.6 / 82.2) for obesity (Table 2, row *oo*).

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[153] 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.
[154] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.
[155] 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.
[156] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.
[157] 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.
[158] 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.

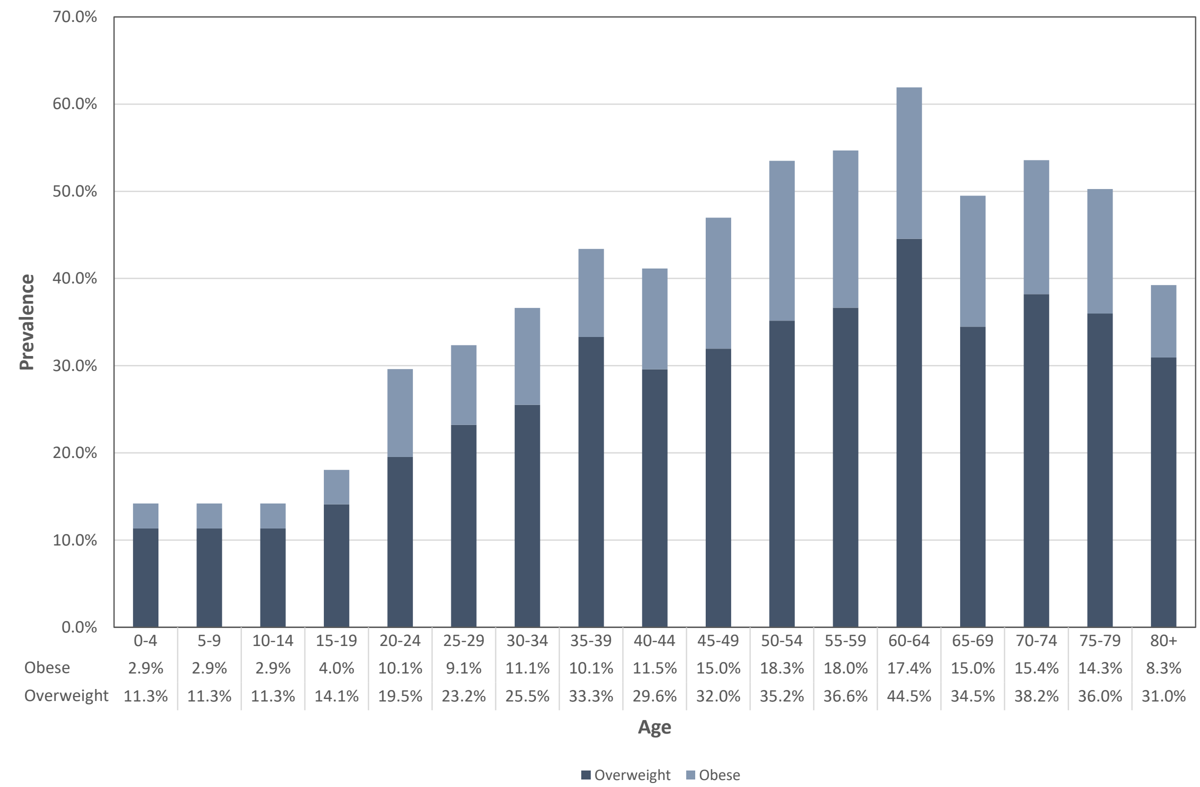

Figure 1: Prevalence of Overweight and Obesity
British Columbia, 2010

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

Age Group	Mean Survival Rate	Years of Life in Birth Cohort	% Overweight	Years of Life Overweight	% Obese	Years of Life Obese
0-4	99.6%	199,198	11.3%	22,572	2.9%	5,711
5-9	99.5%	199,088	11.3%	22,560	2.9%	5,708
10-14	99.5%	199,022	11.3%	22,552	2.9%	5,706
15-19	99.4%	198,868	14.1%	28,034	4.0%	7,856
20-24	99.2%	198,408	19.5%	38,776	10.1%	19,990
25-29	98.9%	197,850	23.2%	45,921	9.1%	18,075
30-34	98.6%	197,290	25.5%	50,330	11.1%	21,927
35-39	98.3%	196,550	33.3%	65,453	10.1%	19,818
40-44	97.8%	195,526	29.6%	57,851	11.5%	22,580
45-49	97.0%	194,070	32.0%	62,018	15.0%	29,161
50-54	96.0%	191,948	35.2%	67,489	18.3%	35,177
55-59	94.4%	188,786	36.6%	69,177	18.0%	34,041
60-64	92.0%	183,998	44.5%	81,961	17.4%	31,970
65-69	88.3%	176,658	34.5%	60,915	15.0%	26,517
70-74	82.7%	165,362	38.2%	63,193	15.4%	25,408
75-79	74.1%	148,142	36.0%	53,308	14.3%	21,158
80+	59.5%	214,284	31.0%	66,334	8.3%	17,784
Total		**3,245,048**	**27.1%**	**878,446**	**10.7%**	**348,584**

- 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*). [159] The overall incidence of type 1 diabetes is 0.000186 (Table 2, row *qq*) with a death rate of 0.00000121 (Table 1-2, row *tt*). [160]

- 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*). [161] 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. [162]

- 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*). [163] The overall incidence of SIDS is 0.00054 (Table 2, row *eee*). [164]

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. [165] 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*).[166] 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. [167] Ovarian cancer is associated with a reduced life expectancy of 16.5 years (see reference Document, Table 2, row *sss*).

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

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[159] 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.
[160] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.
[161] 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.
[162] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.
[163] 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.
[164] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.
[165] 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.
[166] 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.
[167] 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.

Based on these assumptions, the CPB associated with interventions aimed at improving rates of exclusive breastfeeding at 6 months from 0% to 60% is 5,002 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	82.2	√
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	33.7	= 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	27.1%	Table 1-1
hh	Effectiveness of breastfeeding in reducing risk of overweight	24%	√
ii	Reduced years as overweight with intervention	41,591	= g * i * gg* hh
jj	% of life years lost with overweight	0.73%	√
kk	Life years gained with intervention	304	= ii * jj
ll	Average % of years as obese	10.7%	Table 1
mm	Effectiveness of breastfeeding in reducing risk of obesity	24%	√
nn	Reduced years as obese with intervention	16,504	= g * i * ll* mm
oo	% of life years lost with obesity	3.16%	√
pp	Life years gained with intervention	522	= 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	124.4	= 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%**	**1,611**	= y + ff + kk + pp + ww + ddd + hhh + nnn + ttt
vvv	**Potential QALYs gained, Intervention increasing from 0% to 60%**	**5,002**	=(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 = 3,868 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 = 6,466 QALYs
- Assume the effectiveness of breastfeeding in reducing overweight and obesity is reduced from 24% to 14% (Table 2, row *hh* & *mm*): CPB = 3,934 QALYs
- Assume the effectiveness of breastfeeding in reducing overweight and obesity is increased from 24% to 33% (Table 2, row *hh* & *mm*): CPB = 5,963 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)[168] and $106 (2004 USD).[169] A Canadian study suggested additional hospital costs over and above physician and drug costs of 15.6%.[170] We have converted the $156 to 2017 Canadian dollars and then added 15.6% to this cost per case to reflect hospital costs for a total cost per case of $251 (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.[171] 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[172] or $342 (in 2017 CAD) per case per year. Lifetime costs were estimated at $3,420 (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)[173] or $462 in 2017 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)[174] or $523 in 2017 CAD. Based on an average treatment duration of 10 years,[175] the total costs attributable to childhood asthma would be $5,230 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)[176] or $76,598 in 2017 CAD (Table 3, row *kk*).
- **Childhood leukemia -** The lifetime cost per case in the US has been estimated at $136,444 (in 2007 USD)[177] or $134,920 in 2017 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 -$9,021 per QALY (Table 3, row *bbb*).

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[168] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.
[169] 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.
[170] 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.
[171] Barbeau M and Bpharm HL. Burden of atopic dermatitis in Canada. *International Journal of Dermatology*. 2006; 45(1): 31-6.
[172] Ibid.
[173] Ball TM and Wright AL. Health care costs of formula-feeding in the first year of life. *Pediatrics*. 1999; 103(Suppl. 1): 870-6.
[174] 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.
[175] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.
[176] Ibid.
[177] Ibid.

Table 3: CE of Promotion of Breastfeeding in a Birth Cohort of 40,000			
Row Label	Variable	Base Case	Data Source
a	Women eligible for screening/referral in primary care	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	$34.85	Ref Doc
j	Value of patient time and travel for office visit	$59.38	=2 * $29.69
k	Portion of 10-minute office visit for screen/referral	50%	Ref Doc
l	Estimated cost of screening	$1,884,600	= a * (I + j) * k
m	Value of patient time and travel for intervention	$534	=18 * $29.69
n	Estimated cost of intervention over lifetime of birth cohort	$9,451,800	= f * m
	Cost avoided		
o	Cases of otitis media avoided	5,919	Table 2, row l
p	Cost per case	$251	√
q	Costs avoided	$1,485,639	= o * p
r	Cases of atopic dermatitis avoided	540	Table 2, row o
s	Cost per person with atopic dermatitis	$3,420	√
t	Costs avoided	$1,845,803	= r * s
u	Cases of gastrointestinal infection avoided	1,107	Table 2, row r
v	Cost per case	$462	√
w	Costs avoided	$511,212	= u * v
x	Cases of lower respiratory tract infection avoided	229	Table 2, row u
y	Cost per case	$462	√
z	Costs avoided	$105,956	= x * y
aa	Cases of asthma avoided	267	Table 2, row bb
bb	Cost per case	$5,230	√
cc	Costs avoided	$1,396,674	= aa * bb
dd	Years of overweight avoided	41,591	Table 2, row ii
ee	Cost per year	$227	Ref Doc
ff	Costs avoided	$9,441,234	= dd * ee
gg	Years of obesity avoided	16,504	Table 2, row nn
hh	Cost per year	$805	Ref Doc
ii	Costs avoided	$13,285,924	= gg * hh
jj	Cases of type 1 diabetes avoided	0.3	Table 2, row ss
kk	Cost per case	$76,598	√
ll	Costs avoided	$21,082	= jj * kk
mm	Cases of childhood leukemia avoided	0.06	Table 2, row zz
nn	Cost per case	$134,920	√
oo	Costs avoided	$8,095	= mm * nn
pp	Cases of breast cancer avoided	19.3	Table 2, row kkk
qq	Cost per case	$29,707	Ref Doc
rr	Costs avoided	$572,033	= pp * qq
ss	Cases of ovarian cancer avoided	22.9	Table 2, row qqq
tt	Cost per case	$84,534	Ref Doc
uu	Costs avoided	$1,935,551	= ss * tt
	CE calculation		
vv	Cost of intervention over lifetime of birth cohort	$11,336,400	= l + n
ww	Costs avoided	$30,609,203	= q + t + w + z + cc + ff + ii + ll + oo + rr + uu
xx	QALYs saved	1,611	Table 2, row uuu
yy	Cost of intervention over lifetime of birth cohort (1.5% discount)	$11,336,400	Calculated
zz	Costs avoided (1.5% discount)	$19,827,768	Calculated
aaa	QALYs saved (1.5% discount)	941	Calculated
bbb	**CE ($/QALY saved)**	**-$9,021**	= (yy-zz)/aaa

√ = 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 = $19,699 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 = -$14,757 per QALY
- Assume the effectiveness of breastfeeding in reducing overweight and obesity is reduced from 24% to 14% (Table 2, rows *hh* & *mm*): CE = -$3,995 per QALY
- Assume the effectiveness of breastfeeding in reducing overweight and obesity is increased from 24% to 33% (Table 2, rows *hh* & *mm*): CE = -$12,006 per QALY
- Assume the proportion of an office visit required for screening/referral is reduced from 50% to 33% (Table 3, row *k)*: CE = -$9,702 per QALY
- Assume the proportion of an office visit required for screening/referral is increased from 50% to 67% (Table 3, row *k)*: CE = -$8,341 per QALY

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 2,923 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to result in cost savings of $9,021 per QALY (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	**2,923**	2,260	3,779
3% Discount Rate	1,853	1,433	2,396
0% Discount Rate	5,002	3,868	6,466
Gap between B.C. Current and Best in the World			
1.5% Discount Rate	**941**	278	1,797
3% Discount Rate	597	176	1,139
0% Discount Rate	1,611	476	3,075
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**-$9,021**	-$14,757	$19,699
3% Discount Rate	-$4,745	-$13,791	$40,557
0% Discount Rate	-$11,966	-$15,318	$4,818
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	-$20,325	-$20,678	-$18,599
3% Discount Rate	-$22,574	-$23,130	-$19,789
0% Discount Rate	-$18,572	-$18,778	-$17,540

Growth Monitoring and Healthy Weight Management in Children and Youth

United States Preventive Services Task Force Recommendations (2017)[178]

> *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)[179]

> *We recommend growth monitoring[180] at all appropriate[181] 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[182] 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 incorporated family and parent involvement". Furthermore, "where structured behavioural

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178 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.
179 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.
180 **Growth monitoring** consists of measurement of height or length, weight and BMI calculation or weight for length according to age.
181 **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).
182 **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.

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."[183]

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.[184]
- 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." [185]
- 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.[186]
- 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.[187]
- 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[188]).
- 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.[189] Between 2007 and 2010, 21,132 families were referred to MEND 7-13 in that country.[190,191] We were unable to find more recent estimates. In 2016, there were

[183] 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.
[184] 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.
[185] 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.
[186] 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.
[187] 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.
[188] 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.
[189] 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.
[190] 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.
[191] 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[192] with a 19% rate of obesity[193] (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.[194]
- 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."[195] 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.[196]

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."[197] 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

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[192] 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.
[193] 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.
[194] 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.
[195] 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.
[196] 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.
[197] 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.[198]

- 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.[199]
- 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.[200]
- 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.[201]
- Additional information for the fiscal years from 2015/16 through 2019/20 is summarized in Table 1.[202,203] 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.

[198] 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.
[199] 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.
[200] Centre for Healthy Weights - Shapedown BC. *Provincial Management and Evaluation Report Cycles I – VII: January 2013 – June 2015*. September 2015.
[201] Centre for Healthy Weights - Shapedown BC. *Provincial Management and Evaluation Report Cycles I – VII: January 2013 – June 2015*. September 2015.
[202] Centre for Healthy Weights - Shapedown BC. *Provincial Management and Evaluation Report: March 31, 2015 – April 1, 2016*.
[203] 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.[204]
- 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.[205]
- 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.[206]

[204] 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.
[205] 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.
[206] 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.[207]
- 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.[208]

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.[209]
- 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

[207] 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.
[208] 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.
[209] 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.[210]

- 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.[211]
- 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.[212]

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.[213]
- 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.[214]

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[210] Childhood Obesity Foundation. *Generation Health*. Available online at https://childhoodobesityfoundation.ca/early-intervention-program-2/#toggle-id-7. Accessed July 2020.
[211] Childhood Obesity Foundation. *Family Healthy Living Program: Final Evaluation Report June 2019.*
[212] Childhood Obesity Foundation. *Generation Health: Evaluation Report June 2020*.
[213] Childhood Obesity Foundation. *HealthLinkBC Eating and Activity Program for Kids.* Available online at https://childhoodobesityfoundation.ca/healthlinkbc-eating-activity-program-kids/. Accessed July 2020.
[214] 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[215] and the UK[216] (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.[217]
- 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.[218] Poor program adherence is associated with a low level of parental literacy.[219]
- 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.[220]
- In 2017, there were an estimated 33,130 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 2,761 (33,130 / 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 2,761 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.

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215 Hardy L, Mihrshahi S, Gale J et al. Translational research: Are community-based child obesity treatment programs scalable? *BMC Public Health*. 2015; 15: 652.

216 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.

217 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.

218 Hardy L, Mihrshahi S, Gale J et al. Translational research: Are community-based child obesity treatment programs scalable? *BMC Public Health*. 2015; 15: 652.

219 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.

220 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 864,783 children and youth ages 0 – 17 living in BC in 2017 (Table 4).[221] The majority of these children and youth would be eligible for growth monitoring.

- There were 774,402 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, 2017 by Age and Sex

Age Group	Population
Males	
0 - 1	46,522
2 - 5	96,830
6 - 11	146,427
12 - 17	153,653
Subtotal - 0 to 17	**443,432**
Subtotal - 2 to 17	**396,910**
Females	
0 - 1	43,859
2 - 5	90,362
6 - 11	140,980
12 - 17	146,150
Subtotal - 0 to 17	**421,351**
Subtotal - 2 to 17	**377,492**
Total	
0 - 1	90,381
2 - 5	187,192
6 - 11	287,407
12 - 17	299,803
Total - 0 to 17	**864,783**
Total - 2 to 17	**774,402**

[221] BC Stats. *British Columbia Population Estimates*. Available online at https://bcstats.shinyapps.io/popApp/. Accessed June 2020.

- 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.[222] 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.[223]
- 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%.[224]
- 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%).[225] Excess weight rates in Canadian children have

[222] 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.
[223] 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.
[224] 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.
[225] 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.

remained relatively stable since the early 2000s.[226,227] Absent more recent 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).[228]
  - 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).[229]
  - On average, rates of excess weight in BC are lower than the Canadian average.[230] 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[231,232,233] 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).

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[226] 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.
[227] 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.
[228] 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.
[229] 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.
[230] 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.
[231] 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.
[232] 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.
[233] 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 2017, an estimated 157,846 children and youth ages 2-17 in BC had excess weight, with 42,404 having obesity (see Table 8). The 33,130 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, 2017 by Age and Sex							
		Percent			**Number**		
Age Group	**Population**	Overweight	Obese	Excess Weight	Overweight	Obese	Excess Weight
Males							
2 - 5	96,830	12.3%	5.5%	**17.8%**	11,897	5,320	**17,216**
6 - 11	146,427	10.7%	5.3%	**16.0%**	15,671	7,753	**23,424**
12 - 17	153,653	14.1%	8.1%	**22.1%**	21,623	12,411	**34,033**
Subtotal - 2 to 17	**396,910**	**12.4%**	**6.4%**	**18.8%**	**49,190**	**25,483**	**74,673**
Females							
2 - 5	90,362	16.2%	4.4%	**20.6%**	14,633	3,953	**18,586**
6 - 11	140,980	17.8%	3.1%	**21.0%**	25,164	4,395	**29,558**
12 - 17	146,150	18.1%	5.9%	**24.0%**	26,456	8,573	**35,029**
Subtotal - 2 to 17	**377,492**	**17.6%**	**4.5%**	**22.0%**	**66,252**	**16,921**	**83,173**
Total							
2 - 5	187,192	14.2%	5.0%	**19.1%**	26,530	9,273	**35,802**
6 - 11	287,407	14.2%	4.2%	**18.4%**	40,834	12,147	**52,982**
12 - 17	299,803	16.0%	7.0%	**23.0%**	48,079	20,983	**69,062**
Total - 2 to 17	**774,402**	14.9%	5.5%	**20.4%**	**115,443**	**42,404**	**157,846**

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.[234,235]

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[234] 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.
[235] 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*.[236,237]
- 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.[238] 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.[239]
- 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.[240]
- 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.[241] 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

[236] 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.
[237] 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.
[238] 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.
[239] Fontaine K, Redden D, Wang C et al. Years of life lost due to obesity. *JAMA*. 2003; 289(2): 187-93.
[240] 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.
[241] 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.[242,243]

- For modelling purposes we have assumed a mid-point in life years lost (LYL) between the US[244] and Australian estimates[245] 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.[246]

- 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	***5.7***	2.6	8.8
	Class II	2.7%	18.0%	7.35	4.2	10.5			
	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	***4.4***	2.1	6.6
	Class II	2.5%	18.0%	5.55	3.4	7.7			
	Class III	1.7%	12.2%	5.55	3.4	7.7			

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

[242] 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.
[243] 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.
[244] Fontaine K, Redden D, Wang C et al. Years of life lost due to obesity. *JAMA*. 2003; 289(2): 187-93.
[245] 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.
[246] 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.[247] 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.[248] 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.[249] 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.[250]

- For the purposes of this project, we adjusted the PedsQL overall scores as identified by children/youth in the Ul-Haq et al study[251] to reflect Child Health Utility-9 Dimension (CHU-9D) scores.[252] 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

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[247] Williams J, Wake M, Hesketh K et al. Health-related quality of life of overweight and obese children. *JAMA*. 2005; 293(1): 70-6.
[248] 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.
[249] 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.
[250] 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.
[251] 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.
[252] 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.[253]

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.[254] 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.[255]

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] Base	Disutility[2] Low	Disutility[2] High	Weighted Average Disutility for Individual with Obesity Base	Weighted Average Disutility for Individual with Obesity Low	Weighted Average Disutility for Individual with Obesity 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 4,927 QALYs (2,591 in males and 2,336 in females) due to a reduction in QoL associated with obesity (see Table 11 and Table 13, rows h & i).

[253] 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.
[254] 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.
[255] 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	19,904	19,917	5.3%	3.1%	1,054	621	0.026	0.026	27	16
7	19,903	19,915	5.3%	3.1%	1,054	621	0.026	0.026	27	16
8	19,902	19,914	5.3%	3.1%	1,054	621	0.026	0.026	27	16
9	19,900	19,913	5.3%	3.1%	1,054	621	0.026	0.026	27	16
10	19,899	19,912	5.3%	3.1%	1,054	621	0.026	0.026	27	16
11	19,897	19,912	5.3%	3.1%	1,053	621	0.026	0.026	27	16
12	19,895	19,911	8.1%	5.9%	1,607	1,168	0.026	0.026	42	30
13	19,893	19,910	8.1%	5.9%	1,607	1,168	0.026	0.026	42	30
14	19,890	19,908	8.1%	5.9%	1,607	1,168	0.026	0.026	42	30
15	19,886	19,906	8.1%	5.9%	1,606	1,168	0.026	0.026	42	30
16	19,881	19,902	8.1%	5.9%	1,606	1,167	0.026	0.026	42	30
17	19,875	19,897	8.1%	5.9%	1,605	1,167	0.026	0.026	42	30
18	19,867	19,891	7.9%	5.7%	1,568	1,140	0.034	0.040	53	46
19	19,856	19,884	7.7%	5.6%	1,530	1,113	0.034	0.040	52	45
20	19,844	19,878	7.5%	5.5%	1,492	1,085	0.034	0.040	51	43
21	19,829	19,871	7.3%	5.3%	1,454	1,058	0.034	0.040	49	42
22	19,813	19,865	7.1%	5.2%	1,416	1,031	0.034	0.040	48	41
23	19,796	19,858	7.0%	5.1%	1,378	1,004	0.034	0.040	47	40
24	19,780	19,852	6.8%	4.9%	1,340	976	0.034	0.040	45	39
25	19,764	19,845	6.6%	4.8%	1,302	949	0.034	0.040	44	38
26	19,749	19,839	6.4%	4.6%	1,264	922	0.034	0.040	43	37
27	19,734	19,833	6.2%	4.5%	1,226	895	0.034	0.040	42	36
28	19,720	19,826	6.0%	4.4%	1,188	868	0.034	0.040	40	35
29	19,705	19,819	5.8%	4.2%	1,151	841	0.034	0.040	39	34
30	19,690	19,812	5.7%	4.1%	1,113	813	0.034	0.040	38	33
31	19,675	19,804	5.7%	4.1%	1,112	813	0.034	0.040	38	33
32	19,658	19,795	5.7%	4.1%	1,111	813	0.034	0.040	38	33
33	19,640	19,786	5.7%	4.1%	1,110	812	0.034	0.040	38	33
34	19,622	19,776	5.7%	4.1%	1,109	812	0.034	0.040	38	33
35	19,602	19,765	5.7%	4.1%	1,108	812	0.034	0.040	38	33
36	19,582	19,754	5.7%	4.1%	1,107	811	0.034	0.040	38	32
37	19,560	19,741	5.7%	4.1%	1,106	811	0.034	0.040	38	32
38	19,536	19,728	5.7%	4.1%	1,105	810	0.034	0.040	38	32
39	19,511	19,713	5.7%	4.1%	1,103	809	0.034	0.040	37	32
40	19,485	19,697	5.7%	4.1%	1,102	809	0.034	0.040	37	32
41	19,457	19,680	5.7%	4.1%	1,100	808	0.034	0.040	37	32
42	19,427	19,662	5.7%	4.1%	1,098	807	0.034	0.040	37	32
43	19,395	19,642	5.7%	4.1%	1,097	807	0.034	0.040	37	32
44	19,360	19,621	5.7%	4.1%	1,095	806	0.034	0.040	37	32
45	19,323	19,598	5.7%	4.1%	1,093	805	0.034	0.040	37	32
46	19,283	19,573	5.7%	4.1%	1,090	804	0.034	0.040	37	32
47	19,241	19,546	5.7%	4.1%	1,088	803	0.034	0.040	37	32
48	19,195	19,517	5.7%	4.1%	1,085	801	0.034	0.040	37	32
49	19,145	19,485	5.7%	4.1%	1,082	800	0.034	0.040	37	32
50	19,091	19,451	5.7%	4.1%	1,079	799	0.034	0.040	37	32
51	19,034	19,414	5.7%	4.1%	1,076	797	0.034	0.040	37	32
52	18,971	19,375	5.7%	4.1%	1,073	796	0.034	0.040	36	32
53	18,903	19,331	5.7%	4.1%	1,069	794	0.034	0.040	36	32
54	18,830	19,285	5.7%	4.1%	1,065	792	0.034	0.040	36	32
55	18,750	19,234	5.7%	4.1%	1,060	790	0.034	0.040	36	32
56	18,664	19,178	5.7%	4.1%	1,055	787	0.034	0.040	36	32
57	18,570	19,118	5.7%	4.1%	1,050	785	0.034	0.040	36	31
58	18,469	19,053	5.7%	4.1%	1,044	782	0.034	0.040	35	31
59	18,358	18,981	5.7%	4.1%	1,038	779	0.034	0.040	35	31
60	18,239	18,904	5.7%	4.1%	1,031	776	0.034	0.040	35	31
61	18,109	18,819	5.7%	4.1%	1,024	773	0.034	0.040	35	31
62	17,967	18,726	5.7%	4.1%	1,016	769	0.034	0.040	34	31
63	17,813	18,625	5.7%	4.1%	1,007	765	0.034	0.040	34	31
64	17,646	18,514	5.7%	4.1%	998	760	0.034	0.040	34	30
65	17,464	18,392	5.7%	4.1%	987	755	0.034	0.040	34	30
66	17,267	18,259	5.7%	4.1%	976	750	0.034	0.040	33	30
67	17,052	18,113	5.7%	4.1%	964	744	0.034	0.040	33	30
68	16,819	17,954	5.7%	4.1%	951	737	0.034	0.040	32	30
69	16,565	17,778	5.7%	4.1%	937	730	0.034	0.040	32	29
70	16,290	17,586	5.7%	4.1%	921	722	0.034	0.040	31	29
71	15,992	17,375	5.7%	4.1%	904	713	0.034	0.040	31	29
72	15,668	17,144	5.7%	4.1%	886	704	0.034	0.040	30	28
73	15,318	16,890	5.7%	4.1%	866	694	0.034	0.040	29	28
74	14,939	16,612	5.7%	4.1%	845	682	0.034	0.040	29	27
75	14,530	16,307	5.7%	4.1%	822	670	0.034	0.040	28	27
76	14,090	15,973	-	4.1%	-	656	0.034	0.040	-	26
77	13,616	15,608	-	4.1%	-	641	0.034	0.040	-	26
78	13,107	15,209	-	4.1%	-	624	0.034	0.040	-	25
79	12,564	14,774	-	4.1%	-	607	0.034	0.040	-	24
80	11,984	14,300	-	4.1%	-	587	0.034	0.040	-	24
81	11,370	13,785	-	4.1%	-	566	0.034	0.040	-	23
82	-	13,228	-	-	-	-	0.034	0.040	-	-
83	-	12,626	-	-	-	-	0.034	0.040	-	-
84	-	11,980	-	-	-	-	0.034	0.040	-	-
85	-	11,288	-	-	-	-	0.034	0.040	-	-
Total	**1,397,618**	**1,488,063**			**80,025**	**62,101**			**2,591**	**2,336**

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."[256]

- 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.[257] Interventions reduced the prevalence of overweight from 40% to 35% and obesity from 33% to 31% over a duration of up to 36 months.[258]

- 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."[259] 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.[260]

- 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

[256] 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.
[257] 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.
[258] 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.
[259] 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.
[260] 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.

involving at least 30 contact hours, 52% continued to have obesity as adults. By way 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.[261]

- 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.[262]
- 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."[263]
- 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 74.9 QALYs (39.0 in males and 35.9 in females) due to a reduction in QoL associated with obesity (see Table 12 and Table 13, rows t & u).

[261] 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.
[262] 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.
[263] 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

	Life Years Lived with Obesity (Table 11)		Cummulative Proportion Starting Treatment	Finishing Treatment	Obesity Reduction From Treatment	Impacted by Intervention		Quality of Life Reduction		QALYs Saved due to Intervention	
Age	M	F				M	F	M	F	M	F
6	1,054	621	0.8%	73%	18.8%	1.2	0.7	0.026	0.026	0.03	0.02
7	1,054	621	1.6%	73%	18.8%	2.4	1.4	0.026	0.026	0.06	0.04
8	1,054	621	2.5%	73%	18.8%	3.5	2.1	0.026	0.026	0.09	0.05
9	1,054	621	3.3%	73%	18.8%	4.7	2.8	0.026	0.026	0.12	0.07
10	1,054	621	4.1%	73%	18.8%	5.9	3.5	0.026	0.026	0.15	0.09
11	1,053	621	4.9%	73%	18.8%	7.1	4.2	0.026	0.026	0.18	0.11
12	1,607	1,168	5.7%	73%	18.8%	12.6	9.2	0.026	0.026	0.33	0.24
13	1,607	1,168	6.5%	73%	18.8%	14.4	10.5	0.026	0.026	0.38	0.27
14	1,607	1,168	7.4%	73%	18.8%	16.2	11.8	0.026	0.026	0.42	0.31
15	1,606	1,168	8.2%	73%	18.8%	18.0	13.1	0.026	0.026	0.47	0.34
16	1,606	1,167	9.0%	73%	18.8%	19.8	14.4	0.026	0.026	0.52	0.37
17	1,605	1,167	9.8%	73%	18.8%	21.6	15.7	0.026	0.026	0.56	0.41
18	1,568	1,140				21.1	15.4	0.034	0.040	0.72	0.61
19	1,530	1,113				20.6	15.0	0.034	0.040	0.70	0.60
20	1,492	1,085				20.1	14.6	0.034	0.040	0.68	0.59
21	1,454	1,058				19.6	14.3	0.034	0.040	0.66	0.57
22	1,416	1,031				19.1	13.9	0.034	0.040	0.65	0.56
23	1,378	1,004				18.6	13.5	0.034	0.040	0.63	0.54
24	1,340	976				18.0	13.2	0.034	0.040	0.61	0.53
25	1,302	949				17.5	12.8	0.034	0.040	0.60	0.51
26	1,264	922				17.0	12.4	0.034	0.040	0.58	0.50
27	1,226	895				16.5	12.1	0.034	0.040	0.56	0.48
28	1,188	868				16.0	11.7	0.034	0.040	0.54	0.47
29	1,151	841				15.5	11.3	0.034	0.040	0.53	0.45
30	1,113	813				15.0	11.0	0.034	0.040	0.51	0.44
31	1,112	813				15.0	11.0	0.034	0.040	0.51	0.44
32	1,111	813				15.0	10.9	0.034	0.040	0.51	0.44
33	1,110	812				15.0	10.9	0.034	0.040	0.51	0.44
34	1,109	812				14.9	10.9	0.034	0.040	0.51	0.44
35	1,108	812				14.9	10.9	0.034	0.040	0.51	0.44
36	1,107	811				14.9	10.9	0.034	0.040	0.51	0.44
37	1,106	811				14.9	10.9	0.034	0.040	0.51	0.44
38	1,105	810				14.9	10.9	0.034	0.040	0.51	0.44
39	1,103	809				14.9	10.9	0.034	0.040	0.50	0.44
40	1,102	809				14.8	10.9	0.034	0.040	0.50	0.44
41	1,100	808				14.8	10.9	0.034	0.040	0.50	0.44
42	1,098	807				14.8	10.9	0.034	0.040	0.50	0.44
43	1,097	807				14.8	10.9	0.034	0.040	0.50	0.44
44	1,095	806				14.7	10.9	0.034	0.040	0.50	0.43
45	1,093	805				14.7	10.8	0.034	0.040	0.50	0.43
46	1,090	804				14.7	10.8	0.034	0.040	0.50	0.43
47	1,088	803				14.7	10.8	0.034	0.040	0.50	0.43
48	1,085	801				14.6	10.8	0.034	0.040	0.50	0.43
49	1,082	800				14.6	10.8	0.034	0.040	0.50	0.43
50	1,079	799				14.5	10.8	0.034	0.040	0.49	0.43
51	1,076	797				14.5	10.7	0.034	0.040	0.49	0.43
52	1,073	796				14.4	10.7	0.034	0.040	0.49	0.43
53	1,069	794				14.4	10.7	0.034	0.040	0.49	0.43
54	1,065	792				14.3	10.7	0.034	0.040	0.49	0.43
55	1,060	790				14.3	10.6	0.034	0.040	0.48	0.43
56	1,055	787				14.2	10.6	0.034	0.040	0.48	0.42
57	1,050	785				14.1	10.6	0.034	0.040	0.48	0.42
58	1,044	782				14.1	10.5	0.034	0.040	0.48	0.42
59	1,038	779				14.0	10.5	0.034	0.040	0.47	0.42
60	1,031	776				13.9	10.5	0.034	0.040	0.47	0.42
61	1,024	773				13.8	10.4	0.034	0.040	0.47	0.42
62	1,016	769				13.7	10.4	0.034	0.040	0.46	0.41
63	1,007	765				13.6	10.3	0.034	0.040	0.46	0.41
64	998	760				13.4	10.2	0.034	0.040	0.46	0.41
65	987	755				13.3	10.2	0.034	0.040	0.45	0.41
66	976	750				13.1	10.1	0.034	0.040	0.45	0.40
67	964	744				13.0	10.0	0.034	0.040	0.44	0.40
68	951	737				12.8	9.9	0.034	0.040	0.43	0.40
69	937	730				12.6	9.8	0.034	0.040	0.43	0.39
70	921	722				12.4	9.7	0.034	0.040	0.42	0.39
71	904	713				12.2	9.6	0.034	0.040	0.41	0.38
72	886	704				11.9	9.5	0.034	0.040	0.41	0.38
73	866	694				11.7	9.3	0.034	0.040	0.40	0.37
74	845	682				11.4	9.2	0.034	0.040	0.39	0.37
75	822	670				11.1	9.0	0.034	0.040	0.38	0.36
76	-	656				-	8.8	0.034	0.040	-	0.35
77	-	641				-	8.6	0.034	0.040	-	0.35
78	-	624				-	8.4	0.034	0.040	-	0.34
79	-	607				-	8.2	0.034	0.040	-	0.33
80	-	587				-	7.9	0.034	0.040	-	0.32
81	-	566				-	7.6	0.034	0.040	-	0.31
82	-	-				-	-	0.034	0.040	-	-
83	-	-				-	-	0.034	0.040	-	-
84	-	-				-	-	0.034	0.040	-	-
85	-	-				-	-	0.034	0.040	-	-
Total	**80,025**	**62,101**				**990**	**781**			**32.6**	**30.0**

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.[264]
- 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."[265]

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 196 QALYs (see Table 13, row z). The CPB of 196 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.

[264] 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.

[265] 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	1,397,618	Table 11
b	Years of life lived in cohort, female	1,488,063	Table 11
c	Years of life lived in cohort, with obesity, male	80,025	Table 11
d	Years of life lived in cohort, with obesity, female	62,101	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	2,591	Table 11
i	QALYs lost due to obesity, female	2,336	Table 11
j	Number of obese 30 year-olds, male	1,113	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	6,359	= j * l
o	Total life years lost due to obesity, female	3,550	= k * m
p	Total life years lost due to obesity	9,909	= 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	32.6	Table 12
u	QALYs saved due to treatment, female	30.0	Table 12
v	Reduction in number of obese 30 year-olds, male	15.0	Table 12
w	Reduction in number of obese 30 year-olds, female	11.0	Table 12
x	Life years saved due to intervention, male	85.6	= v * l
y	Life years saved due to intervention, female	47.8	= w * m
z	**QALYs Gained due to intervention**	196	= 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 = 264
- 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 = 421

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.[266]
- 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%.[267]
- 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 physician's office (e.g. public health nurses carrying out a well-child visit at a community setting)."[268] 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.[269]
- 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).[270]

[266] 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.

[267] 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*)

[268] 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.

[269] 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.

[270] 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.

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	19,940	100.0%	100.0%	19,927	19,940	13.0%	2,591	2,592
1	19,915	19,930	69.3%	69.3%	13,801	13,812	13.0%	1,794	1,796
2	19,910	19,926	69.3%	69.3%	13,798	13,809	13.0%	1,794	1,795
3	19,909	19,923	69.3%	69.3%	13,797	13,806	13.0%	1,794	1,795
4	19,907	19,920	69.3%	69.3%	13,795	13,804	13.0%	1,793	1,795
5	19,905	19,918	69.3%	69.3%	13,794	13,803	13.0%	1,793	1,794
6	19,904	19,917	69.3%	69.3%	13,793	13,802	13.0%	1,793	1,794
7	19,903	19,915	69.3%	69.3%	13,793	13,801	13.0%	1,793	1,794
8	19,902	19,914	69.3%	69.3%	13,792	13,801	13.0%	1,793	1,794
9	19,900	19,913	69.3%	69.3%	13,791	13,800	13.0%	1,793	1,794
10	19,899	19,912	69.3%	69.3%	13,790	13,799	13.0%	1,793	1,794
11	19,897	19,912	69.3%	69.3%	13,789	13,799	13.0%	1,793	1,794
12	19,895	19,911	69.3%	69.3%	13,787	13,798	13.0%	1,792	1,794
13	19,893	19,910	69.3%	69.3%	13,786	13,797	13.0%	1,792	1,794
14	19,890	19,908	69.3%	69.3%	13,784	13,796	13.0%	1,792	1,794
15	19,886	19,906	70.5%	70.5%	14,020	14,033	13.0%	1,823	1,824
16	19,881	19,902	70.5%	70.5%	14,016	14,031	13.0%	1,822	1,824
17	19,875	19,897	70.5%	70.5%	14,012	14,027	13.0%	1,822	1,824
Total	**358,197**	**358,473**			**255,064**	**255,260**		**33,158**	**33,184**

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 2017 ($25.16[271]) plus 18% benefits for an average cost per hour of $29.69. In the absence of specific data on the amount of time required, we assume two hours per service (2 * $29.69 = $59.38) (Table 16, row *f*).
- The estimated cost of a visit to a GP of $34.85 (Table 16, row *e*) is based on the average cost of an office visit between the ages of 2 and 79.[272] 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. These costs have remained constant over the last several years.[273]

[271] Statistics Canada. *Average Hourly Wages of Employees by Selected Characteristics and Occupation, Unadjusted Data, by Province (monthly) (British Columbia)*. 2017. Available at http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/labr69k-eng.htm. Accessed July 2017.
[272] Ministry of Health. *Medical Services Commission Payment Schedule*. 2016. Available at http://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msc-payment-schedule-december-2016.pdf. Accessed July 2017.
[273] Arlene Cristall, Provincial Lead, The Centre for Healthy Weights – Shapedown BC. September 2020. Personal communication.

- 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). 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).[274] 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.[275]
- Not all families that enroll actually start the program. Based on data to date,[276] 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[277]) suggesting that 157 children would start the program once fully implemented.
- Estimated costs for Generation Health once fully implemented are $695,700 per year.[278] 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).
- 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 thus be $7,681 (207*$8,671 + 63*$4,431)/270)). Once Generation Health is fully implemented, we would expect the weighted cost per child to decrease to $6,842 (207*$8,671 + 157*$4,431)/364)).
- For modelling purposes, we assumed a program cost per child of $7,681 (Table 16, row *j*) and reduced this to $6,842 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 $89.07 ($29.69 * 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.

[274] Childhood Obesity Foundation. *Generation Health: Evaluation Report June 2020*.
[275] Karen Strange, Project Director, Generation Health, Childhood Obesity Foundation. October 9, 2020. Personal communication.
[276] Childhood Obesity Foundation. *Generation Health: Evaluation Report June 2020*.
[277] Childhood Obesity Foundation. *Generation Health: Evaluation Report June 2020*.
[278] Karen Strange, Project Director, Generation Health, Childhood Obesity Foundation. October 9, 2020. Personal communication.

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	1,053	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	1,606	1,168	0.8%	13.1	9.5
16	1,606	1,167	0.8%	13.1	9.5
17	1,605	1,167	0.8%	13.1	9.5
Total	**15,959**	**10,730**	**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) (Table 16, rows *s* & *t*).[279]

- 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.

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 $29,436 / QALY(Table 16, row *v*).

[279] 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.

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	33,158	Table 14
c	Healthy weight monitoring screens conducted, 0 - 17 years, females	33,184	Table 14
d	Proportion of office visit required for short screen	50.0%	√
e	Cost of 10-minute office visit	$34.85	√
f	Patient time costs / office visit	$59.38	√
g	**Cost of healthy weight screening**	**$3,125,709**	= (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	$7,681	√
k	**Cost of healthy weight intervention**	**$1,674,282**	= (h + i) * j
l	Patient time costs per session	$89.07	√
m	Number of intervention sessions	10	√
n	**Patient time cost**	**$194,141**	= (h + i) * l * m
o	**Total cost of intervention**	**$1,868,423**	= k + n
p	**Total cost of screening and healthy weight intervention, cohort**	**$4,994,133**	= g + o
	Costs Avoided due to Healthy Weight Intervention		
q	Life years with avoided obesity, lifetime, males	990	Table 12
r	Life years with avoided obesity, lifetime, females	781	Table 12
s	Annual excess medical cost for individuals with obesity, males	$698	√
t	Annual excess medical cost for individuals with obesity, females	$952	√
u	Cost avoided due to healthy weight intervention, males	$691,359	= q * s
v	Cost avoided due to healthy weight intervention, females	$743,736	= r * t
w	**Cost avoided due to healthy weight intervention, cohort**	**$1,435,095**	= u + v
	Cost Effectiveness of Screening and Healthy Weight Intervention		
x	Net Cost of Screening and Healthy Weight Intervention	$3,559,037	= p - w
y	QALYs gained due to intervention	196	Table 13, row z
z	CE ($/QALY Saved)	$18,148	= x / y
aa	Net Cost of Screening and Healthy Weight Intervention, 1.5% Discount	$3,527,856	Calculated
ab	QALYs saved, 1.5% Discount	120	Calculated
ac	**CE ($/QALY Saved), 1.5% Discount**	**$29,436**	= 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 = $46,693
- 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 = $21,575
- 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 = $32,727
- 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 = $26,903
- Assume that the reduction in obesity due to completing the intervention decreases from 18.8% to 6.1% (Table 13, row *s*): CE = $105,072
- Assume that the reduction in obesity due to completing the intervention increases from 18.8% to 40.2% (Table 13, row *s*): CE = $10,148
- Assume that the proportion of an office visit for weight measurement is decreased from 50% to 33% (Table 16, row *d*): CE = $21,731
- Assume that the proportion of an office visit for weight measurement is increased from 50% to 67% (Table 16, row *d*): CE = $37,141
- Assume that the cost of the weight management program per individual is reduced from $7,681 to $6,842 (Table 16, row *j*): CE = $28,162
- 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 = $524,527

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 120 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $29,436 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	**120**	**39**	**257**
3% Discount Rate	76	24	162
0% Discount Rate	196	63	421
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$29,436**	**$10,148**	**$524,527**
3% Discount Rate	$43,604	$16,879	$586,306
0% Discount Rate	$18,148	$4,551	$469,124
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$13,518	$2,729	$281,502
3% Discount Rate	$21,170	$6,423	$311,321
0% Discount Rate	$7,114	-$591	$254,265

Preventing Tobacco Use

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).*[280]

United States Preventive Services Task Force Recommendations (2013)

> *The USPSTF recommends that primary care clinicians provide interventions, including education or brief counselling, to prevent initiation of tobacco use in school-aged children and adolescents. (B Recommendation)*[281]

In their review of the evidence,[282] 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 youths and young adults.[283] These strategies include coordinated, multi-component campaigns 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 that aim to reduce tobacco use among children and adolescents."[284]

Modelling the Clinically Preventable Burden

In this section, we model CPB 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 among children and youth.

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[280] 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.

[281] Moyer VA. Primary care interventions to prevent tobacco use in children and adolescents: U.S. Preventive Services Task Force recommendation statement. *Annals of Internal Medicine*. 2013; 159(8): 552-7.

[282] 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.

[283] 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.

[284] 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.

In modelling CPB, we made the following assumptions:

- Interventions aimed at reducing smoking initiation among non-smoking children and adolescents have an effectiveness of 18% (RR 0.82, 95% CI of 0.72 to 0.94).[285]
- 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).[286]
- An estimated 12.34% of 19 year-olds were daily or occasional smokers in BC in 2010 (see Table 1).[287]

Table 1: Smokers in British Columbia in 2010
Based on 2010 CCHS Data
Ages 12 to 19

	Total Population			Daily Smokers			Occasional Smokers			Current Smokers as % of Pop.		
Age Group	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total
12-14	73,171	68,779	**141,950**	459	-	**459**	97	-	**97**	0.76%	0.00%	0.39%
15-17	81,088	74,831	**155,919**	4,383	2,994	**7,377**	1,274	208	**1,482**	6.98%	4.28%	5.68%
18-19	57,055	55,256	**112,311**	4,661	4,479	**9,140**	3,541	1,175	**4,716**	14.38%	10.23%	12.34%
Total	**211,314**	**198,866**	**410,180**	**9,503**	**7,473**	**16,976**	**4,912**	**1,383**	**6,295**	**6.82%**	**4.45%**	**5.67%**

- On average, 57.3% of smokers would quit (become former smokers) by the age of 25-34 (Table 3, row *e*), 60.4% by age 35-44 (Table 3, row *h*) and 68.9% by age 45-54 (Table 3, row *k*) (see Table 2).[288]

Table 2: Smoking Occurrence
British Columbia, 2010

SMOKING CATEGORY	AGE GROUP 18-24	25-34	35-44	45-54	55-64	65+
DAILY SMOKER	50,238	91,696	94,232	114,679	70,612	47,346
OCCASIONAL SMOKER (FORMER DAILY SMOKER)	17,203	27,935	21,481	18,486	9,914	12,950
ALWAYS AN OCCASIONAL SMOKER	31,786	18,272	15,056	7,787	6,320	296
FORMER DAILY SMOKER	27,365	77,671	110,446	203,967	183,720	256,094
FORMER OCCASIONAL SMOKER	53,224	107,195	89,353	108,870	83,717	92,489
NEVER SMOKED	225,389	267,255	288,143	265,911	209,738	223,185
SMOKERS	179,816	322,769	330,568	453,789	354,283	409,175
% of FORMER SMOKERS	44.8%	57.3%	60.4%	68.9%	75.5%	85.2%

- An average of 11.5 life years lost per smoker (Table 3, row *c*). An average of 10.5 of those life-years can be regained by stopping smoking at age 30 (Table 3, row *g*), 9.5 by stopping smoking at age 40 (Table 3, row *j*) and 6.5 by stopping smoking at age 50 (Table 3, row *l*).[289]
- Other assumptions used in assessing the clinically preventable burden are detailed in the Reference Document.

[285] 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): e310-6.
[286] 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): e310-6.
[287] This analysis is based on the Statistics Canada's Canadian Community Health 2010 Public Use Microdata File. All computations, use and interpretation of these data are entirely that of H. Krueger & Associates Inc.
[288] This analysis is based on the Statistics Canada's Canadian Community Health 2010 Public Use Microdata File. All computations, use and interpretation of these data are entirely that of H. Krueger & Associates Inc.
[289] 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.

Based on these assumptions, the CPB associated with interventions aimed at preventing and / or treating tobacco smoking among children and youth is 4,123 QALYs (Table 3, row *gg*). The CPB of 4,123 represents the gap between no coverage and the 'best in the world' coverage, which was estimated at 53%.

Table 3: CPB of Interventions for Tobacco Use Prevention and Cessation in Children and Youth for Birth Cohort of 40,000 Individuals (B.C.)			
Estimate of Life Years Lost without Intervention		**Base Case**	**Data Source**
a	% of 19 year-olds who smoke in B.C.	12.34%	Table 1
b	Estimated # in birth cohort initiating smoking by age 19	4,935	= a* 40,000
c	Life-years lost per smoker	11.5	√
d	Potential life-years lost	56,751	= c * b
e	Proportion former smokers at age 30	57.3%	Table 2
f	Former smokers at age 30	2,828	= e * b
g	Life-years gained by stopping smoking at age 30	10.5	√
h	Proportion former smokers at age 40	60.4%	Table 2
i	Former smokers at age 40	2,981	= h * b
j	Life-years gained by stopping smoking at age 40	9.5	√
k	Proportion former smokers at age 50	68.9%	Table 2
l	Life-years gained by stopping smoking at age 50	6.5	√
m	Former smokers at age 50	3,400	= k * b
n	Life-years gained by stopping smoking	33,871	= (f*g)+(i-f)*j+(m-i)*l
o	**Estimated Life Years Lost without Intervention**	**22,881**	= d - n
Estimate of Life Years Lost with Intervention			
p	Effectiveness of intervention	34.0%	√
q	Estimated # in birth cohort initiating smoking by age 19	3,257	= a * (1 - p) *40,000
r	Life-years lost per smoker	11.5	√
s	Potential life-years lost	37,456	= r * q
t	Proportion former smokers at age 30	57.3%	Table 2
u	Former smokers at age 30	1,866	= t * q
v	Life-years gained by stopping smoking at age 30	10.5	√
w	Proportion former smokers at age 40	60.4%	Table 2
x	Former smokers at age 40	1,967	= w * q
y	Life-years gained by stopping smoking at age 40	9.5	√
z	Proportion former smokers at age 50	68.9%	Table 2
aa	Life-years gained by stopping smoking at age 50	6.5	√
bb	Former smokers at age 50	2,244	= z * q
cc	Life-years gained by stopping smoking	22,355	= (u*v)+(x-u)*y+(bb-x)*aa
dd	**Estimated Life Years Lost with Intervention**	**15,101**	= s - cc
Calculation of CPB			
ee	Life-years gained with 100% adherence	7,779	= o - dd
ff	Potential coverage of this service	53%	Ref Doc
gg	Potential CPB in BC	**4,123**	= ee * ff

√ = Estimates from the literature

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

- Assume the effectiveness of interventions aimed at smoking cessation among children and adolescents is reduced from 34% to 5% (Table 3, row *p*): CPB = 606.

- Assume the effectiveness of interventions aimed at smoking cessation among children and adolescents is increased from 34% to 69% (Table 3, row *p*): CPB = 8,367.

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 among children and youth.

In estimating CE, we made the following assumptions:

- The USPSTF evidence review suggests that the effectiveness of the intervention lasts for at least two years.[290] We have assumed that an intervention would be required seven times between the ages of 5 and 19 for maximum effect (Table 4, row *d*).
- 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 smoking among children and youth is -$7,349 per QALY (Table 4, row *p*).

Table 4: Cost Effectiveness of Interventions for Tobacco Use Prevention in Children and Youth for Birth Cohort of 40,000 Individuals (B.C.)

		Base Case	Data Source
Cost of counseling			
a	Cost of 10-minute office visit	$34.85	Ref Doc
b	Cost of patient time and travel for office visit	$59.38	Ref Doc
c	Portion of office visit needed for counseling	50%	Ref Doc
d	# of interventions	7.0	√
e	Total cost of counseling per individual	$329.81	= (a+b)*c*d
f	Estimated Cost of Counselling	$13,192,200	= e * 40,000
Estimated Cost Avoidance			
g	Annual medical costs avoided per additional year as never smoker	$1,195	Ref Doc
h	Years of smoking avoided due to intervention	43,950	Calculated
i	Costs avoided	$52,520,012	= g * h
CE calculation			
j	Estimated Cost of Counselling	$13,192,200	= f
k	Costs avoided	$52,520,012	= i
l	Potential QALYs saved	4,123	= Table 3, row gg
m	Estimated Cost of Counselling (1.5% discount rate)	$11,830,577	Calculated
n	Costs avoided (1.5% discount rate)	$27,965,774	Calculated
o	Potential QALYs saved (1.5% discount rate)	2,195	Calculated
p	**Cost per QALY (CE)**	**-$7,349**	= (m - n) / o

Notes: *√ = Estimates from the literature*

[290] 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.

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

- Assume the effectiveness of interventions aimed at smoking cessation among children and adolescents is reduced from 34% to 5% (Table 3, row *p*): $/QALY = $23,905.
- Assume the effectiveness of interventions aimed at smoking cessation among children and adolescents is increased from 34% to 69% (Table 3, row *p*): $/QALY = -$10,083.
- Assume the portion of an office visit needed for counselling is reduced from 50% to 33% (Table 4, row *c*): $/QALY = -$9,182.
- Assume the portion of an office visit needed for counselling is increased from 50% to 67% (Table 4, row *c*): $/QALY = -$5,517.

Summary

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 is estimated to be 2,195 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to result in cost savings of $7,349 per QALY (see Table 5).

Table 5: Interventions for Tobacco Use Prevention and Cessation in Children and Youth for Birth Cohort of 40,000

Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume No Current Service			
1.5% Discount Rate	**2,195**	323	4,455
3% Discount Rate	1,206	177	2,447
0% Discount Rate	4,123	606	8,367
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**-$7,349**	-$10,083	$23,905
3% Discount Rate	-$3,909	-$8,388	$47,299
0% Discount Rate	-$9,538	-$11,161	$9,019
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	-$10,745	-$11,756	$814
3% Discount Rate	-$9,473	-$11,129	$9,466
0% Discount Rate	-$11,555	-$12,155	-$4,691

Preventive Medication / Devices

Fluoride Varnish and Fissure Sealants for Dental Health in Children

United States Preventive Service Task Force Recommendations (2014)

> *Dental caries is the most common chronic disease in children in the United States. According to the 1999–2004 National Health and Nutrition Examination Survey (NHANES), ~ 42% of children ages 2 to 11 years have dental caries in their primary teeth. After decreasing from the early 1970s to the mid-1990s, the prevalence of dental caries in children has been increasing, particularly in young children ages 2 to 5 years.*
>
> *The U.S. Preventive Services Task Force recommends that primary care clinicians prescribe oral fluoride supplementation starting at age 6 months for children whose water supply is deficient in fluoride. (B recommendation)*
>
> *The U.S. Preventive Services Task Force recommends that primary care clinicians apply fluoride varnish to the primary teeth of all infants and children starting at the age of primary tooth eruption. (B recommendation)*[291]

Canadian Task Force on Preventive Health Care Recommendations (1994)

> *Lower dental caries prevalence and the need for efficiency in the provision of preventive and therapeutic dental services require selective use of dental caries preventives and targeting of services toward persons at greatest risk. The following recommendations are based on a review of the available evidence.*
>
> *There is good evidence of effectiveness of the following measures in preventing dental caries (A Recommendation):*
>
> > *1. Water fluoridation for preventing coronal and root caries;*
> >
> > *2. Fluoride supplements in low fluoride areas with careful adherence to low dosage schedules;*
> >
> > *3. Professional topical fluoride applications and self-administered fluoride mouth rinses for those with very active decay or at high future risk for dental caries;*
> >
> > *4. Fluoride dentifrices, with special supervision and the use of small amounts for young children;*
> >
> > *5. Professionally-applied fissure sealants for selective use on permanent molar teeth soon after their eruption.*[292]

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*

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[291] Moyer VA. Prevention of dental caries in children from birth through age 5 years: US Preventive Services Task Force recommendation statement. *Pediatrics*. 2014; 133(5): 1-10.

[292] Lewis DW and Ismail AI. *Canadian Guide to Clinical Preventive Health Care: Chapter 36: Prevention of Dental Caries*. 1994. Available at http://canadiantaskforce.ca/wp-content/uploads/2013/03/Chapter36_dental_caries94.pdf?0136ff. Accessed November 2013.

moderate-quality evidence that resin-based sealants reduced caries by between 11% and 51% compared to no sealant, when measured at 24 months.[293]

Fluoride Varnish – Modelling the Clinically Preventable Burden

In this section, we model the CPB associated with applying fluoride varnish every six months between the ages of one and five for the prevention of dental caries in children.

In modelling CPB, we made the following assumptions:

- In 2012/13, 91.8% of BC kindergarten children were screened for dental health. Of these, 67.3% were caries free, 18.1% had treated caries and 14.6% had visible decay (Table 1, row *a*).[294]
- The effectiveness of fluoride varnish in reducing decayed, missing and filled teeth is 37% with a 95% CI of 24% to 51% (Table 1, row *b*).[295]
- Other assumptions used in assessing the clinically preventable burden are detailed in the Reference Document.

Based on these assumptions, the CPB associated with applying fluoride varnish every six months between the ages of one and five for the prevention of dental caries in children is 150 (Table 1, row *i*).

Table 1: CPB of Flouride Varnish for the Prevention of Dental Caries in Children < 5 Years of Age in a Birth Cohort of 40,000 (B.C.)

Row Label	Variable	Base Case	Data Source
a	Proportion of B.C. kindergarten children caries free	67.3%	√
b	Effectiveness of fluoride varnish in reducing decayed, missing and filled tooth surfaces	37.0%	√
c	Adherence with intervention	62%	Ref Doc
d	Children with treated caries or visible decay	13,080	= (1-a)*40,000
e	Children benefitting from intervention	3,001	= (d * c) * b
f	Years of benefits (from ages 1 to 5) per child	5.0	√
g	Life-years lived with poor oral health	15,003	= e * f
h	Change in QoL associated with improved oral health	0.01	Ref Doc
i	**Potential QALYs gained, CPB**	**150**	= g * h

√ = Estimates from the literature

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

- Assume the effectiveness of fluoride varnish in reducing decayed, missing and filled teeth is reduced from 37% to 24% (Table 1, row *b*): CPB = 97
- Assume the effectiveness of fluoride varnish in reducing decayed, missing and filled teeth is increased from 37% to 51% (Table 1, row *b*): CPB = 207

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[293] 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.

[294] Healthy Development and Women's Health Directorate - BC Ministry of Health. *BC Dental Survey of Kindergarten Children 2012-2013: A Provincial and Regional Analysis* 2014. Available at http://www.health.gov.bc.ca/women-and-children/pdf/provincial-kindergarten-dental-survey-2012-13.pdf. Accessed July 2014.

[295] Marinho VC, Worthington HV, Walsh T et al. Fluoride varnishes for preventing dental caries in children and adolescents. *Cochrane Database of Systematic Reviews.* 2013.

- Assume the change in QoL associated with improved oral health is reduced from 0.01 to 0.005 (Table 1, row *h*): CPB = 75
- Assume the change in QoL associated with improved oral health is increased from 0.01 to 0.019 (Table 1, row *h*): CPB = 285

Fluoride Varnish – Modelling Cost-Effectiveness

In this section, we model the CE associated with applying fluoride varnish every six months between the ages of one and five for the prevention of dental caries in children.

In modelling CE, we made the following assumptions:

- Fluoride varnish would be available for application to all children in BC with a 62% adherence rate (Table 2, row *b*).
- Assume fluoride varnish would need to be applied once every six months from age 1 to age 5 for a total of 9 applications (Table 2, row *f*).[296]
- For patient time and travel costs, we assumed an hour of patient time required per dental visit and three hours of patient time for dental day surgery. Dental day surgery in BC lasts an average of 83 minutes.[297]
- Assume 2.9 new carious surfaces per untreated 5 year-old (Table 2, row *g*).[298]
- The prevalence for day surgery for dental cavities in BC is estimated to be 1.38% of children (Table 2, row *l*).[299]
- 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 applying fluoride varnish every six months between the ages of one and five for the prevention of dental caries in children is $43,048 per QALY (Table 2, row *y*).

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[296] Fluoride Recommendations Work Group. Recommendations for using fluoride to prevent and control dental caries in the United States. *Morbidity and Mortality Weekly Report Recommendations and Reports*. 2001; 50(RR-14): 1-42.
[297] 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 2014.
[298] Ramos-Gomez FJ and Shepard DS. Cost-effectiveness model for prevention of early childhood caries. *Journal of the California Dental Association*. 1999; 27(7): 539-44.
[299] 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 2014.

Table 2: CE of Flouride Varnish for the Prevention of Dental Caries in Children < 5 Years of Age in a Birth Cohort of 40,000 (B.C.)			
Label	**Variable**	**Base Case**	**Data Source**
a	Children eligible for intervention	40,000	√
b	Adherence with intervention	62%	= Table 1 row c
c	Children with treated caries or visible decay	13,080	= Table 1 row d
	Costs of intervention		
d	Cost of flouride varnish application	$10.61	Ref Doc
e	Value of patient time and travel for office visit	$29.69	Ref Doc
f	# of times flouride varnish applied from age 1 to 5	9	√
g	Estimated cost of intervention over lifetime of birth cohort	$8,994,960	= (d + e) * f *a *b
	Cost avoided		
h	New carious surfaces per untreated 5 year-old	2.9	√
i	Dental caries avoided	14,035	= g * c * Table 1 row b
j	Cost per filling	$92.75	Ref Doc
k	Value of patient time and travel for office visit	$59.38	Ref Doc
l	Filling costs avoided	-$2,135,120	= (i + j) * h
m	Prevalence of day surgery for caries	1.38%	√
n	Day surgeries without intervention in birth cohort	552	= a * m
o	Day surgeries avoided with intervention in birth cohort	204	= m * Table 1 row b
p	Cost of day surgery	$1,884	Ref Doc
q	Value of patient time and travel for day surgery	$89.07	Ref Doc
r	Day surgery costs avoided	-$402,980	= (p + q) * o
	CE calculation		
s	Cost of intervention over lifetime of birth cohort	$8,994,960	= g
t	Costs avoided	-$2,538,100	= l + r
u	QALYs saved	150	Table 8-1 row i
v	Cost of intervention over lifetime of birth cohort (1.5% discount)	$8,605,388	Calculated
w	Costs avoided (1.5% discount)	-$2,428,175	Calculated
x	QALYs saved (1.5% discount)	144	Calculated
y	**CE ($/QALY saved)**	**$43,038**	= (v + w) / x

√ = Estimates from the literature

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

- Assume the effectiveness of fluoride varnish in reducing decayed, missing and filled teeth is reduced from 37% to 24% (Table 1, row *b*): CE = $75,514
- Assume the effectiveness of fluoride varnish in reducing decayed, missing and filled teeth is increased from 37% to 51% (Table 1, row *b*): CE = $26,579
- Assume the change in QoL associated with improved oral health is reduced from 0.01 to 0.005 (Table 1, row *h*): CE = $86,076
- Assume the change in QoL associated with improved oral health is increased from 0.01 to 0.019 (Table 1, row *h*): CE = $22,651
- Assume that the application of fluoride varnish is equally effective if applied annually (versus every six months) (Table 2, row *f*). The evidence on frequency of applications is inconclusive[300]: CE = $16,391
- Assume that the cost per filling is reduced from $92.75 to $83.10 (Table 2, row *j*): CE = $43,941

[300] Marinho VC, Worthington HV, Walsh T et al. Fluoride varnishes for preventing dental caries in children and adolescents. *Cochrane Database of Systematic Reviews.* 2013.

- Assume that the cost per filling is increased from $92.75 to $102.40 (Table 2, row *j*): CE = $42,135

Fluoride Varnish – Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with applying fluoride varnish every six months between the ages of one and five for the prevention of dental caries in children is estimated to be 144 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $43,038 per QALY (see Table 3).

Table 3: Application of Fluoride Varnish for Children < 5 Years of Age in a Birth Cohort of 40,000

Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume No Current Service			
1.5% Discount Rate	**144**	72	273
3% Discount Rate	137	69	261
0% Discount Rate	150	75	285
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$43,038**	$16,391	$86,076
3% Discount Rate	$43,038	$16,391	$86,076
0% Discount Rate	$43,038	$16,391	$86,076
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$4,543	-$2,472	$9,087
3% Discount Rate	$4,543	-$2,472	$9,087
0% Discount Rate	$4,543	-$2,472	$9,087

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.[301]

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:

- 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.[302]
- 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

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301 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.

302 Ahovuo-Saloranta A, Forss H, Walsh T et al. Sealants for preventing dental decay in the permanent teeth. *Cochrane Database of Systematic Reviews.* 2013.

mouth.[303] 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 4, row *j*).

- 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 4, row *m*). The CPB of 157 represents the gap between no coverage and improving coverage to 59%.

Table 4: CPB of Dental Sealants in Children/Youth 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	39,818	Ref Doc
b	Adherence with intervention	59%	Ref Doc
c	Children 'accepting' intervention	23,492	= 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	180,615	= c * d
g	Estimated new caries with intervention	57,718	= c * e
h	New caries avoided with intervention	122,898	= f - g
i	Life-years lived without caries due to intervention	130,643	Calculated
j	Proportion of children living with caries with significant pain	12.0%	√
k	Life-years lived without caries or pain due to intervention	15,677	= I * j
l	Change in QoL associated with improved oral health	0.01	Ref Doc
m	Potential QALYs gained, Intervention increasing from 0% to 59%	157	= k * l

√ = 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 4, row *l*): CPB = 78
- Assume the change in QoL associated with improved oral health is increased from 0.01 to 0.019 (Table 4, row *l*): 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 5, row *d*).
- For patient time and travel costs, we estimated two hours of patient time per dental visit.

[303] 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.

- An average of 1.84 fillings would be treated each time fillings are required (Table 5, row *l*).[304]
- 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 -$24,690 per QALY (Table 5, row *v*).

Table 5: CE of Dental Sealants in Children/Youth with Permanent Teeth in a Birth Cohort of 40,000 (B.C.)

Label	Variable	Base Case	Data Source
a	Children eligible for intervention	39,818	= Table 4, row a
b	Adherence with intervention	59%	= Table 4, row b
c	Children 'accepting' intervention	23,492	= Table 4, row c
	Costs of intervention		
d	Cost of dental sealant applications	$280.24	√
e	Value of patient time and travel for office visit	$59.38	Ref Doc
f	# of sealant applications (at age 6, 10 and 12)	3	√
g	Estimated cost of intervention over lifetime of birth cohort	$6,583,506	= c * d
h	Estimated cost of patient time over lifetime of birth cohort	$4,184,933	= c * e * f
	Cost avoided		
i	Dental caries avoided with intervention	122,898	Calculated
j	Cost per filling	$92.75	Ref Doc
k	Value of patient time and travel for office visit	$59.38	Ref Doc
l	# of fillings per visit	1.84	√
m	# of dental visits avoided	66,792	= i / l
n	Filling costs avoided	-$11,398,770	= i * j
o	Patient costs avoided	-$3,966,125	= m * k
	CE calculation		
p	Cost of intervention over lifetime of birth cohort	$10,768,439	= g + h
q	Costs avoided	-$15,364,896	= n + o
r	QALYs saved	157	Table 4, row k
s	Cost of intervention over lifetime of birth cohort (1.5% discount)	$10,096,096	Calculated
t	Costs avoided (1.5% discount)	-$13,499,918	Calculated
u	QALYs saved (1.5% discount)	138	Calculated
v	**CE ($/QALY saved)**	**-$24,690**	= (s + t) / u

√ = Estimates from the literature

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 4, row *l*): CE = -$24,359
- Assume the change in QoL associated with improved oral health is increased from 0.01 to 0.019 (Table 4, row *l*): CE = -$24,851
- Assume that the cost per filling is reduced from $92.75 to $83.10 (Table 5, row *j*): CE = -$17,132

[304] 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.

- Assume that the cost per filling is increased from $92.75 to $102.40 (Table 5, row *j*): CE = -$32,248

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 138 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to result in cost savings of $24,690 per QALY (see Table 6).

Table 6: 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	**138**	69	262
3% Discount Rate	121	61	231
0% Discount Rate	157	78	298
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**-$24,690**	-$32,248	-$17,132
3% Discount Rate	-$19,774	-$27,326	-$12,222
0% Discount Rate	-$29,320	-$36,884	-$21,755
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	-$27,902	-$35,460	-$20,344
3% Discount Rate	-$24,922	-$32,474	-$14,370
0% Discount Rate	-$30,715	-$38,280	-$23,150

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)* [305]

United States Preventive Services Task Force Recommendations (2016)

> *The USPSTF recommends biennial screening mammography for women aged 50 to 74 years. (B recommendation)*[306]

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 2010 to 2012, a total of 3,938 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 1,990 deaths in females between the ages of 45 and 64 in BC in 2012, with 215 (10.8%) of these deaths due to breast cancer (ICD-10 codes C50). There were also 3,566 deaths between the ages of 65 and 79 that year, with 230 (6.4%) of these deaths due to breast cancer.[307] This suggests that 288 of the 3,938 (7.3%) 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).

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[305] Canadian Task Force on Preventive Health Care. *Screening for Breast Cancer*. 2011. Available at http://canadiantaskforce.ca/guidelines/2011-breast-cancer/. Accessed October 2013.

[306] 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.

[307] British Columbia Vital Statistics Agency. *Selected Vital Statistics and Health Status Indicators: One Hundred and Forty-First Annual Report*. Apendix 2. 2012. British Colubmia Ministry of Health. Available at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2012/pdf/annual-report-2012.pdf. Accessed December 2017.

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	*Mean Survival Rate* Males	*Mean Survival Rate* Females	*Individuals in Birth Cohort* Males	*Individuals in Birth Cohort* Females	*Individuals in Birth Cohort* Total	*Life Years Lived*	*Deaths in Birth Cohort* %	*Deaths in Birth Cohort* #	*Deaths due to* Breast Cancer %	*Deaths due to* Breast Cancer #	*Life Years Lost* Per Death	*Life Years Lost* Total
45-49		0.977		19,546	19,546							
50-54		0.969		19,375	19,375	96,873	0.9%	171	10.8%	19	33.8	626
55-59		0.956		19,118	19,118	95,591	1.3%	256	10.8%	28	29.2	809
60-64		0.936		18,726	18,726	93,630	2.1%	392	10.8%	42	24.7	1,046
65-69		0.906		18,113	18,113	90,567	3.4%	613	6.4%	39	20.4	800
70-74		0.857		17,144	17,144	85,720	5.7%	969	6.4%	62	16.3	1,011
75-79		0.780		15,608	15,608	78,041	9.8%	1,536	6.4%	98	12.6	1,238
								3,938	**7.3%**	**288**	**19.2**	**5,530**

- 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%.[308]
- For every death avoided, 204 women will have false positive results.[309] We have assumed a one-time QALY loss of 0.013 (4.7 days) after a false-positive mammography result.[310]
- For every death avoided, 26 women will have an unnecessary biopsy.[311]
- For every death avoided, 3 women will have an unnecessary lumpectomy or mastectomy (with a 3:1 ratio for lumpectomy vs. mastectomy).[312]
- 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 1,189 QALYs saved (Table 2, row *o*). The CPB of 1,189 represents the gap between no coverage and the 'best in the world' coverage estimated at 88%. The CPB of 486 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%.

308 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.
309 Ibid.
310 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.
311 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.
312 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	288	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	331	= a / (1 - d * c)
	Benefits of Screening		
g	Deaths avoided - 100% adherence	82	= f * c
h	Deaths avoided - 88% adherence	72	= g * e
i	Deaths avoided - 52% adherence	42	= g * d
j	Life expectancy at average age of breast cancer death	19.2	Table 1
k	QALYs saved with 88% adherence to screening	1,379	= 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	-191	= h * l * m
	Summary of Benefits and Harms		
o	Potential QALYs saved - Utilization increasing from 0% to 88%	1,189	= k + n
p	Potential QALYs saved - Utilization increasing from 52% to 88%	486	= 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 = 526.
- Assume the effectiveness of screening mammography in reducing deaths from breast cancer is increased from 21% to 32% (Table 2, row *b*): CPB = 1,963.

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.[313] There are a total of 462,381 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 184,952 screens for the birth cohort assuming 100% adherence. At 88% adherence, the number of screens would be reduced to 162,758 (Table 3, row *a* & *b*).

[313] 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 $5,152 and a mastectomy of $7,260 (see reference document) for a weighted cost of $5,679 (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 $57.56, 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 $19,720 / 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	184,952	√
b	Screening visits with 88% Adherence	162,758	= a * Table 2, row e
c	Cost per screen	$79.35	Ref Doc
d	Value of patient time (per hour)	$29.69	Ref Doc
e	Screening costs	$12,914,856	= b * c
f	Patient time costs	$9,664,577	= (b * d) * 2
g	Deaths avoided	72	Table 2, row h
h	Costs avoided per death prevented	-$47,230	Ref Doc
i	Costs avoided due to deaths prevented	-$3,394,150	= g * h
j	Unnecessary lumpectomies / mastectomies for every death avoided	3	√
k	Costs per lumpectomy / mastectomy	$5,679	Ref Doc
l	Costs associated with unnecessary lumpectomies / mastectomies	$1,224,352	= g * j * k
m	Unnecessary biopsies per death avoided	26	√
n	Cost per unnecessary biopsy	$386	Ref Doc
o	Costs for unnecessary biopsies	$721,230	= n * f * o
p	Patient time and travel costs associated with unnecessary procedures	$656,098	= ((g * j * 7.5)+(g * m * 37.5)) * d
q	Net costs undiscounted	$21,786,962	= e + f + i + l + o + p
r	CPB undiscounted	1,189	Table 2, row o
s	Net costs 1.5% discount	$18,103,440	Calculated
t	CPB 1.5% discount	918	Calculated
u	CE ($/QALY saved)- 1.5% discount	$19,720	= 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*): $/QALY = $45,514.
- Assume the effectiveness of screening mammography in reducing deaths from breast cancer is increased from 21% to 32% (Table 2, row *b*): $/QALY = $11,659.

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 918 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $19,720 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	**918**	406	1,516
3% Discount Rate	721	319	1,191
0% Discount Rate	1,189	526	1,963
Gap between B.C. Current (52%) and 'Best in the World' (88%)			
1.5% Discount Rate	376	166	620
3% Discount Rate	295	131	487
0% Discount Rate	486	215	803
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$19,720**	$11,659	$45,514
3% Discount Rate	$21,048	$12,444	$48,580
0% Discount Rate	$18,326	$10,835	$42,298
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$10,378	$5,769	$25,132
3% Discount Rate	$11,077	$6,156	$26,825
0% Discount Rate	$9,645	$5,360	$23,356

Screening (Cytology-Based) for Cervical Cancer

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)*[314]

United States Preventive Services Task Force Recommendations (2017)

> *The USPSTF recommends screening for cervical cancer in women age 21 to 65 years with cytology (Pap smear) every 3 years or, for women age 30 to 65 years who want to lengthen the screening interval, screening with a combination of cytology and human papillomavirus (HPV) testing every 5 years.*[315]

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with screening women ages 25 to 69 years of age for cervical cancer, using cytology screening, every 3 years.

In modelling CPB, we made the following assumptions:

- Based on BC life tables for 2010 to 2012, a total of 2,721 deaths would be expected in females between the ages of 25-74 in a BC birth cohort of 40,000 (see Table 1). While routine screening occurs to age 69, we have assumed the protective effect of that routine screening would continue to age 74.
- Based on BC vital statistics data, there were 357 deaths in females between the ages of 25 and 44 in BC in 2012, with 8 (2.2%) of these deaths due to cervical cancer (ICD-10 codes C53). There were also 1,990 deaths between the ages of 45 and 64 that year, with 20 (1.0%) of these deaths due to cervical cancer. Finally, there were 3,566 deaths between the ages of 65 and 79 that year, with 10 (1.0%) of these deaths due to cervical cancer.[316] This suggests that 18 of the 2,721 (0.7%) of the female deaths in the BC birth cohort between the ages of 25 and 74 would be due to cervical cancer (see Table 1).

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[314] Canadian Task Force on Preventive Health Care. Recommendations on screening for cervical cancer. *Canadian Medical Association Journal*. 2013; 185(1): 35-45.
[315] US Preventive Services Task Force. Draft Recommendation Statement *Cervical Cancer: Screening.* 2017. Available online at https://www.uspreventiveservicestaskforce.org/Page/Document/draft-recommendation-statement/cervical-cancer-screening2. Accessed December 2017.
[316] British Columbia Vital Statistics Agency. *Selected Vital Statistics and Health Status Indicators: One Hundred and Forty-First Annual Report*. Apendix 2. 2012. British Colubmia Ministry of Health. Available at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2012/pdf/annual-report-2012.pdf. Accessed December 2017.

Table 1: Mortality Due to Cervical Cancer Between the Ages of 25 and 74
in a British Columbia Birth Cohort of 40,000

Age Group	*Mean Survival Rate*		*Individuals in Birth Cohort*			*Life Years Lived*	*Deaths in Birth Cohort*		*Deaths due to Cervical Cancer*		*Life Years Lost*	
	Males	Females	Males	Females	Total		%	#	%	#	Per Death	Total
20-24		0.993		19,865								
25-29		0.992		19,833		99,163	0.2%	32	2.2%	0.7	57.8	41
30-34		0.990		19,795		98,975	0.2%	38	2.2%	0.8	52.9	45
35-39		0.987		19,741		98,706	0.3%	54	2.2%	1.2	48.1	58
40-44		0.983		19,662		98,311	0.4%	79	2.2%	1.8	43.2	76
45-49		0.977		19,546		97,730	0.6%	116	1.0%	1.2	38.5	45
50-54		0.969		19,375		96,873	0.9%	171	1.0%	1.7	33.8	58
55-59		0.956		19,118		95,591	1.3%	256	1.0%	2.6	29.2	75
60-64		0.936		18,726		93,630	2.1%	392	1.0%	3.9	24.7	97
65-69		0.906		18,113		90,567	3.4%	613	0.3%	1.6	20.4	32
70-74		0.857		17,144		85,720	5.7%	969	0.3%	2.5	16.3	40
								2,721	**0.7%**	**18.0**	**31.6**	**568**

- Cervical cancer screening in women ages 25-69 leads to a reduction in cervical cancer mortality of 35% (RR 0.65, 95% CI of 0.47 to 0.90).[317]
- Cervical cancer screening in women ages 25-69 leads to a reduction in cervical cancer incidence of 44% (RR 0.56, 95% CI of 0.42 to 0.75).[318]
- Potential harms associated with cervical cancer screening include anxiety caused by false positive screening results and pain, bleeding or discharge after an unnecessary biopsy or loop electrosurgical excision and an increase in preterm births caused by excisional treatment of CIN.[319]
- The false positive rate associated with cytology screening ranges from 3.2% to 6.5%.[320] We have used the midpoint for our base case (4.9%) and the range in our sensitivity analysis. A false-positive Pap smear result is associated with a disutility of 0.046 for a period of approximately 10 months (or a one-time QALY loss of 0.038).[321]
- 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 25 to 69 years of age for cervical cancer every 3 years is 1,471 QALYs saved (Table 2, row *v*). The CPB of 1,471 represents the gap between no coverage and the 'best in the world' coverage estimated at 88%. The CPB of 317 QALYs saved (see Table 2, row *w*) represents the gap between the current coverage of 69% and the 'best in the world' coverage estimated at 88%.

[317] Peirson L, Fitzpatrick-Lewis D, Ciliska D, et al. Screening for cervical cancer: A systematic review and meta-analysis. *Systematic Reviews*. 2013; 2(35).
[318] Ibid.
[319] Habbema D, Weinmann S, Arbyn M, et al. Harms of cervical cancer screening in the United States and the Netherlands. *International Journal of Cancer*. 2017; 140: 1215-22.
[320] Melnikow J, Henderson J, Burda B, et al. *Draft Evidence Review: Cervical Cancer Screening, U.S. Preventive Services Task Force. October 2017.* Table 6. Available online at https://www.uspreventiveservicestaskforce.org/Page/Document/draft-evidence-review/cervical-cancer-screening2. Accessed December 2017.
[321] 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.

Table 2. Calculation of Clinically Preventable Burden for Cervical Cancer in Average Risk Women in a BC Birth Cohort of 40,000			
Row	**Variable**	**Base Case**	**Data Source**
	Estimated Current Status		
a	Total cervical cancer mortality in a birth cohort of 40,000 between the ages of 25 and 74	18.0	Table 1
b	Ratio of nonfatal cervical cancers per fatal cervical cancer	10.1	Ref Doc
c	Estimated nonfatal cervical cancers	181.4	= a * b
d	Effectiveness of screening in reducing mortality	35%	√
e	Effectiveness of screening in reducing incidence	44%	√
f	Current screening rate in BC	69%	Ref Doc
g	Potential screening rate	88%	Ref Doc
h	Predicted deaths in the absence of screening	23.7	= a / (1 - f * d)
i	Predicted nonfatal cervical cancers in absence of screening	260.5	= c / (1 - f * e)
	Benefits of Screening		
j	Deaths avoided - 100% adherence	8.3	= h * d
k	Deaths avoided - 88% adherence	7.3	= j * g
l	Deaths avoided - 69% adherence	5.7	= j * f
m	Nonfatal cancers avoided - 100% adherence	114.6	= i * e
n	Nonfatal cancers avoided - 88% adherence	100.9	= m * g
o	Nonfatal cancers avoided - 69% adherence	79.1	= m * f
p	LE at average age of cervical cancer death	31.6	Table 1
q	Life years lost per nonfatal cervical cancer	17	Ref Doc
r	QALYs saved with 88% adherence to screening	1,945	= (k * p) + (n * q)
	Harms Associated with Screening		
s	False-positive screening rate	4.9%	√
t	Reduced QALYs per false positive	0.038	√
u	Reduced QALYs associated with false positives	-475	= -(s * Table 3, row c) * t
	Summary of Benefits and Harms		
v	Potential QALY saved - Utilization increasing from 0% to 88%	1,471	= r + u
w	Potential QALY saved - Utilization increasing from 69% to 88%	317	= v * (g - f) / g

√ = Estimates from the literature

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

- Assume the effectiveness of screening in reducing cervical cancer deaths is reduced from 35% to 10% and the effectiveness of reducing cervical cancer incidence is reduced from 44% to 25% (Table 2, rows *d* & *e*): CPB = 399.
- Assume the effectiveness of screening in reducing cervical cancer deaths is increased from 35% to 53% and the effectiveness of reducing cervical cancer incidence is increased from 44% to 58% (Table 2, rows *d* & *e*): CPB = 2,567.
- Assume that the false-positive screening rate is reduced from 4.9% to 3.2% (Table 2, row *s*): CPB = 1,635.
- Assume that the false-positive screening rate is increased from 4.9% to 6.5% (Table 2, row *s*): CPB = 1,315.

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with screening women ages 25 to 69 years of age for cervical cancer every 3 years.

In estimating the CE of screening for cervical cancer, we made the following assumptions:

- We assumed a screening rate of once every 3 years starting at age 25. There are an estimated 869,546 life years lived by women between the ages of 25 and 69 in a BC birth cohort of 40,000, resulting in an estimated 255,067 screens (with 88% adherence) between the ages of 25 and 69 in this birth cohort. We have also assumed that 5% of screens would have a mildly abnormal Pap resulting in a rescreen.[322] Total screens in this cohort are therefore estimated at 267,820 (Table 3, row *d*).
- Based on the BC HPV FOCAL study, the colposcopy referral rate is 3.1% (with a 95% CI of 2.8% to 3.5%). The participation rate for these referrals is approximately 85%.[323] Women are typically recalled for multiple follow-ups if something is identified on the initial colposcopy. We have assumed an average of two colposcopies per accepted referral,[324] yielding a colposcopy rate of 5.3% (0.031 * 0.85 * 2).
- In 2007, the rate of detection of CIN2/3 lesions in BC was 5.9 per 1,000 screens (Table 3, row *o*).[325] These would typically be treated by a loop electrosurgical excision procedure (LEEP) as an ambulatory procedure in a colposcopy suite. Three Canadian studies estimated the cost per treatment for a precancerous lesion to be $965[326], $1,032[327] and $1,071[328] in 2005 or 2006 CAD. We updated these estimates to 2017 CAD and then used the average for the base case estimate and the extremes in the sensitivity analysis ($1,216 with a range from $1,137 to $1,295, in 2017 CAD).
- 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.
- 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 25 to 69 years of age for cervical cancer every 3 years would be $25,542 / QALY (Table 3, row *af*).

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[322] Dr. Andy Coldman, Vice President, Population Oncology, BC Cancer Agency. Personal communication, May 2014.

[323] BC Cancer Agency. *Cervical Cancer Screening Program 2012 Annual Report*. 2012. Available at http://www.screeningbc.ca/NR/rdonlyres/4545C16F-3F34-496C-ABF4-CB4B9BA04076/66569/CCSPAnnualReport2012PrintVersionLowRes.pdf. Accessed October, 2013.

[324] Dr. Andy Coldman, Vice President, Population Oncology, BC Cancer Agency. Personal communication, May 2014.

[325] Ibid.

[326] 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.

[327] 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.

[328] 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.

Table 3. Summary of CE Estimate for Cervical Cancer Screening B.C. Birth Cohort of 40,000			
Row	**Variable**	**Base Case Ages 25-69**	**Data Source**
	Costs of Screening and Treatment		
a	Life years lived between age 25 and 69 in birth cohort	869,546	Table 1
b	Screening visits at 100% adherence	289,849	= a / 3
c	Screening visits at 88% adherence	255,067	= b * Table 2, row g
d	Screening visits with 5% rescreen rate	267,820	= c * 1.05
e	Cost per screening visit	$70	Ref Doc
f	Screening costs	$18,747,412	= e * d
g	Value of patient time (per hour)	$29.69	Ref Doc
h	Patient time per screening visit (in hours)	2	Ref Doc
i	Value of patient time - screening	$15,903,162	= d * h * g
j	Rate of colposcopies per screen	5.3%	√
k	Cost per colposcopy	$251	Ref Doc
l	Colposcopy costs	$3,562,812	= j * d * k
m	Patient time per colposcopy (in hours)	7.5	√
n	Value of patient time - colposcopy	$3,160,753	= d * j * m * g
o	Proportion of screens resulting in treatment for CIN2 or 3	0.59%	√
p	Treatment costs per CIN2/3	$1,216	Ref Doc
q	Treatment costs for CIN2/3	$1,921,449	= d * o * p
r	Patient time per treatment for CIN2/3 (in hours)	7.5	√
s	Value of patient time - treatment of CIN2/3	$351,857	= d * o * r * g
t	**Costs of screening and treatment**	**$43,647,445**	= f + i + l + n + q + s
	Costs Avoided		
u	Deaths prevented	7.3	Table 2, row k
v	Costs avoided per death prevented	-$46,603	Ref Doc
w	Costs avoided due to deaths prevented	-$339,908	= u * v
x	# of cervical cancers prevented	100.9	Table 2, row n
y	Costs avoided per cervical cancer prevented	-$36,021	Ref Doc
z	Costs avoided due to cervical cancers prevented	-$3,633,357	= x * y
aa	**Costs avoided**	**-$3,973,265**	= w + z
ab	Net costs	$39,674,180	= t + aa
ac	CPB undiscounted	1,471	Table 2, row v
ad	Net costs (1.5% discount)	$24,509,536	Calculated
ae	CPB (1.5% discount)	960	Calculated
af	**CE ($/QALY saved)**	**$25,542**	= ad / ae

√ = Estimates from the literature

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

- Assume the effectiveness of screening in reducing cervical cancer deaths is reduced from 35% to 10% and the effectiveness of reducing cervical cancer incidence is reduced from 44% to 25% (Table 2, rows *d* & *e*): CE = $99,328.
- Assume the effectiveness of screening in reducing cervical cancer deaths is increased from 35% to 53% and the effectiveness of reducing cervical cancer incidence is increased from 44% to 58% (Table 2, rows *d* & *e*): CE = $13,818.
- Assume that the false-positive screening rate is reduced from 4.9% to 3.2% (Table 2, row *s*): CE = $22,968.

- Assume that the false-positive screening rate is increased from 4.9% to 6.5% (Table 2, row *s*): CE = $28,553.
- Assume the cost per screening visit is reduced from $70 to $33 (Table 3, row *e*): CE = $19,162.
- Assume the cost per screening visit is increased from $70 to $108 (Table 3, row *e*): CE = $32,094.
- Assume the cost per colposcopy is reduced from $251 to $176 (Table 3, row *k*): CE = $24,857.
- Assume the cost per colposcopy is increased from $251 to $392 (Table 3, row *k*): CE = $26,831.

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening women ages 25 to 69 years of age for cervical cancer every 3 years is estimated to be 960 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $25,542 per QALY (see Table 4).

Table 4: Cervical Cancer Screening Being Offered to a Birth Cohort of 40,000 Women Between the Ages of 25 to 69
Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume No Current Service			
1.5% Discount Rate	**960**	260	1,675
3% Discount Rate	657	178	1,147
0% Discount Rate	1,471	399	2,567
Gap between B.C. Current (69%) and 'Best in the World' (88%)			
1.5% Discount Rate	207	56	362
3% Discount Rate	142	38	248
0% Discount Rate	318	86	554
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$25,542**	$13,818	$99,328
3% Discount Rate	$28,928	$15,524	$113,289
0% Discount Rate	$26,980	$14,596	$104,919
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$13,042	$6,658	$53,225
3% Discount Rate	$14,594	$7,314	$60,424
0% Discount Rate	$13,776	$7,033	$56,221

Screening (HPV-Based) for Cervical Cancer

United States Preventive Services Task Force Recommendations (2017)

> *The USPSTF recommends screening for cervical cancer in women age 21 to 65 years with cytology (Pap smear) every 3 years or, for women age 30 to 65 years who want to lengthen the screening interval, screening with a combination of cytology and human papillomavirus (HPV) testing every 5 years.*[329]

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with incorporating HPV-based screening in females ages 30-65 in a BC birth cohort of 40,000.

In modelling CPB, we made the following assumptions:

- Based on BC life tables for 2010 to 2012, a total of 1,719 deaths would be expected in females between the ages of 30-69 in a BC birth cohort of 40,000 (see Table 1). While routine HPV-based screening occurs to age 65, we have assumed the protective effect of routine screening would continue to age 69.
- Based on BC vital statistics data, there were 357 deaths in females between the ages of 25 and 44 in BC in 2012, with 8 (2.2%) of these deaths due to cervical cancer (ICD-10 codes C53). There were also 1,990 deaths between the ages of 45 and 64 that year, with 20 (1.0%) of these deaths due to cervical cancer. Finally, there were 3,566 deaths between the ages of 65 and 79 that year, with 10 (1.0%) of these deaths due to cervical cancer.[330] This suggests that 14.8 of the 1,719 (0.9%) of the female deaths in the BC birth cohort between the ages of 30 and 69 would be due to cervical cancer (see Table 1).

Table 1: Mortality Due to Cervical Cancer Between the Ages of 30 and 69
in a British Columbia Birth Cohort of 40,000

Age Group	Mean Survival Rate Males	Mean Survival Rate Females	Individuals in Birth Cohort Males	Individuals in Birth Cohort Females	Individuals in Birth Cohort Total	*Life Years Lived*	Deaths in Birth Cohort %	Deaths in Birth Cohort #	Deaths due to Cervical Cancer %	Deaths due to Cervical Cancer #	Life Years Lost Per Death	Life Years Lost Total
25-29		0.992		19,833		99,163						
30-34		0.990		19,795		98,975	0.2%	38	2.2%	0.8	52.9	45
35-39		0.987		19,741		98,706	0.3%	54	2.2%	1.2	48.1	58
40-44		0.983		19,662		98,311	0.4%	79	2.2%	1.8	43.2	76
45-49		0.977		19,546		97,730	0.6%	116	1.0%	1.2	38.5	45
50-54		0.969		19,375		96,873	0.9%	171	1.0%	1.7	33.8	58
55-59		0.956		19,118		95,591	1.3%	256	1.0%	2.6	29.2	75
60-64		0.936		18,726		93,630	2.1%	392	1.0%	3.9	24.7	97
65-69		0.906		18,113		90,567	3.4%	613	0.3%	1.6	20.4	32
								1,719	**0.9%**	**14.8**	**32.9**	**487**

- HPV-based screening is associated with a 55% reduction in the incidence of cervical cancers (RR of 0.45, 95% CI of 0.25 to 0.81) in females ages 30 – 64, when

[329] US Preventive Services Task Force. Draft Recommendation Statement *Cervical Cancer: Screening.* 2017. Available online at https://www.uspreventiveservicestaskforce.org/Page/Document/draft-recommendation-statement/cervical-cancer-screening2. Accessed December 2017.

[330] British Columbia Vital Statistics Agency. *Selected Vital Statistics and Health Status Indicators: One Hundred and Forty-First Annual Report*. Apendix 2. 2012. British Colubmia Ministry of Health. Available at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2012/pdf/annual-report-2012.pdf. Accessed December 2017.

compared to cytology-based screening.[331] The effectiveness of HPV-based screening is observed primarily in the reduction in adenocarcinomas. We assumed that the effectiveness of HPV-based screening in reducing mortality from cervical cancers would be the same as the observed effectiveness in reducing the incidence of cervical cancers.

- The cumulative incidence of cervical cancer is lower at 5.5 years after a negative HPV test than 3.5 years after a negative cytology test, indicating that 5 year screening intervals with HPV testing are safer than 3 year screening intervals with cytology testing.[332]

In estimating the effect of the additional CPB associated with incorporating HPV-based we first re-ran the model for cytology-based screening above but modified the age range to 30-69 (from 25-74). The result is a modest reduction in QALYs saved, from 1,471 (based on ages 25-74) to 1,188 (based on ages 30-69) (see Table 2).

Table 2. Calculation of Clinically Preventable Burden for Cervical Cancer in Average Risk Women in a BC Birth Cohort of 40,000

Row	Variable	Base Case	Data Source
	Estimated Current Status		
a	**Total cervical cancer mortality in a birth cohort of 40,000 between the ages of 30 and 69**	14.8	Table 1
b	Ratio of nonfatal cervical cancers per fatal cervical cancer	10.1	Ref Doc
c	Estimated nonfatal cervical cancers	149.3	= a * b
d	Effectiveness of screening in reducing mortality	35%	√
e	Effectiveness of screening in reducing incidence	44%	√
f	Current screening rate in BC	69%	Ref Doc
g	Potential screening rate	88%	Ref Doc
h	Predicted deaths in the absence of screening	19.5	= a / (1 - f * d)
i	Predicted nonfatal cervical cancers in absence of screening	214.4	= c / (1 - f * e)
	Benefits of Screening		
j	Deaths avoided - 100% adherence	6.8	= h * d
k	Deaths avoided - 88% adherence	6.0	= j * g
l	Deaths avoided - 69% adherence	4.7	= j * f
m	Nonfatal cancers avoided - 100% adherence	94.3	= i * e
n	Nonfatal cancers avoided - 88% adherence	83.0	= m * g
o	Nonfatal cancers avoided - 69% adherence	65.1	= m * f
p	LE at average age of cervical cancer death	32.9	Table 1
q	Life years lost per nonfatal cervical cancer	17	Ref Doc
r	QALYs saved with 88% adherence to screening	1,609	= (k * p) + (n * q)
	Harms Associated with Screening		
s	False-positive screening rate	4.9%	√
t	Reduced QALYs per false positive	0.038	√
u	Reduced QALYs associated with false positives	-421	= -(s * Table 4, row c) * t
	Summary of Benefits and Harms		
v	Potential QALY saved - Utilization increasing from 0% to 88%	1,188	= r + u
w	Potential QALY saved - Utilization increasing from 69% to 88%	257	= v * (g - f) / g

√ = Estimates from the literature

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[331] Ronco G, Dillner J, Elfström KM 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(9916): 524-32.

[332] Ronco G, Dillner J, Elfström KM 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(9916): 524-32.

We then adjusted the assumptions in this table to reflect HPV-based screening. This meant that the effectiveness of HPV-based screening improved by 55% compared to cytology-based screening (Table 3, row *j*) while the false-positive screening rate increased from 4.9% to 7.28% (Table 3, row *p*).[333]

The result is a gain of 975 QALYs saved, from 1,188 (see Table 2, row *v*) to 2,163 (Table 3, row *s*) associated with incorporating HPV-based screening in females ages 30-65 in a BC birth cohort of 40,000.

Table 3. Calculation of CPB for HPV-Based Cervical Cancer Screening in Average Risk Women in a BC Birth Cohort of 40,000

Row	Variable	Base Case	Data Source
	Estimated Current Status - Cytology-based Screening		
a	**Total cervical cancer mortality in a birth cohort of 40,000 between the ages of 30 and 69**	14.8	Table 1
b	Ratio of nonfatal cervical cancers per fatal cervical cancer	10.1	Ref Doc
c	Estimated nonfatal cervical cancers	149.3	= a * b
d	Effectiveness of screening in reducing mortality	35%	Table 2, row d
e	Effectiveness of screening in reducing incidence	44%	Table 2, row e
f	Current screening rate in BC	69%	Ref Doc
g	Potential screening rate	88%	Ref Doc
h	Predicted deaths in the absence of screening	19.5	Table 2, row h
i	Predicted nonfatal cervical cancers in absence of screening	214.4	Table 2, row i
	Benefits of HPV-based Screening		
j	Rate ratio comparing HPV- to cytology-based screening	55%	√
k	Deaths avoided - 88% adherence	9.3	= Table 2, row k + (Table 2, row k * j)
l	Nonfatal cancers avoided - 88% adherence	128.7	= Table 2, row n + (Table 2, row n * j)
m	LE at average age of cervical cancer death	32.9	Table 1
n	Life years lost per nonfatal cervical cancer	17	Ref Doc
o	QALYs saved with 88% adherence to screening	2,494	= (k * l) + (l * n)
	Harms Associated with Screening		
p	False-positive screening rate	7.28%	√
q	Reduced QALYs per false positive	0.038	√
r	Reduced QALYs associated with false positives	-331	= -(p * Table 5, row e) * q
	Summary of Benefits and Harms		
s	Potential QALY saved - Utilization increasing from 0% to 88%	2,163	= o + r

√ = Estimates from the literature

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

- Assume that the effectiveness of HPV-based screening compared to cytology-based screening is reduced from 55% to 19% (Table 3, rows *j*): CPB = 395.
- Assume that the effectiveness of HPV-based screening compared to cytology-based screening is reduced from 55% to 75% (Table 3, rows *j*): CPB = 1,296.

[333] Melnikow J, Henderson J, Burda B, et al. *Draft Evidence Review: Cervical Cancer Screening, U.S. Preventive Services Task Force. October 2017.* Table 6. Available online at https://www.uspreventiveservicestaskforce.org/Page/Document/draft-evidence-review/cervical-cancer-screening2. Accessed December 2017.

Modelling Cost-effectiveness

Note that in modelling cost-effectiveness we are trying to tease out the additional benefits and costs associated with HPV-based screening to generate a cost/QALY associated with moving from cytology-based screening every three years in women ages 30-69 to HPV-based screening every five years in women ages 30-65 in a BC birth cohort of 40,000.

In estimating the effect on CE associated with incorporating HPV-based screening, we first re-ran the model for cytology-based screening used in the previous section but modified the age range to 30-69 (from 25-74). The result is a reduction in net costs from $39,674,180 (based on ages 25-74) to $35,399,781 (based on ages 30-69) (see Table 4, row *ab*).

Table 4. Summary of Net Costs for Cervical Cancer Screening B.C. Birth Cohort of 40,000

Row	Variable	Base Case Ages 30-69	Data Source
	Costs of Screening and Treatment		
a	Life years lived between age 30 and 69 in birth cohort	770,383	Table 1
b	Screening visits at 100% adherence	256,794	= a / 3
c	Screening visits at 88% adherence	225,979	= b * Table 2, row g
d	Screening visits with 5% rescreen rate	237,278	= c * 1.05
e	Cost per screening visit	$70	Ref Doc
f	Screening costs	$16,609,457	= e * d
g	Value of patient time (per hour)	$29.69	Ref Doc
h	Patient time per screening visit (in hours)	2	Ref Doc
i	Value of patient time - screening	$14,089,566	= d * h * g
j	Rate of colposcopies per screen	5.3%	√
k	Cost per colposcopy	$251	Ref Doc
l	Colposcopy costs	$3,156,509	= j * d * k
m	Patient time per colposcopy (in hours)	7.5	√
n	Value of patient time - colposcopy	$2,800,301	= d * j * m * g
o	Proportion of screens resulting in treatment for CIN2 or 3	0.59%	√
p	Treatment costs per CIN2/3	$1,216	Ref Doc
q	Treatment costs for CIN2/3	$1,702,327	= d * o * p
r	Patient time per treatment for CIN2/3 (in hours)	7.5	√
s	Value of patient time - treatment of CIN2/3	$311,732	= d * o * r * g
t	**Costs of screening and treatment**	**$38,669,892**	= f + i + l + n + q + s
	Costs Avoided		
u	Deaths prevented	6.0	Table 2, row k
v	Costs avoided per death prevented	-$46,603	Ref Doc
w	Costs avoided due to deaths prevented	-$279,754	= u * v
x	# of cervical cancers prevented	83.0	Table 2, row n
y	Costs avoided per cervical cancer prevented	-$36,021	Ref Doc
z	Costs avoided due to cervical cancers prevented	-$2,990,356	= x * y
aa	**Costs avoided**	**-$3,270,110**	= w + z
ab	**Net costs**	**$35,399,781**	= t + aa

√ = Estimates from the literature

We then estimated the net costs of incorporating HPV-based screening in females ages 30-65 in a BC birth cohort of 40,000. In doing so, we made the following assumptions:

- **Number of HPV-based screens** – We assumed a screening rate of once every five years starting at age 30. Based on the initial results of the HPV FOCAL trial, 91.9% of tests are negative and the woman is recalled at 5 years. The 8.1% of women with hr-HPV positive tests (Table 5, row *f*) are reflexed to cytology (Table 5, row *g*). Cytology results are negative for 64% of these women (Table 5, row *h*). Women with positive results are referred to colposcopy. Women who are hr-HPV positive but cytology negative are retested with HPV and cytology after 6-12 months. 43% of these women are both HPV and cytology negative and move into routine HPV-based screening at 5-year intervals. The 57% of women who are HPV and/or cytology positive are referred to colposcopy.[334] This approach results in 125,850 HPV-based screens (Table 5, row *l*) and 15,894 cytology-based screens (Table 5, row *m*) in females between the ages of 30 and 65 in a BC birth cohort of 40,000.

- Based on the BC HPV FOCAL study, the colposcopy referral rate associated with cytology-based screening is 3.1% (with a 95% CI of 2.8% to 3.5%) while the colposcopy referral rate associated with HPV-based screening is 5.9% (with a 95% CI of 5.5% to 6.3%).[335] The participation rate for these referrals is approximately 85%.[336] Women are typically recalled for multiple follow-ups if something is identified on the initial colposcopy. We have assumed an average of two colposcopies per accepted referral,[337] yielding a HPV-based colposcopy rate of 10.0% (0.059 * 0.85 * 2).
- In 2007, the rate of detection of CIN2/3 lesions in BC was 5.9 per 1,000 screens.[338] Based on the BC HPV FOCAL study, the detection rate of CIN2/3 lesions is increased by 50% with HPV-based screening, to 8.85 per 1,000 screens.[339] These lesions would typically be treated by a loop electrosurgical excision procedure (LEEP) as an ambulatory procedure in a colposcopy suite.
- 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.
- Other costs and assumptions used in assessing net costs are detailed in the Reference Document.

Based on these assumptions, the estimated net costs of incorporating HPV-based screening in females ages 30-65 in a BC birth cohort of 40,000 is $22,776,189 (see Table 5, row *ak*). This is $12,623,593 less than the estimated net costs associated with the current cytology-based screening (ref. Table 4, row *ab*) for females ages 30-69 in a BC birth cohort of 40,000.

[334] Ogilvie G, Krajden M, Van Niekerk D et al. Primary cervical cancer screening with HPV testing compared with liquid-based cytology: results of round 1 of a randomised controlled trial–the HPV FOCAL Study. *British Journal of Cancer*. 2012; 107(12): 1917-24.
[335] Melnikow J, Henderson J, Burda B, et al. *Draft Evidence Review: Cervical Cancer Screening, U.S. Preventive Services Task Force. October 2017.* Table 6. Available online at https://www.uspreventiveservicestaskforce.org/Page/Document/draft-evidence-review/cervical-cancer-screening2. Accessed December 2017.
[336] BC Cancer Agency. *Cervical Cancer Screening Program 2012 Annual Report*. 2012. Available at http://www.screeningbc.ca/NR/rdonlyres/4545C16F-3F34-496C-ABF4-CB4B9BA04076/66569/CCSPAnnualReport2012PrintVersionLowRes.pdf. Accessed October, 2013.
[337] Dr. Andy Coldman, Vice President, Population Oncology, BC Cancer Agency. Personal communication, May 2014.
[338] Ibid.
[339] Melnikow J, Henderson J, Burda B, et al. *Draft Evidence Review: Cervical Cancer Screening, U.S. Preventive Services Task Force. October 2017.* Table 6. Available online at https://www.uspreventiveservicestaskforce.org/Page/Document/draft-evidence-review/cervical-cancer-screening2. Accessed December 2017.

Table 5. Summary of Net Cost for HPV-Based Cervical Cancer Screening			
Row Label	**Variable**	**Base Case**	**Data Source**
	Costs of Screening and Treatment		
a	Life years lived between age 30 and 65 in birth cohort	679,816	Table 1
b	Annual frequency of HPV-based screening	20%	√
c	Number of HPV-based screens - 100% adherence	135,963	= a * b
d	Adherence with HPV-based screening	88%	Table 3, row g
e	Number of HPV-based screens - 88% adherence	119,648	= c * d
f	Proportion of screens hrHPV-positive	8.1%	√
g	Number of reflex cytology screens	9,691	= e * f
h	Proportion of reflex cytology screens negative	64%	√
i	Number of reflex cytology screens negative	6,203	= g * h
j	Number of follow-up cytology screens	6,203	= i
k	Number of follow-up HPV screens	6,203	= i
l	HPV-based screening - number of HPV-based screens	125,850	= e + k
m	HPV-based screening - number of cytology-based screens	15,894	= g + j
n	Cost per HPV-based screen	$96	Ref Doc
o	Cost for HPV-based screening	$12,081,614	= l * n
p	Value of patient time (per hour)	$29.69	Ref Doc
q	Patient time per screening visit (in hours)	2	√
r	Value of patient time - screening	$8,416,767	= (l + m) * q * p
s	Rate of colposcopies per screen	10.0%	√
t	Cost per colposcopy	$251	Ref Doc
u	Colposcopy costs	$3,158,839	= l * s * t
v	Patient time per colposcopy (in hours)	7.5	√
w	Value of patient time - colposcopy	$2,664,253	= e * s * v * p
x	Proportion of screens resulting in treatment for CIN2 or 3	0.885%	√
y	Treatment costs per CIN2/3	$1,216	Ref Doc
z	Treatment costs for CIN2/3	$1,287,600	= e * x * y
aa	Patient time per treatment for CIN2/3 (in hours)	7.5	√
ab	Value of patient time - treatment of CIN2/3	$235,786	= e * x * aa * p
ac	**Costs of screening and treatment**	**$27,844,859**	= o + r + u + w + z + ab
	Costs Avoided		
ad	Deaths prevented	9.3	Table 3, row k
ae	Costs avoided per death prevented	-$46,603	Ref Doc
af	Costs avoided due to deaths prevented	-$433,618	= ad * ae
ag	# of cervical cancers prevented	128.7	Table 3, row l
ah	Costs avoided per cervical cancer prevented	-$36,021	Ref Doc
ai	Costs avoided due to cervical cancers prevented	-$4,635,053	= ag * ah
aj	**Costs avoided**	**-$5,068,671**	= af + ai
ak	**Net costs**	**$22,776,189**	**= af + aj**

√ = Estimates from the literature

After discounting costs and QALYs by 1.5%, the cost per QALY associated with cytology-based cervical cancer screening is $33,340 (see Table 6, row *i*) compared to the cost per QALY associated with HPV-based cervical cancer screening of $11,784 (see Table 6, row *l*). Implementing HPV-based cervical cancer screening in females ages 30-65 in a BC birth cohort of 40,000 is estimated to cost $21,556 ***less*** per QALY than the current cytology-based screening in this cohort (see Table 6, row *m*).

Table 6. Summary of CE Estimate for HPV-Based Cervical Cancer Screening B.C. Birth Cohort of 40,000			
Row	Variable	Base Case Ages 30-65	Data Source
	Undiscounted Cost / QALY		
a	Net costs for cytology-based cervical cancer screening	$35,399,781	Table 4, row ab
b	QALYs gained with cytology-based cervical cancer screening	1,188	Table 2, row v
c	Undiscounted cost / QALY	$29,796	= a / c
d	Net costs for HPV-based cervical cancer screening	$22,776,189	Table 5, row ak
e	QALYs gained with HPV-based cervical cancer screening	2,163	Table 3, row s
f	Undiscounted cost / QALY	$10,531	= d / e
	Discounted Cost / QALY - 1.5%		
g	Net costs for cytology-based cervical cancer screening	$26,636,256	Calculated
h	QALYs gained with cytology-based cervical cancer screening	799	Calculated
i	Discounted cost / QALY	$33,340	= g / h
j	Net costs for HPV-based cervical cancer screening	$17,137,744	Calculated
k	QALYs gained with HPV-based cervical cancer screening	1,454	Calculated
l	Discounted cost / QALY	$11,784	= j / k
m	Cost / QALY saved with incorporating HPV-based cervical cancer screening	-$21,556	= l - i

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

- Assume that the effectiveness of HPV-based screening compared to cytology-based screening is reduced from 55% to 19% (Table 3, rows *j*): CE = -$16,414.
- Assume that the effectiveness of HPV-based screening compared to cytology-based screening is reduced from 55% to 75% (Table 3, rows *j*): CE = -$23,377.

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with incorporating HPV-based screening in females ages 30-65 is estimated to be 655 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to result in cost savings of $21,556 per QALY (see Table 7).

Table 7: HPV-based Cervical Cancer Screening Being Offered to a Birth Cohort of 40,000 Between the Ages of 30 and 65 Summary			
	Base Case	Range	
CPB (Potential QALYs gained in moving from cytology- to HPB-based screening)			
Gap between B.C. Current (0%) and 'Best in the World' (88%)			
1.5% Discount Rate	**655**	266	872
3% Discount Rate	459	186	611
0% Discount Rate	975	395	1,296
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**-$21,556**	-$16,414	-$23,377
3% Discount Rate	-$23,624	-$17,989	-$25,620
0% Discount Rate	-$19,264	-$14,669	-$20,892
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	-$11,210	-$8,210	-$12,273
3% Discount Rate	-$12,286	-$8,998	-$13,450
0% Discount Rate	-$10,019	-$7,337	-$10,968

Screening for Colorectal Cancer

United States Preventive Services Task Force Recommendations (2021)[340]

> *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)*

Canadian Task Force on Preventive Health Care (2016)[341]

> *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)*

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.[342]
- 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.[343]
- 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.[344]

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[340] US Preventive Services Task Force. Screening for colorectal cancer: US Preventive Services Task Force Recommendation statement. *JAMA*. 2021; 325(19): 1965-1977.
[341] Canadian Task Force on Preventive Health Care. Recommendations on screening for colorectal cancer. *Canadian Medical Association Journal*. 2016; 188(5): 340-8.
[342] 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.
[343] 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.
[344] 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.[345]

- 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.[346] 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.[347]

- 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.[348]

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).[349]

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345 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.
346 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.
347 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.
348 US Preventive Services Task Force. Screening for colorectal cancer: US Preventive Services Task Force Recommendation statement. *JAMA*. 2021; 325(19): 1965-1977.
349 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.

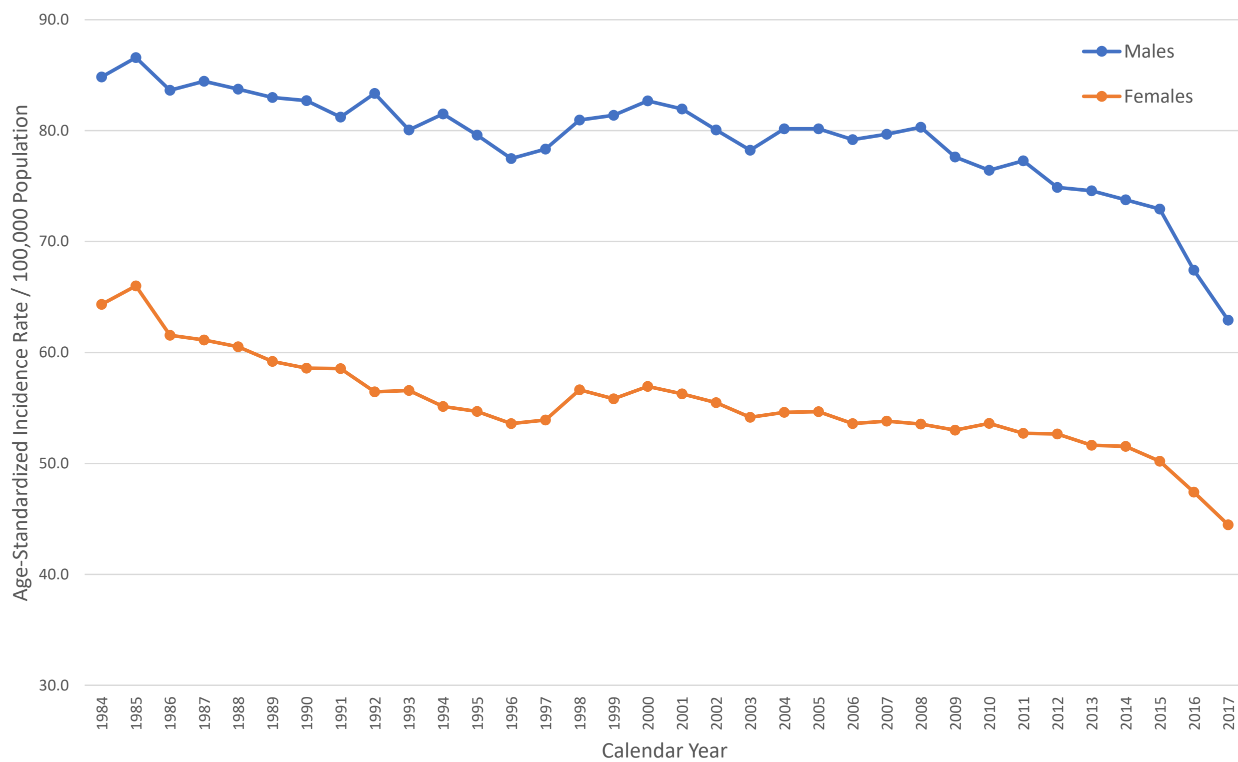
Table 1: Colorectal Cancer in British Columbia
Incidence and Mortality in 2018

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."[350]

Figure 1: Trends in ASIR for Colorectal Cancer in Canada (excluding Quebec)
1984 to 2017



[350] 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.[351]
- 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.[352]
- 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%).[353]
- The Canadian Association of Gastroenterology and the Canadian Digestive Health Foundation published a guideline for colorectal cancer screening in 2004,[354] 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.[355]
- 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).[356]
- 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**.

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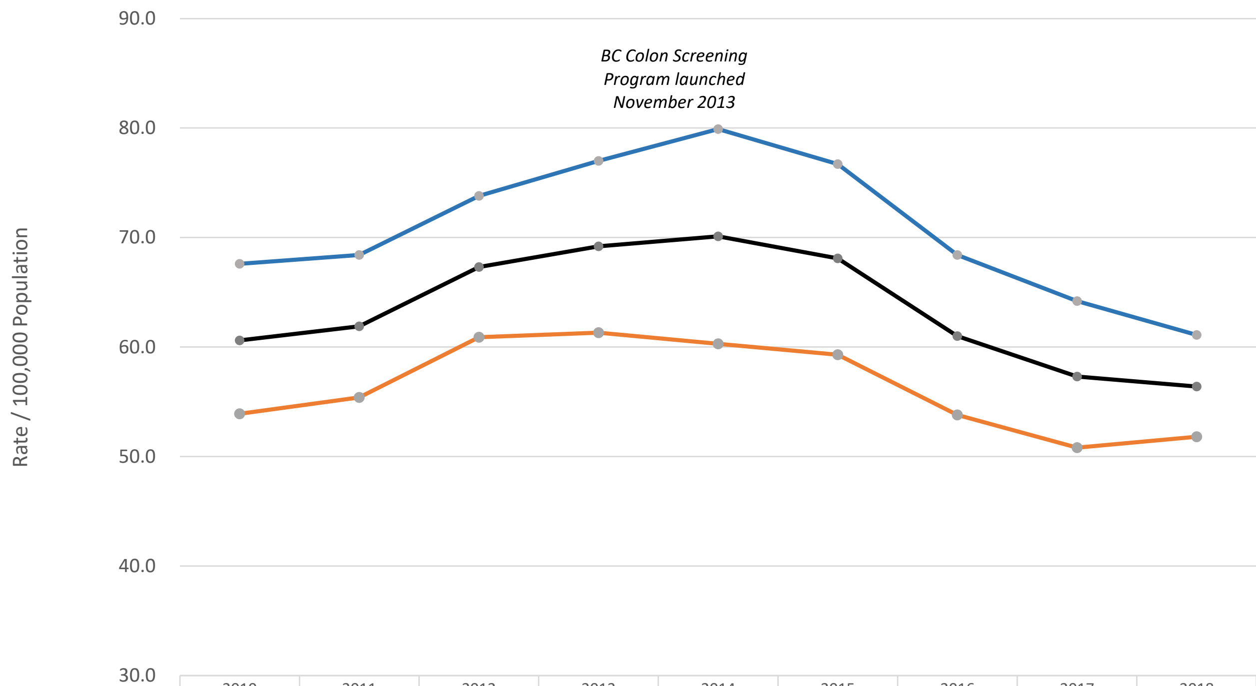
[351] Siegel R, Fedewa S, Anderson W et al. Colorectal cancer incidence patterns in the United States, 1974 – 2013. *Journal of the National Cancer Institute*. 2017; 108(8).
[352] Brenner D, Ruan Y, Shaw E et al. Increasing colorectal cancer incidence trends among younger adults in Canada. *Preventive Medicine*. 2017; 105: 345-9.
[353] 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.
[354] 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.
[355] Brenner D, Ruan Y, Shaw E et al. Increasing colorectal cancer incidence trends among younger adults in Canada. *Preventive Medicine*. 2017; 105: 345-9.
[356] 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.

Figure 2: Incidence of Colorectal Cancer in British Columbia
2010 to 2018 by Sex



	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

Calendar Year

- 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 1,852 new CRC cases BC birth cohort of 40,000 between the ages of 45 and age 79 (788 in females and 1,064 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***		
Age	**Total Life Years**	Incidence Rate / 100,000	Estimated New CRC	**Total Life Years**	Incidence Rate / 100,000	Estimated New CRC	**Total Life Years**	Incidence Rate / 100,000	Estimated New CRC
45	19,706	17.4	3.4	19,342	42.1	8.1	39,048	29.6	11.6
46	19,689	17.4	3.4	19,304	42.1	8.1	38,993	29.6	11.6
47	19,672	17.4	3.4	19,263	42.1	8.1	38,934	29.6	11.5
48	19,653	17.4	3.4	19,218	42.1	8.1	38,871	29.6	11.5
49	19,632	17.4	3.4	19,171	42.1	8.1	38,803	29.6	11.5
50	19,610	50.1	9.8	19,119	57.1	10.9	38,729	53.6	20.7
51	19,586	50.1	9.8	19,064	57.1	10.9	38,650	53.6	20.7
52	19,560	50.1	9.8	19,003	57.1	10.9	38,563	53.5	20.7
53	19,532	50.1	9.8	18,938	57.1	10.8	38,470	53.5	20.6
54	19,502	50.1	9.8	18,868	57.1	10.8	38,370	53.5	20.5
55	19,469	61.5	12.0	18,792	104.5	19.6	38,261	82.6	31.6
56	19,434	61.5	12.0	18,709	104.5	19.6	38,142	82.6	31.5
57	19,395	61.5	11.9	18,619	104.5	19.5	38,014	82.6	31.4
58	19,354	61.5	11.9	18,522	104.5	19.4	37,875	82.5	31.3
59	19,309	61.5	11.9	18,416	104.5	19.2	37,725	82.5	31.1
60	19,260	102.4	19.7	18,301	171.5	31.4	37,561	136.1	51.1
61	19,207	102.4	19.7	18,176	171.5	31.2	37,383	136.0	50.8
62	19,150	102.4	19.6	18,041	171.5	30.9	37,190	135.9	50.5
63	19,087	102.4	19.5	17,893	171.5	30.7	36,980	135.8	50.2
64	19,019	102.4	19.5	17,733	171.5	30.4	36,752	135.7	49.9
65	18,944	141.0	26.7	17,559	205.0	36.0	36,503	171.8	62.7
66	18,863	141.0	26.6	17,370	205.0	35.6	36,233	171.7	62.2
67	18,774	141.0	26.5	17,164	205.0	35.2	35,938	171.6	61.7
68	18,678	141.0	26.3	16,940	205.0	34.7	35,618	171.4	61.1
69	18,572	141.0	26.2	16,697	205.0	34.2	35,269	171.3	60.4
70	18,456	211.6	39.1	16,434	328.6	54.0	34,889	266.7	93.1
71	18,329	211.6	38.8	16,147	328.6	53.1	34,476	266.4	91.8
72	18,190	211.6	38.5	15,837	328.6	52.0	34,026	266.1	90.5
73	18,037	211.6	38.2	15,500	328.6	50.9	33,537	265.7	89.1
74	17,870	211.6	37.8	15,136	328.6	49.7	33,006	265.3	87.5
75	17,687	277.7	49.1	14,743	408.3	60.2	32,429	337.1	109.3
76	17,486	277.7	48.6	14,318	408.3	58.5	31,804	336.5	107.0
77	17,265	277.7	47.9	13,861	408.3	56.6	31,126	335.9	104.5
78	17,023	277.7	47.3	13,370	408.3	54.6	30,393	335.2	101.9
79	16,758	277.7	46.5	12,844	408.3	52.4	29,602	334.4	99.0
Total	***659,754***	**119**	**788**	***608,413***	**175**	**1,064**	***1,268,167***	**146**	**1,852**

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.[357] 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).[358]

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.[359] 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:[360]

[357] 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.
[358] 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.
[359] Dukes C, Bussey H. The spread of rectal cancer and its effect on prognosis. *British Journal of Cancer*. 1958; 12(3): 309-20.
[360] 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[361]	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.[362]

Stage at Diagnosis[363]	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:[364]

  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:[365]

  Dukes' A – 91 (13.0%)

  Dukes' B – 231 (33.0%)

  Dukes' C – 189 (27.0%)

  Distant Spread – 189 (27.0%)

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361 "**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."

362 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.

363 Based on the Tumor Node Metastasis (TNM) staging classification system.

364 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.

365 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.[366,367,368] 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 1,852 new CRCs, 269 would be Dukes' stage A, 660 would be Dukes stage B, 518 would be Dukes' stage C and 406 would have distant spread. The stage of the CRC at diagnosis has a significant effect on subsequent patient mortality.

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	0.8	8.1	1.2	2.9	2.3	1.8	11.6	1.7	4.1	3.2	2.5
46	3.4	0.5	1.2	1.0	0.8	8.1	1.2	2.9	2.3	1.8	11.6	1.7	4.1	3.2	2.5
47	3.4	0.5	1.2	1.0	0.7	8.1	1.2	2.9	2.3	1.8	11.5	1.7	4.1	3.2	2.5
48	3.4	0.5	1.2	1.0	0.7	8.1	1.2	2.9	2.3	1.8	11.5	1.7	4.1	3.2	2.5
49	3.4	0.5	1.2	1.0	0.7	8.1	1.2	2.9	2.3	1.8	11.5	1.7	4.1	3.2	2.5
50	9.8	1.4	3.5	2.7	2.2	10.9	1.6	3.9	3.1	2.4	20.7	3.0	7.4	5.8	4.5
51	9.8	1.4	3.5	2.7	2.1	10.9	1.6	3.9	3.0	2.4	20.7	3.0	7.4	5.8	4.5
52	9.8	1.4	3.5	2.7	2.1	10.9	1.6	3.9	3.0	2.4	20.7	3.0	7.4	5.8	4.5
53	9.8	1.4	3.5	2.7	2.1	10.8	1.6	3.9	3.0	2.4	20.6	3.0	7.3	5.8	4.5
54	9.8	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
55	12.0	1.7	4.3	3.3	2.6	19.6	2.8	7.0	5.5	4.3	31.6	4.6	11.3	8.8	6.9
56	12.0	1.7	4.3	3.3	2.6	19.6	2.8	7.0	5.5	4.3	31.5	4.6	11.2	8.8	6.9
57	11.9	1.7	4.2	3.3	2.6	19.5	2.8	6.9	5.4	4.3	31.4	4.6	11.2	8.8	6.9
58	11.9	1.7	4.2	3.3	2.6	19.4	2.8	6.9	5.4	4.2	31.3	4.5	11.1	8.7	6.8
59	11.9	1.7	4.2	3.3	2.6	19.2	2.8	6.9	5.4	4.2	31.1	4.5	11.1	8.7	6.8
60	19.7	2.9	7.0	5.5	4.3	31.4	4.6	11.2	8.8	6.9	51.1	7.4	18.2	14.3	11.2
61	19.7	2.9	7.0	5.5	4.3	31.2	4.5	11.1	8.7	6.8	50.8	7.4	18.1	14.2	11.1
62	19.6	2.8	7.0	5.5	4.3	30.9	4.5	11.0	8.7	6.8	50.5	7.3	18.0	14.1	11.1
63	19.5	2.8	7.0	5.5	4.3	30.7	4.5	10.9	8.6	6.7	50.2	7.3	17.9	14.0	11.0
64	19.5	2.8	6.9	5.4	4.3	30.4	4.4	10.8	8.5	6.7	49.9	7.2	17.8	14.0	10.9
65	26.7	3.9	9.5	7.5	5.9	36.0	5.2	12.8	10.1	7.9	62.7	9.1	22.3	17.5	13.7
66	26.6	3.9	9.5	7.4	5.8	35.6	5.2	12.7	10.0	7.8	62.2	9.0	22.2	17.4	13.6
67	26.5	3.8	9.4	7.4	5.8	35.2	5.1	12.5	9.8	7.7	61.7	8.9	22.0	17.2	13.5
68	26.3	3.8	9.4	7.4	5.8	34.7	5.0	12.4	9.7	7.6	61.1	8.9	21.7	17.1	13.4
69	26.2	3.8	9.3	7.3	5.7	34.2	5.0	12.2	9.6	7.5	60.4	8.8	21.5	16.9	13.2
70	39.1	5.7	13.9	10.9	8.6	54.0	7.8	19.2	15.1	11.8	93.1	13.5	33.1	26.0	20.4
71	38.8	5.6	13.8	10.8	8.5	53.1	7.7	18.9	14.8	11.6	91.8	13.3	32.7	25.7	20.1
72	38.5	5.6	13.7	10.8	8.4	52.0	7.5	18.5	14.6	11.4	90.5	13.1	32.2	25.3	19.8
73	38.2	5.5	13.6	10.7	8.4	50.9	7.4	18.1	14.2	11.2	89.1	12.9	31.7	24.9	19.5
74	37.8	5.5	13.5	10.6	8.3	49.7	7.2	17.7	13.9	10.9	87.5	12.7	31.2	24.5	19.2
75	49.1	7.1	17.5	13.7	10.8	60.2	8.7	21.4	16.8	13.2	109.3	15.9	38.9	30.6	23.9
76	48.6	7.0	17.3	13.6	10.6	58.5	8.5	20.8	16.4	12.8	107.0	15.5	38.1	29.9	23.4
77	47.9	7.0	17.1	13.4	10.5	56.6	8.2	20.2	15.8	12.4	104.5	15.2	37.2	29.2	22.9
78	47.3	6.9	16.8	13.2	10.4	54.6	7.9	19.4	15.3	12.0	101.9	14.8	36.3	28.5	22.3
79	46.5	6.7	16.6	13.0	10.2	52.4	7.6	18.7	14.7	11.5	99.0	14.4	35.3	27.7	21.7
Total	**788**	**114**	**281**	**220**	**173**	**1,064**	**154**	**379**	**298**	**233**	**1,852**	**269**	**660**	**518**	**406**

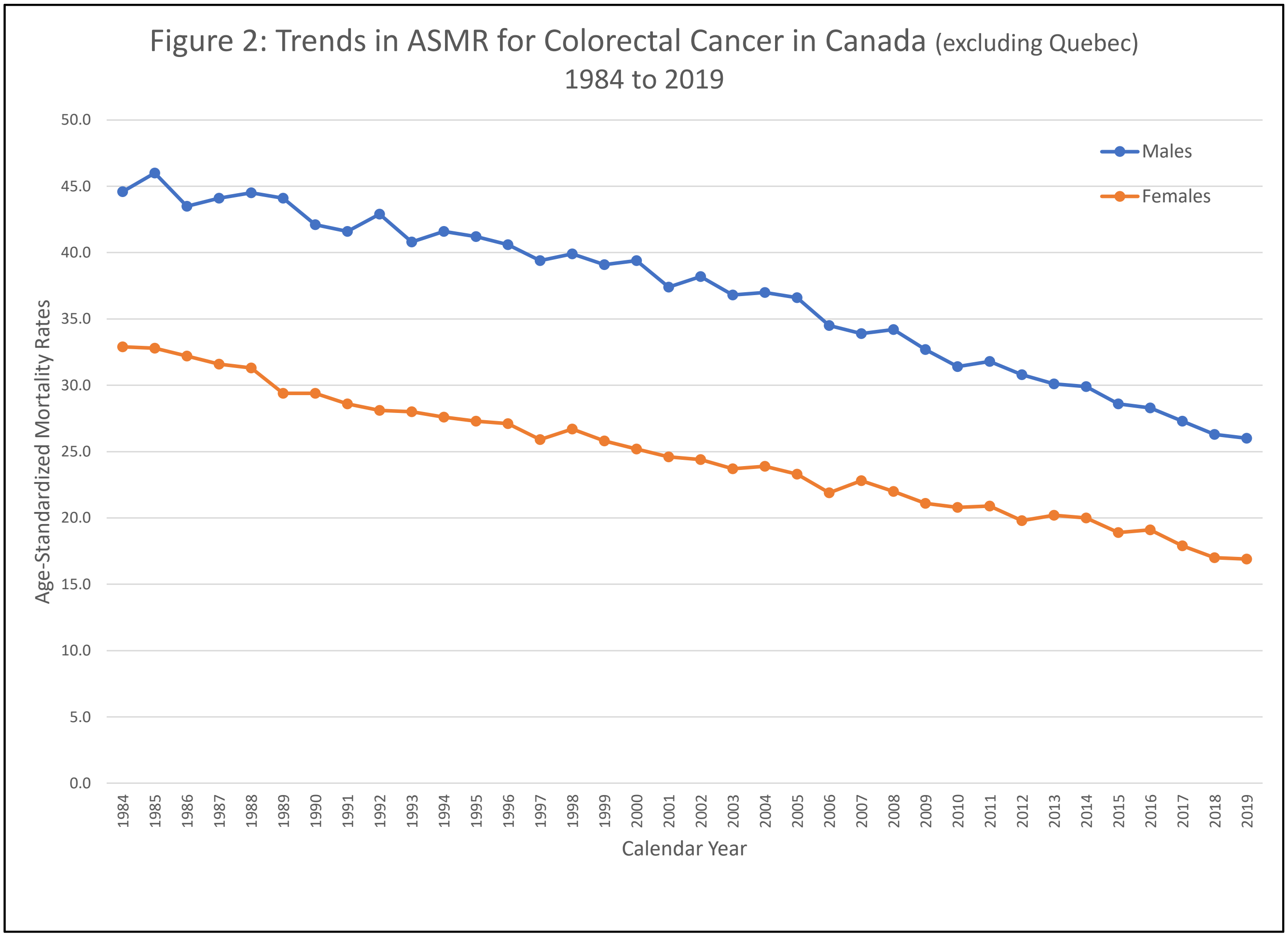
366 Mandel J, Bond J, Church T et al. Reducing mortality from colorectal cancer by screening for fecal occult blood. *New England Journal of Medicine*. 1993; 328: 1365-71.

367 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.

368 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.

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."[369]



[369] 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.

Survival Following a Diagnosis of Colorectal Cancer

- 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.[370]

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.[371]

Table 6: Colorectal Cancer Survival
By Age and Stage
Alberta and Manitoba, 2004 - 2007

Stage	Age Group	Cancer of the Colon 1 Yr	Cancer of the Colon 3 Yr	Cancer of the Rectum 1 Yr	Cancer of the Rectum 3 Yr	Colorectal Cancer 1 Yr	Colorectal Cancer 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%**

[370] BC Cancer. *Cancer Survival Rates*. Available online at http://www.bccancer.bc.ca/health-info/disease-system-statistics/cancer-survival-rates. Accessed December 2021.
[371] 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.[372] 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 729, with 309 in females and 420 in males (see Table 8).

[372] 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	0.3	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	2.5	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	2.1	**4.1**
50	0.1	0.4	0.4	1.2	2.1	0.2	0.7	0.8	1.8	3.5	0.3	1.1	1.2	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	1.4	3.4	**6.4**
52	0.1	0.6	0.7	1.7	3.1	0.2	0.9	0.9	2.0	3.9	0.3	1.5	1.6	3.7	**7.1**
53	0.2	0.7	0.8	1.8	3.4	0.2	0.9	0.9	2.0	4.0	0.4	1.7	1.7	3.8	**7.5**
54	0.2	0.9	0.9	1.8	3.8	0.2	0.9	1.0	2.0	4.2	0.4	1.8	1.8	3.8	**7.9**
55	0.2	0.9	0.9	2.0	4.0	0.2	1.1	1.1	2.8	5.3	0.5	2.0	2.0	4.8	**9.3**
56	0.2	0.9	1.0	2.1	4.2	0.3	1.3	1.3	3.1	5.9	0.5	2.2	2.2	5.2	**10.1**
57	0.2	1.0	1.0	2.2	4.4	0.3	1.4	1.5	3.4	6.6	0.5	2.4	2.5	5.6	**11.0**
58	0.2	1.0	1.0	2.2	4.5	0.4	1.6	1.6	3.5	7.0	0.6	2.6	2.6	5.7	**11.5**
59	0.2	1.0	1.1	2.2	4.6	0.4	1.7	1.7	3.6	7.4	0.7	2.7	2.8	5.8	**12.0**
60	0.3	1.2	1.2	2.9	5.6	0.4	1.9	1.9	4.7	8.9	0.7	3.1	3.1	7.6	**14.5**
61	0.3	1.3	1.3	3.2	6.2	0.5	2.1	2.2	5.1	9.8	0.8	3.4	3.5	8.3	**16.0**
62	0.3	1.4	1.5	3.5	6.7	0.5	2.3	2.4	5.5	10.7	0.9	3.7	3.9	9.0	**17.5**
63	0.4	1.6	1.6	3.5	7.1	0.6	2.5	2.6	5.6	11.3	1.0	4.1	4.2	9.1	**18.4**
64	0.4	1.7	1.8	3.6	7.5	0.6	2.7	2.8	5.7	11.8	1.1	4.4	4.5	9.3	**19.3**
65	0.4	1.8	1.9	4.3	8.4	0.7	2.8	2.8	6.2	12.4	1.1	4.6	4.7	10.4	**20.8**
66	0.5	2.0	2.0	4.5	8.9	0.7	2.9	2.9	6.3	12.8	1.1	4.8	4.9	10.8	**21.7**
67	0.5	2.1	2.1	4.8	9.5	0.7	2.9	3.0	6.5	13.1	1.2	5.0	5.2	11.2	**22.6**
68	0.5	2.2	2.3	4.8	9.8	0.7	3.0	3.1	6.5	13.3	1.2	5.2	5.3	11.3	**23.1**
69	0.6	2.3	2.4	4.9	10.1	0.7	3.1	3.1	6.4	13.4	1.3	5.4	5.5	11.3	**23.5**
70	0.8	3.4	3.5	7.9	15.6	1.1	4.5	4.8	10.8	21.2	1.9	7.9	8.3	18.7	**36.8**
71	0.8	3.6	4.0	8.0	16.4	1.1	4.9	5.4	10.9	22.3	2.0	8.5	9.4	18.8	**38.7**
72	0.9	3.9	4.4	8.0	17.2	1.2	5.2	6.0	10.9	23.3	2.1	9.1	10.4	18.9	**40.5**
73	0.9	4.0	4.5	7.9	17.3	1.3	5.4	6.1	10.6	23.3	2.2	9.4	10.6	18.5	**40.7**
74	1.0	4.2	4.6	7.7	17.5	1.3	5.6	6.1	10.3	23.3	2.3	9.7	10.7	18.0	**40.8**
75	1.1	4.6	5.0	9.3	19.9	1.4	5.9	6.5	11.6	25.4	2.5	10.5	11.5	20.9	**45.4**
76	1.1	4.7	5.3	9.5	20.6	1.4	6.0	6.6	11.6	25.6	2.5	10.7	11.9	21.1	**46.3**
77	1.1	4.9	5.5	9.7	21.3	1.4	6.0	6.7	11.6	25.8	2.6	10.9	12.3	21.3	**47.0**
78	1.2	5.0	5.6	9.6	21.5	1.4	6.0	6.7	11.3	25.4	2.6	11.1	12.3	20.9	**46.9**
79	1.2	5.2	5.7	9.5	21.6	1.4	6.0	6.6	10.9	25.0	2.7	11.2	12.3	20.5	**46.6**
Total	**16.3**	**69.8**	**75.3**	**148.2**	**309.5**	**22.2**	**94.9**	**102.0**	**200.5**	**419.6**	**38.5**	**164.7**	**177.2**	**348.7**	**729.1**

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.[373,374] See pages 60-62 of the Reference document for a detailed discussion of how QoL adjustments are calculated and utilized in the LPS modelling.[375]
- Based on data from the GBD, the diagnosis and treatment phase for colorectal cancer lasts an average of 4 months[376] and is associated with a utility loss of -0.288 (95% CI of -0.193 to -0.399).[377] 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).[378] 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)[379] and is associated with a utility loss of -0.451 (95% CI of -0.307 to -0.600).[380] 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

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373 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.

374 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.

375 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.

376 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.

377 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.

378 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.

379 Dr. Jonathan Loree, Medical Oncologist at BC Cancer. Personal Communication. February 2022.

380 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 17.6 life years lost (12,805 / 729), with 18.6 life years lost per death for females (5,743 / 309) and 16.8 life years lost per death for males (7,062 / 420) (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	13	29	43
46	0.3	0.8	1.2	0.3	0.8	1.1	0.8	1.9	2.7	1	4	5	24	51	75
47	0.3	0.8	1.2	0.5	1.2	1.6	1.1	2.7	3.8	2	5	7	33	72	105
48	0.3	0.8	1.2	0.6	1.5	2.1	1.4	3.3	4.7	2	6	8	39	85	124
49	0.3	0.8	1.2	0.7	1.8	2.5	1.6	3.8	5.5	3	6	9	45	97	142
50	1.0	1.1	2.1	1.2	2.3	3.5	2.9	4.8	7.8	5	8	13	76	114	190
51	1.0	1.1	2.1	1.7	2.7	4.4	3.6	5.1	8.8	6	9	15	92	117	209
52	1.0	1.1	2.1	2.1	3.1	5.2	4.3	5.4	9.7	7	10	17	106	121	227
53	1.0	1.1	2.1	2.4	3.5	6.0	4.7	5.6	10.3	8	10	18	113	120	233
54	1.0	1.1	2.1	2.8	3.9	6.7	5.2	5.7	10.9	9	11	20	120	120	239
55	1.2	2.0	3.2	3.3	4.8	8.1	5.5	7.2	12.8	10	14	24	125	147	272
56	1.2	2.0	3.2	3.7	5.6	9.3	5.8	8.2	13.9	11	16	26	126	160	286
57	1.2	2.0	3.2	4.2	6.4	10.6	6.0	9.1	15.1	11	17	29	127	173	300
58	1.2	2.0	3.2	4.6	7.1	11.7	6.1	9.7	15.8	12	19	31	126	178	304
59	1.2	2.0	3.2	5.1	7.8	12.9	6.3	10.2	16.5	13	20	33	125	181	306
60	2.1	3.3	5.4	6.1	9.4	15.5	7.8	12.6	20.5	16	25	41	147	211	358
61	2.1	3.3	5.3	6.9	10.7	17.6	8.7	13.9	22.6	18	28	46	157	223	381
62	2.1	3.2	5.3	7.7	11.9	19.6	9.5	15.1	24.7	19	30	50	167	235	402
63	2.1	3.2	5.3	8.5	13.1	21.6	10.1	15.9	26.0	21	32	53	170	238	407
64	2.0	3.2	5.2	9.2	14.3	23.5	10.6	16.7	27.2	22	34	56	172	240	411
65	2.8	3.8	6.6	10.3	15.7	26.0	11.9	17.6	29.4	25	37	62	186	243	428
66	2.8	3.7	6.5	11.4	17.1	28.5	12.6	18.0	30.7	27	39	66	189	239	429
67	2.8	3.7	6.5	12.4	18.5	30.9	13.4	18.5	31.9	29	41	69	193	235	428
68	2.8	3.6	6.4	13.5	19.8	33.2	13.8	18.7	32.5	30	42	72	192	227	419
69	2.7	3.6	6.3	14.4	21.1	35.5	14.3	18.9	33.2	31	44	75	189	220	409
70	3.8	5.3	9.1	16.8	24.4	41.1	23.3	31.5	54.8	44	61	105	280	330	610
71	3.8	5.2	9.0	18.2	26.4	44.6	24.5	33.2	57.6	46	65	111	281	332	613
72	3.8	5.1	8.9	19.6	28.2	47.8	25.6	34.7	60.4	49	68	117	281	331	612
73	3.7	5.0	8.7	20.9	30.0	50.9	25.8	34.8	60.6	51	70	120	271	315	586
74	3.7	4.9	8.6	22.2	31.7	54.0	26.0	34.7	60.7	52	71	123	258	298	557
75	4.8	5.9	10.7	24.1	34.0	58.1	29.7	37.9	67.6	59	78	136	281	308	589
76	4.8	5.7	10.5	25.9	36.1	62.0	30.7	38.2	68.9	61	80	141	274	295	569
77	4.7	5.6	10.3	27.7	38.1	65.8	31.7	38.4	70.1	64	82	146	268	279	546
78	4.6	5.4	10.0	29.3	40.0	69.3	32.0	37.9	69.8	66	83	149	255	259	515
79	4.6	5.1	9.7	31.0	41.7	72.7	32.2	37.3	69.5	68	84	152	242	240	482
	79	**107**	**187**	**370**	**535**	**905**	**450**	**608**	**1,058**	**899**	**1,251**	**2,150**	**5,743**	**7,062**	**12,805**

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.[381]
- 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).[382]
- 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).[383]
- 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.[384] 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.[385]

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[381] 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.
[382] US Preventive Services Task Force. Screening for colorectal cancer: US Preventive Services Task Force Recommendation statement. *JAMA*. 2021; 325(19): 1965-1977.
[383] Ibid.
[384] H. Krueger & Associates Inc. for the BC FIT Review Working Group. *Technical Analysis of Fecal Immunochemical Test (FIT) Cut-off Values*. June 17, 2015.
[385] Ibid.

- 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.[386]

- 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.[387]

- 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.[388]

- Based on the combined results from three early RCTs assessing the effectiveness of screening with FOBT,[389,390,391] 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.

386 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.
387 *BC Cancer Screening – Colon*. Available online at http://www.bccancer.bc.ca/screening/health-professionals/colon/refer. Accessed November 2021.
388 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.
389 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.
390 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.
391 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 1,852 (see Table 4) to 1,538 (see Table 11), a reduction of 314 (16.9%) in new cases. In addition, the number of cases diagnosed in Dukes' Stage A would increase by 45% (from 269 [Table 4] to 389 [Table 11]), those in Stage B would decrease by 25% (from 660 [Table 4] to 496 [Table 11]), those in Stage C by 24% (from 518 [Table 4] to 395 [Table 11]) and those with distant spread by 36% (from 406 [Table 4] to 258 [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	6.8	1.7	2.2	1.7	1.1	9.6	2.4	3.1	2.5	1.6
46	2.8	0.7	0.9	0.7	0.5	6.8	1.7	2.2	1.7	1.1	9.6	2.4	3.1	2.5	1.6
47	2.8	0.7	0.9	0.7	0.5	6.7	1.7	2.2	1.7	1.1	9.6	2.4	3.1	2.5	1.6
48	2.8	0.7	0.9	0.7	0.5	6.7	1.7	2.2	1.7	1.1	9.6	2.4	3.1	2.5	1.6
49	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	2.5	1.6
50	8.2	2.1	2.6	2.1	1.4	9.1	2.3	2.9	2.3	1.5	17.2	4.4	5.6	4.4	2.9
51	8.2	2.1	2.6	2.1	1.4	9.0	2.3	2.9	2.3	1.5	17.2	4.3	5.5	4.4	2.9
52	8.1	2.1	2.6	2.1	1.4	9.0	2.3	2.9	2.3	1.5	17.2	4.3	5.5	4.4	2.9
53	8.1	2.1	2.6	2.1	1.4	9.0	2.3	2.9	2.3	1.5	17.1	4.3	5.5	4.4	2.9
54	8.1	2.1	2.6	2.1	1.4	8.9	2.3	2.9	2.3	1.5	17.1	4.3	5.5	4.4	2.9
55	9.9	2.5	3.2	2.6	1.7	16.3	4.1	5.3	4.2	2.7	26.3	6.6	8.5	6.7	4.4
56	9.9	2.5	3.2	2.6	1.7	16.2	4.1	5.2	4.2	2.7	26.2	6.6	8.4	6.7	4.4
57	9.9	2.5	3.2	2.5	1.7	16.2	4.1	5.2	4.2	2.7	26.1	6.6	8.4	6.7	4.4
58	9.9	2.5	3.2	2.5	1.7	16.1	4.1	5.2	4.1	2.7	26.0	6.6	8.4	6.7	4.4
59	9.9	2.5	3.2	2.5	1.7	16.0	4.0	5.2	4.1	2.7	25.8	6.5	8.3	6.6	4.3
60	16.4	4.1	5.3	4.2	2.7	26.1	6.6	8.4	6.7	4.4	42.5	10.7	13.7	10.9	7.1
61	16.3	4.1	5.3	4.2	2.7	25.9	6.5	8.3	6.7	4.3	42.2	10.7	13.6	10.9	7.1
62	16.3	4.1	5.2	4.2	2.7	25.7	6.5	8.3	6.6	4.3	42.0	10.6	13.5	10.8	7.0
63	16.2	4.1	5.2	4.2	2.7	25.5	6.4	8.2	6.6	4.3	41.7	10.6	13.4	10.7	7.0
64	16.2	4.1	5.2	4.2	2.7	25.3	6.4	8.1	6.5	4.2	41.4	10.5	13.4	10.7	6.9
65	22.2	5.6	7.2	5.7	3.7	29.9	7.6	9.6	7.7	5.0	52.1	13.2	16.8	13.4	8.7
66	22.1	5.6	7.1	5.7	3.7	29.6	7.5	9.5	7.6	5.0	51.7	13.1	16.7	13.3	8.7
67	22.0	5.6	7.1	5.7	3.7	29.2	7.4	9.4	7.5	4.9	51.2	13.0	16.5	13.2	8.6
68	21.9	5.5	7.1	5.6	3.7	28.8	7.3	9.3	7.4	4.8	50.7	12.8	16.3	13.0	8.5
69	21.8	5.5	7.0	5.6	3.6	28.4	7.2	9.2	7.3	4.8	50.2	12.7	16.2	12.9	8.4
70	32.4	8.2	10.5	8.3	5.4	44.9	11.3	14.5	11.5	7.5	77.3	19.6	24.9	19.9	13.0
71	32.2	8.1	10.4	8.3	5.4	44.1	11.1	14.2	11.3	7.4	76.3	19.3	24.6	19.6	12.8
72	32.0	8.1	10.3	8.2	5.4	43.2	10.9	13.9	11.1	7.2	75.2	19.0	24.2	19.3	12.6
73	31.7	8.0	10.2	8.1	5.3	42.3	10.7	13.6	10.9	7.1	74.0	18.7	23.9	19.0	12.4
74	31.4	7.9	10.1	8.1	5.3	41.3	10.4	13.3	10.6	6.9	72.7	18.4	23.4	18.7	12.2
75	40.8	10.3	13.1	10.5	6.8	50.0	12.6	16.1	12.9	8.4	90.8	23.0	29.3	23.3	15.2
76	40.3	10.2	13.0	10.4	6.8	48.6	12.3	15.7	12.5	8.1	88.9	22.5	28.7	22.8	14.9
77	39.8	10.1	12.8	10.2	6.7	47.0	11.9	15.2	12.1	7.9	86.8	22.0	28.0	22.3	14.6
78	39.3	9.9	12.7	10.1	6.6	45.3	11.5	14.6	11.7	7.6	84.6	21.4	27.3	21.7	14.2
79	38.7	9.8	12.5	9.9	6.5	43.6	11.0	14.0	11.2	7.3	82.2	20.8	26.5	21.1	13.8
Total	**654**	**166**	**211**	**168**	**110**	**884**	**224**	**285**	**227**	**148**	**1,538**	**389**	**496**	**395**	**258**

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 193 or 26.4% (from 729 [Table 8] to 537 [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	**0.8**
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	0.2	0.4	0.4	1.1	**2.1**
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	**2.6**
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	0.3	0.6	0.6	1.2	2.6	0.4	0.9	0.9	2.0	**4.1**
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	2.2	**4.6**
52	0.2	0.5	0.5	1.1	2.3	0.3	0.6	0.7	1.3	2.9	0.5	1.1	1.2	2.3	**5.2**
53	0.3	0.6	0.6	1.1	2.5	0.3	0.7	0.7	1.3	3.0	0.6	1.2	1.3	2.4	**5.5**
54	0.3	0.6	0.7	1.2	2.8	0.3	0.7	0.7	1.3	3.1	0.6	1.4	1.4	2.4	**5.8**
55	0.3	0.7	0.7	1.3	3.0	0.4	0.8	0.8	1.8	3.8	0.7	1.5	1.5	3.1	**6.8**
56	0.3	0.7	0.7	1.3	3.1	0.4	0.9	1.0	2.0	4.3	0.7	1.6	1.7	3.3	**7.4**
57	0.3	0.7	0.8	1.4	3.2	0.5	1.1	1.1	2.2	4.8	0.8	1.8	1.9	3.6	**8.0**
58	0.3	0.8	0.8	1.4	3.3	0.5	1.2	1.2	2.2	5.1	0.9	1.9	2.0	3.6	**8.4**
59	0.4	0.8	0.8	1.4	3.4	0.6	1.3	1.3	2.3	5.5	1.0	2.1	2.1	3.7	**8.8**
60	0.4	0.9	0.9	1.9	4.0	0.6	1.4	1.5	3.0	6.5	1.0	2.3	2.4	4.8	**10.5**
61	0.4	1.0	1.0	2.0	4.5	0.7	1.6	1.7	3.2	7.2	1.1	2.6	2.7	5.3	**11.6**
62	0.5	1.1	1.1	2.2	4.9	0.8	1.7	1.8	3.5	7.8	1.3	2.8	3.0	5.7	**12.7**
63	0.5	1.2	1.2	2.3	5.2	0.9	1.9	2.0	3.6	8.3	1.4	3.1	3.2	5.8	**13.5**
64	0.6	1.3	1.3	2.3	5.5	0.9	2.0	2.1	3.6	8.7	1.5	3.3	3.4	5.9	**14.2**
65	0.6	1.4	1.4	2.7	6.1	1.0	2.1	2.2	3.9	9.1	1.6	3.5	3.6	6.6	**15.3**
66	0.7	1.5	1.5	2.9	6.5	1.0	2.2	2.2	4.0	9.4	1.6	3.6	3.8	6.9	**15.9**
67	0.7	1.6	1.6	3.0	6.9	1.0	2.2	2.3	4.1	9.6	1.7	3.8	3.9	7.1	**16.6**
68	0.8	1.7	1.7	3.1	7.2	1.0	2.3	2.4	4.1	9.8	1.8	3.9	4.1	7.2	**16.9**
69	0.8	1.7	1.8	3.1	7.5	1.1	2.3	2.4	4.1	9.9	1.9	4.1	4.2	7.2	**17.3**
70	1.2	2.5	2.7	5.0	11.4	1.6	3.4	3.7	6.9	15.5	2.7	5.9	6.4	11.9	**26.9**
71	1.2	2.7	3.0	5.1	12.1	1.6	3.7	4.1	6.9	16.3	2.9	6.4	7.2	12.0	**28.4**
72	1.3	2.9	3.4	5.1	12.7	1.7	3.9	4.6	6.9	17.2	3.0	6.8	8.0	12.0	**29.8**
73	1.4	3.0	3.4	5.0	12.8	1.8	4.1	4.6	6.7	17.3	3.2	7.1	8.1	11.7	**30.1**
74	1.4	3.1	3.5	4.9	13.0	1.9	4.2	4.7	6.5	17.3	3.3	7.3	8.2	11.4	**30.3**
75	1.5	3.4	3.8	5.9	14.7	2.0	4.4	5.0	7.4	18.8	3.6	7.9	8.8	13.3	**33.5**
76	1.6	3.6	4.0	6.0	15.2	2.0	4.5	5.1	7.4	19.0	3.6	8.1	9.1	13.4	**34.2**
77	1.7	3.7	4.2	6.2	15.7	2.0	4.5	5.1	7.4	19.1	3.7	8.2	9.4	13.5	**34.8**
78	1.7	3.8	4.3	6.1	15.9	2.1	4.5	5.1	7.2	18.9	3.8	8.3	9.4	13.3	**34.8**
79	1.8	3.9	4.3	6.1	16.1	2.1	4.5	5.1	6.9	18.6	3.9	8.4	9.4	13.0	**34.7**
Total	**23.6**	**52.5**	**57.5**	**94.2**	**227.7**	**32.2**	**71.3**	**77.8**	**127.5**	**308.8**	**55.8**	**123.8**	**135.3**	**221.7**	**536.6**

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 3,405 or 26.6% (from 12,805 [Table 9] to 9,400 [Table 13]) while the QALYs lost would be reduced by 410 or 19.1% (from 2,150 [Table 9] to 1,740 [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	0.2	0.4	0.5	0.3	0.7	1.0	1	2	3	9	20	29
46	0.3	0.7	1.0	0.3	0.7	1.0	0.6	1.3	1.9	1	3	4	16	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	74
48	0.3	0.7	1.0	0.5	1.3	1.8	1.0	2.4	3.4	2	4	6	28	61	90
49	0.3	0.7	1.0	0.6	1.5	2.2	1.2	2.8	4.0	2	5	7	33	71	104
50	0.9	1.0	1.8	1.1	2.0	3.1	2.1	3.5	5.6	4	6	10	54	83	137
51	0.9	0.9	1.8	1.4	2.4	3.8	2.6	3.7	6.3	5	7	12	66	86	151
52	0.9	0.9	1.8	1.8	2.7	4.5	3.1	4.0	7.1	6	8	13	77	88	165
53	0.9	0.9	1.8	2.1	3.1	5.2	3.5	4.1	7.5	6	8	15	83	88	171
54	0.9	0.9	1.8	2.5	3.4	5.9	3.8	4.2	8.0	7	9	16	88	88	176
55	1.0	1.7	2.8	2.9	4.2	7.1	4.1	5.2	9.3	8	11	19	91	106	198
56	1.0	1.7	2.7	3.3	4.9	8.2	4.2	5.9	10.2	9	13	21	93	116	209
57	1.0	1.7	2.7	3.7	5.6	9.3	4.4	6.6	11.0	9	14	23	93	126	219
58	1.0	1.7	2.7	4.1	6.2	10.3	4.5	7.1	11.6	10	15	25	93	130	223
59	1.0	1.7	2.7	4.5	6.9	11.3	4.6	7.5	12.2	10	16	26	92	134	226
60	1.8	2.8	4.6	5.3	8.2	13.6	5.7	9.2	14.9	13	20	33	107	154	260
61	1.8	2.8	4.5	6.1	9.4	15.5	6.3	10.1	16.4	14	22	36	115	163	277
62	1.8	2.8	4.5	6.8	10.5	17.2	6.9	11.0	18.0	15	24	40	122	171	293
63	1.7	2.7	4.5	7.4	11.5	19.0	7.4	11.7	19.0	17	26	43	124	174	299
64	1.7	2.7	4.5	8.1	12.6	20.7	7.8	12.3	20.1	18	28	45	126	177	303
65	2.4	3.2	5.6	9.1	13.8	22.9	8.7	12.9	21.5	20	30	50	136	178	314
66	2.4	3.2	5.6	10.0	15.1	25.1	9.2	13.2	22.5	22	31	53	139	175	314
67	2.4	3.1	5.5	11.0	16.3	27.2	9.8	13.6	23.4	23	33	56	141	172	314
68	2.4	3.1	5.5	11.9	17.4	29.3	10.1	13.8	23.9	24	34	59	141	167	308
69	2.3	3.1	5.4	12.7	18.6	31.3	10.5	13.9	24.4	26	36	61	139	162	301
70	3.3	4.6	7.9	14.8	21.5	36.3	17.0	23.0	40.1	35	49	84	204	241	446
71	3.3	4.5	7.8	16.1	23.3	39.4	18.0	24.3	42.3	37	52	90	206	243	450
72	3.3	4.4	7.7	17.4	25.0	42.3	18.9	25.6	44.4	40	55	94	207	244	450
73	3.2	4.3	7.6	18.6	26.6	45.2	19.1	25.7	44.8	41	57	98	200	233	433
74	3.2	4.2	7.4	19.8	28.2	47.9	19.3	25.8	45.1	42	58	101	192	222	414
75	4.2	5.1	9.3	21.5	30.2	51.6	21.9	28.0	49.9	48	63	111	208	228	435
76	4.1	5.0	9.1	23.1	32.1	55.2	22.7	28.3	51.0	50	65	115	203	218	421
77	4.1	4.8	8.9	24.6	33.9	58.6	23.4	28.5	51.9	52	67	119	198	206	404
78	4.0	4.6	8.7	26.2	35.6	61.8	23.7	28.1	51.8	54	68	122	189	193	382
79	4.0	4.5	8.4	27.6	37.2	64.9	23.9	27.7	51.7	56	69	125	180	179	359
	68	**92**	**161**	**327**	**473**	**801**	**331**	**448**	**779**	**726**	**1,013**	**1,740**	**4,216**	**5,184**	**9,400**

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.[392]
- 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.[393] Of those referred to a follow-up colonoscopy, 77.4% would receive the colonoscopy.[394] 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 0.62 death (see Table 14).

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

Age	Total Life Years	FIT #	Colonoscopy #	Colonoscopy Pos	Colonoscopy Neg	Complications Minor Bleed	Complications Major Bleed	Complications Perforation	Complications Death
45	19,706	7,587	728	364	364	0.6	0.8	0.4	0.01
46	19,689	7,216	693	346	346	0.6	0.7	0.4	0.01
47	19,672	6,863	659	329	329	0.6	0.7	0.3	0.01
48	19,653	6,527	626	313	313	0.5	0.7	0.3	0.01
49	19,632	6,205	596	298	298	0.5	0.6	0.3	0.01
50	19,610	5,899	566	283	283	0.5	0.6	0.3	0.01
51	19,586	5,607	538	269	269	0.5	0.6	0.3	0.01
52	19,560	5,328	511	256	256	0.4	0.6	0.3	0.01
53	19,532	5,061	486	243	243	0.4	0.5	0.3	0.01
54	19,502	4,807	461	231	231	0.4	0.5	0.2	0.01
55	19,469	4,928	473	236	236	0.4	0.5	0.3	0.01
56	19,434	5,024	482	241	241	0.4	0.5	0.3	0.01
57	19,395	5,097	489	245	245	0.4	0.5	0.3	0.01
58	19,354	5,150	494	247	247	0.4	0.5	0.3	0.01
59	19,309	5,183	497	249	249	0.4	0.5	0.3	0.01
60	19,260	5,199	499	249	249	0.4	0.5	0.3	0.01
61	19,207	5,198	499	249	249	0.4	0.5	0.3	0.01
62	19,150	5,182	497	249	249	0.4	0.5	0.3	0.01
63	19,087	5,152	494	247	247	0.4	0.5	0.3	0.01
64	19,019	5,109	490	245	245	0.4	0.5	0.3	0.01
65	18,944	5,072	487	243	243	0.4	0.5	0.3	0.01
66	18,863	5,038	484	242	242	0.4	0.5	0.3	0.01
67	18,774	5,007	481	240	240	0.4	0.5	0.3	0.01
68	18,678	4,977	478	239	239	0.4	0.5	0.3	0.01
69	18,572	4,946	475	237	237	0.4	0.5	0.3	0.01
70	18,456	4,913	472	236	236	0.4	0.5	0.2	0.01
71	18,329	4,878	468	234	234	0.4	0.5	0.2	0.01
72	18,190	4,839	464	232	232	0.4	0.5	0.2	0.01
73	18,037	4,795	460	230	230	0.4	0.5	0.2	0.01
74	17,870	4,746	456	228	228	0.4	0.5	0.2	0.01
75	17,687	4,691	450	225	225	0.4	0.5	0.2	0.01
Total		***166,225***	***15,954***	***7,977***	***7,977***	***13.4***	***17.2***	***8.5***	***0.32***

Male

Age	Total Life Years	FIT #	Colonoscopy #	Colonoscopy Pos	Colonoscopy Neg	Complications Minor Bleed	Complications Major Bleed	Complications Perforation	Complications Death
45	19,342	7,447	715	357	357	0.6	0.8	0.4	0.01
46	19,304	7,075	679	339	339	0.6	0.7	0.4	0.01
47	19,263	6,719	645	322	322	0.5	0.7	0.3	0.01
48	19,218	6,380	612	306	306	0.5	0.7	0.3	0.01
49	19,171	6,055	581	291	291	0.5	0.6	0.3	0.01
50	19,119	5,745	551	276	276	0.5	0.6	0.3	0.01
51	19,064	5,448	523	261	261	0.4	0.6	0.3	0.01
52	19,003	5,163	496	248	248	0.4	0.5	0.3	0.01
53	18,938	4,890	469	235	235	0.4	0.5	0.2	0.01
54	18,868	4,629	444	222	222	0.4	0.5	0.2	0.01
55	18,792	4,734	454	227	227	0.4	0.5	0.2	0.01
56	18,709	4,815	462	231	231	0.4	0.5	0.2	0.01
57	18,619	4,872	468	234	234	0.4	0.5	0.2	0.01
58	18,522	4,907	471	235	235	0.4	0.5	0.2	0.01
59	18,416	4,921	472	236	236	0.4	0.5	0.3	0.01
60	18,301	4,916	472	236	236	0.4	0.5	0.3	0.01
61	18,176	4,894	470	235	235	0.4	0.5	0.2	0.01
62	18,041	4,855	466	233	233	0.4	0.5	0.2	0.01
63	17,893	4,799	461	230	230	0.4	0.5	0.2	0.01
64	17,733	4,730	454	227	227	0.4	0.5	0.2	0.01
65	17,559	4,663	448	224	224	0.4	0.5	0.2	0.01
66	17,370	4,597	441	221	221	0.4	0.5	0.2	0.01
67	17,164	4,531	435	217	217	0.4	0.5	0.2	0.01
68	16,940	4,463	428	214	214	0.4	0.5	0.2	0.01
69	16,697	4,392	421	211	211	0.4	0.5	0.2	0.01
70	16,434	4,315	414	207	207	0.3	0.4	0.2	0.01
71	16,147	4,233	406	203	203	0.3	0.4	0.2	0.01
72	15,837	4,143	398	199	199	0.3	0.4	0.2	0.01
73	15,500	4,045	388	194	194	0.3	0.4	0.2	0.01
74	15,136	3,938	378	189	189	0.3	0.4	0.2	0.01
75	14,743	3,821	367	183	183	0.3	0.4	0.2	0.01
Total		***155,132***	***14,889***	***7,444***	***7,444***	***12.5***	***16.1***	***7.9***	***0.30***

Total Population

Age	Total Life Years	FIT #	Colonoscopy #	Complications Minor Bleed	Complications Major Bleed	Complications Perforation	Complications Death
45	39,048	15,033	1,443	1.2	1.6	0.8	0.03
46	38,993	14,291	1,372	1.2	1.5	0.7	0.03
47	38,934	13,583	1,304	1.1	1.4	0.7	0.03
48	38,871	12,906	1,239	1.0	1.3	0.7	0.02
49	38,803	12,261	1,177	1.0	1.3	0.6	0.02
50	38,729	11,644	1,118	0.9	1.2	0.6	0.02
51	38,650	11,055	1,061	0.9	1.1	0.6	0.02
52	38,563	10,491	1,007	0.8	1.1	0.5	0.02
53	38,470	9,952	955	0.8	1.0	0.5	0.02
54	38,370	9,435	906	0.8	1.0	0.5	0.02
55	38,261	9,662	927	0.8	1.0	0.5	0.02
56	38,142	9,839	944	0.8	1.0	0.5	0.02
57	38,014	9,969	957	0.8	1.0	0.5	0.02
58	37,875	10,056	965	0.8	1.0	0.5	0.02
59	37,725	10,104	970	0.8	1.0	0.5	0.02
60	37,561	10,115	971	0.8	1.0	0.5	0.02
61	37,383	10,092	969	0.8	1.0	0.5	0.02
62	37,190	10,037	963	0.8	1.0	0.5	0.02
63	36,980	9,952	955	0.8	1.0	0.5	0.02
64	36,752	9,839	944	0.8	1.0	0.5	0.02
65	36,503	9,735	934	0.8	1.0	0.5	0.02
66	36,233	9,636	925	0.8	1.0	0.5	0.02
67	35,938	9,538	915	0.8	1.0	0.5	0.02
68	35,618	9,440	906	0.8	1.0	0.5	0.02
69	35,269	9,337	896	0.8	1.0	0.5	0.02
70	34,889	9,228	886	0.7	1.0	0.5	0.02
71	34,476	9,111	874	0.7	0.9	0.5	0.02
72	34,026	8,982	862	0.7	0.9	0.5	0.02
73	33,537	8,840	848	0.7	0.9	0.4	0.02
74	33,006	8,684	833	0.7	0.9	0.4	0.02
75	32,429	8,512	817	0.7	0.9	0.4	0.02
Total		***321,358***	***30,843***	***26***	***33***	***16***	***0.62***

392 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.

393 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.

394 Ibid.

- We assumed a utility loss equivalent to 2 days per colonoscopy performed (0.0055 QALYs per colonoscopy).[395]
- We assumed a utility loss equivalent to 2 days per minor bleeding event (0.0055 per bleeding event).[396]
- 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).[397]
- The colonoscopies and associated minor/major complications are associated with an estimated 210 QALYs lost while the 0.62 death attributable to colonoscopy is associated with 16 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	4.6	9.3	0.00	0.00	0.01	0.01	0.01	0.01	4.7	4.6	9.3	0.6	0.5	1.1
46	4.5	4.4	8.8	0.00	0.00	0.01	0.01	0.01	0.01	4.5	4.4	8.9	0.5	0.5	1.0
47	4.2	4.2	8.4	0.00	0.00	0.01	0.01	0.01	0.01	4.3	4.2	8.4	0.5	0.5	1.0
48	4.0	3.9	8.0	0.00	0.00	0.01	0.01	0.01	0.01	4.0	4.0	8.0	0.5	0.4	0.9
49	3.8	3.7	7.6	0.00	0.00	0.01	0.01	0.01	0.01	3.8	3.8	7.6	0.4	0.4	0.8
50	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
51	3.6	3.5	7.1	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	6.8	0.00	0.00	0.01	0.01	0.01	0.01	3.4	3.3	6.8	0.3	0.3	0.6
53	3.3	3.1	6.4	0.00	0.00	0.01	0.01	0.01	0.01	3.3	3.2	6.4	0.3	0.3	0.6
54	3.1	3.0	6.1	0.00	0.00	0.01	0.00	0.00	0.01	3.1	3.0	6.1	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	3.1	6.2	0.3	0.3	0.5
56	3.2	3.1	6.3	0.00	0.00	0.01	0.01	0.00	0.01	3.2	3.1	6.3	0.3	0.2	0.5
57	3.3	3.1	6.4	0.00	0.00	0.01	0.01	0.01	0.01	3.3	3.1	6.4	0.3	0.2	0.5
58	3.3	3.2	6.5	0.00	0.00	0.01	0.01	0.01	0.01	3.3	3.2	6.5	0.3	0.2	0.5
59	3.3	3.2	6.5	0.00	0.00	0.01	0.01	0.01	0.01	3.3	3.2	6.5	0.3	0.2	0.5
60	3.4	3.2	6.7	0.00	0.00	0.01	0.01	0.01	0.01	3.4	3.3	6.7	0.3	0.2	0.5
61	3.4	3.2	6.7	0.00	0.00	0.01	0.01	0.01	0.01	3.4	3.2	6.7	0.3	0.2	0.5
62	3.4	3.2	6.6	0.00	0.00	0.01	0.01	0.01	0.01	3.4	3.2	6.6	0.2	0.2	0.4
63	3.4	3.2	6.6	0.00	0.00	0.01	0.01	0.01	0.01	3.4	3.2	6.6	0.2	0.2	0.4
64	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
65	3.4	3.1	6.4	0.00	0.00	0.01	0.01	0.00	0.01	3.4	3.1	6.4	0.2	0.2	0.4
66	3.3	3.0	6.4	0.00	0.00	0.01	0.01	0.00	0.01	3.3	3.0	6.4	0.2	0.2	0.4
67	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
68	3.3	2.9	6.2	0.00	0.00	0.01	0.01	0.00	0.01	3.3	3.0	6.3	0.2	0.1	0.3
69	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
70	3.4	3.0	6.4	0.00	0.00	0.01	0.01	0.00	0.01	3.4	3.0	6.5	0.2	0.1	0.3
71	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
72	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
73	3.3	2.8	6.2	0.00	0.00	0.01	0.01	0.00	0.01	3.4	2.8	6.2	0.1	0.1	0.2
74	3.3	2.7	6.1	0.00	0.00	0.01	0.01	0.00	0.01	3.3	2.8	6.1	0.1	0.1	0.2
75	3.3	2.7	5.9	0.00	0.00	0.00	0.01	0.00	0.01	3.3	2.7	6.0	0.1	0.1	0.2
	108.5	**101.1**	**209.6**	**0.09**	**0.08**	**0.18**	**0.17**	**0.16**	**0.34**	**108.8**	**101.4**	**210.2**	**8.8**	**7.5**	**16.3**

[395] 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.
[396] 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.
[397] 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 3,588 QALYs (Table 16, row *am*). The CPB of 3,588 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	1,268,167	Table 2
	Total Burden (QALYs) in Birth Cohort Without Screening		
e	Incidence of CRC per 100,000 life years	146	Table 2
	# of new CRC **cases** by Dukes' Stage		
f	A	269	Table 4
g	B	660	Table 4
h	C	518	Table 4
i	Distant	406	Table 4
j	Total new CRC case in birth cohort	1,852	Table 4
	# of CRC **deaths** by Dukes' Stage		
k	A	39	Table 8
l	B	165	Table 8
m	C	177	Table 8
n	Distant	349	Table 8
o	Total new CRC deaths in birth cohort	729	Table 8
p	Life years lost due to CRC deaths	12,805	Table 9
q	Life years lost per CRC death	17.6	= p / o
r	QALYs lost due to living with CRC	2,150	Table 9
s	***Total QALYs lost without screening***	**14,955**	= 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	389	Table 11
w	B	496	Table 11
x	C	395	Table 11
y	Distant	258	Table 11
z	Total new CRC case in birth cohort	1,538	Table 11
	# of CRC **deaths** by Dukes' Stage		
aa	A	56	Table 12
ab	B	124	Table 12
ac	C	135	Table 12
ad	Distant	222	Table 12
ae	Total new CRC deaths in birth cohort	537	Table 12
af	Life years lost due to CRC deaths	9,400	Table 13
ag	Life years lost per CRC death	17.5	= af / ae
ah	QALYs lost due to living with CRC	1,740	Table 13
	Harms Due to Colonoscopies		
ai	Life years lost due to colonoscopies	16	Table 15
aj	QALYs lost due to colonoscopies	210	Table 15
	Net QALYs Gained With Screening		
ak	Net life years gained	3,388	= p - af - ai
al	Net QALYs gained	200	= r - ah - aj
am	**Total QALYs gained (CPB) -** No screening to 77%	**3,588**	= ak + al
an	**Total QALYs gained (CPB) -** Screening rate improves from 50% to 77%	1,258	= (1-50/77) * am
ao	**Total QALYs gained (CPB) -** Screening rate improves from 35% to 77%	1,957	= (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 = 3,108
- Assume that the effectiveness of screening in reducing the incidence of CRC is increased from 22% to 26%: CPB = 3,972
- 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 = 3,452
- 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 = 3,739
- Screening rate reduced from 77% to 50% (Table 16, row *t*): CPB = 2,006

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 1,582 QALYs (Table 17, row *am*). The CPB of 1,582 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	659,754	Table 2
	Total Burden (QALYs) in Birth Cohort Without Screening		
e	Incidence of CRC per 100,000 life years	119	Table 2
	# of new CRC **cases** by Dukes' Stage		
f	A	114	Table 4
g	B	281	Table 4
h	C	220	Table 4
i	Distant	173	Table 4
j	Total new CRC case in birth cohort	788	Table 4
	# of CRC **deaths** by Dukes' Stage		
k	A	16	Table 8
l	B	70	Table 8
m	C	75	Table 8
n	Distant	148	Table 8
o	Total new CRC deaths in birth cohort	310	Table 8
p	Life years lost due to CRC deaths	5,743	Table 9
q	Life years lost per CRC death	18.6	= p / o
r	QALYs lost due to living with CRC	899	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	99	=(z / d) * 100,000
	# of new CRC **cases** by Dukes' Stage		
v	A	166	Table 11
w	B	211	Table 11
x	C	168	Table 11
y	Distant	110	Table 11
z	Total new CRC case in birth cohort	654	Table 11
	# of CRC **deaths** by Dukes' Stage		
aa	A	24	Table 12
ab	B	52	Table 12
ac	C	57	Table 12
ad	Distant	94	Table 12
ae	Total new CRC deaths in birth cohort	228	Table 12
af	Life years lost due to CRC deaths	4,216	Table 13
ag	Life years lost per CRC death	18.5	= af / ae
ah	QALYs lost due to living with CRC	726	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	1,518	= p - af - ai
al	Net QALYs gained	64	= r - ah - aj
am	**Total QALYs gained (CPB) -** No screening to 77%	**1,582**	= 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 = 1,369
- Assume that the effectiveness of screening in reducing the incidence of CRC is increased from 22% to 26%: CPB = 1,752
- 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 = 1,525
- 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 = 1,646
- Screening rate reduced from 77% to 50% (Table 17, row *t*): CPB = 882

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 2,006 QALYs (Table 18, row *am*). The CPB of 2,006 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	608,413	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	154	Table 4
g	B	379	Table 4
h	C	298	Table 4
i	Distant	233	Table 4
j	Total new CRC case in birth cohort	1,064	Table 4
	# of CRC **deaths** by Dukes' Stage		
k	A	22	Table 8
l	B	95	Table 8
m	C	102	Table 8
n	Distant	201	Table 8
o	Total new CRC deaths in birth cohort	420	Table 8
p	Life years lost due to CRC deaths	7,062	Table 9
q	Life years lost per CRC death	16.8	= p / o
r	QALYs lost due to living with CRC	1,251	Table 9
s	***Total QALYs lost without screening***	**8,312**	= 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	224	Table 11
w	B	285	Table 11
x	C	227	Table 11
y	Distant	148	Table 11
z	Total new CRC case in birth cohort	884	Table 11
	# of CRC **deaths** by Dukes' Stage		
aa	A	32	Table 12
ab	B	71	Table 12
ac	C	78	Table 12
ad	Distant	127	Table 12
ae	Total new CRC deaths in birth cohort	309	Table 12
af	Life years lost due to CRC deaths	5,184	Table 13
ag	Life years lost per CRC death	16.8	= af / ae
ah	QALYs lost due to living with CRC	1,013	Table 13
	Harms Due to Colonoscopies		
ai	Life years lost due to colonoscopies	7	Table 15
aj	QALYs lost due to colonoscopies	101	Table 15
	Net QALYs Gained With Screening		
ak	Net life years gained	1,870	= p - af - ai
al	Net QALYs gained	136	= r - ah - aj
am	**Total QALYs gained (CPB) -** No screening to 77%	**2,006**	= ak + al
an	**Total QALYs gained (CPB) -** Screening rate improves from 50% to 77%	703	= (1-50/77) * am
ao	**Total QALYs gained (CPB) -** Screening rate improves from 35% to 77%	1,094	= (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 = 1,739
- Assume that the effectiveness of screening in reducing the incidence of CRC is increased from 22% to 26%: CPB = 2,220
- 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 = 1,927
- 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 = 2,094
- Screening rate reduced from 77% to 50% (Table 18, row *t*): CPB = 1,124

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 $11.81 million in 2017$) per year. The fixed costs include costs for the screening registry, program infrastructure, communications and advertising, and sending activity reports to primary care physicians.[398]
- 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.[399] If we divide the annual fixed program cost by the number of annual screens we calculate an average fixed program cost of $30.34 per screen ($11.81 million / 389,245).
- Based on data from Ontario, the cost of the FIT kit and processing is $31.11 (in 2013$ or $32.48 in 2017$).[400]
- 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.

[398] 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.
[399] 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.
[400] 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.

- The cost of an office visit to a General Practitioner (GP) in BC is estimated at $34.85.[401]
- Based on data from Ontario, the cost of a colonoscopy (no polypectomy) is $872 (in 2013$ or $910 in 2017$).[402]
- Based on data from Ontario, the cost of a colonoscopy (with polypectomy) is $1,097 (in 2013$ or $1,145 in 2017$).[403]
- 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 2017 ($25.16[404]) plus 18% benefits for an average cost per hour of $29.69. In the absence of specific data on the amount of time required, we assume two hours per service.
- Patient time costs are truncated at $222.67 per day (7.5 hours times $29.69). If, for example, we are valuing a patient's time costs while in hospital, each day would be assessed a value of $222.67 (rather than 24 hours times $29.69 or $712.56).
- We have assumed two days of patient time lost per colonoscopy, including the time for bowel preparation, the procedure and recovery time.[405]
- Over the lifetime of the BC birth cohort, total colorectal screening costs (excluding patient time costs) would be $69.21 million, consisting of $9.75 million in fixed program costs, $17.34 million in physician visit costs, $10.44 million for the cost of the FIT kit and processing and $31.69 million for colonoscopies (see Table 19).
- Over the lifetime of the BC birth cohort, patient time costs would be $43.27 million, consisting of $29.54 for time spent visiting their physician and $13.74 million for time spent for bowel preparation, the procedure and recovery time for colonoscopies (see Table 20).

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401 Ministry of Health. *Medical Services Commission Payment Schedule*. 2016. Available at http://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msc-payment-schedule-december-2016.pdf. Accessed July 2017.
402 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.
403 Ibid.
404 Statistics Canada. *Average Hourly Wages of Employees by Selected Characteristics and Occupation, Unadjusted Data, by Province (monthly) (British Columbia)*. 2017. Available at http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/labr69k-eng.htm. Accessed July 2017.
405 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				
Age	# of FIT	Colonoscopy #	Colonoscopy Pos	Colonoscopy Neg	Fixed Program Costs	Physician Visits # of	Physician Visits $ of	Cost of FIT Kit & Processing	Cost of Colonoscopies	# of FIT	Colonoscopy #	Colonoscopy Pos	Colonoscopy Neg	Fixed Program Costs	Physician Visits # of	Physician Visits $ of	Cost of FIT Kit & Processing	Cost of Colonoscopies	Fixed Program	Physician	FIT Kit	Colonoscopies	Total
45	7,587	728	364	364	$0.23	11,744	$0.41	$0.25	$0.75	7,447	715	357	357	$0.23	11,527	$0.40	$0.24	$0.73	$0.46	$0.81	$0.49	$1.48	$3.24
46	7,216	693	346	346	$0.22	11,171	$0.39	$0.23	$0.71	7,075	679	339	339	$0.21	10,951	$0.38	$0.23	$0.70	$0.43	$0.77	$0.46	$1.41	$3.08
47	6,863	659	329	329	$0.21	10,624	$0.37	$0.22	$0.68	6,719	645	322	322	$0.20	10,401	$0.36	$0.22	$0.66	$0.41	$0.73	$0.44	$1.34	$2.93
48	6,527	626	313	313	$0.20	10,103	$0.35	$0.21	$0.64	6,380	612	306	306	$0.19	9,876	$0.34	$0.21	$0.63	$0.39	$0.70	$0.42	$1.27	$2.78
49	6,205	596	298	298	$0.19	9,606	$0.33	$0.20	$0.61	6,055	581	291	291	$0.18	9,374	$0.33	$0.20	$0.60	$0.37	$0.66	$0.40	$1.21	$2.64
50	5,899	566	283	283	$0.18	9,132	$0.32	$0.19	$0.58	5,745	551	276	276	$0.17	8,893	$0.31	$0.19	$0.57	$0.35	$0.63	$0.38	$1.15	$2.51
51	5,607	538	269	269	$0.17	8,679	$0.30	$0.18	$0.55	5,448	523	261	261	$0.17	8,433	$0.29	$0.18	$0.54	$0.34	$0.60	$0.36	$1.09	$2.38
52	5,328	511	256	256	$0.16	8,247	$0.29	$0.17	$0.53	5,163	496	248	248	$0.16	7,993	$0.28	$0.17	$0.51	$0.32	$0.57	$0.34	$1.03	$2.26
53	5,061	486	243	243	$0.15	7,835	$0.27	$0.16	$0.50	4,890	469	235	235	$0.15	7,570	$0.26	$0.16	$0.48	$0.30	$0.54	$0.32	$0.98	$2.14
54	4,807	461	231	231	$0.15	7,441	$0.26	$0.16	$0.47	4,629	444	222	222	$0.14	7,165	$0.25	$0.15	$0.46	$0.29	$0.51	$0.31	$0.93	$2.03
55	4,928	473	236	236	$0.15	7,628	$0.27	$0.16	$0.49	4,734	454	227	227	$0.14	7,329	$0.26	$0.15	$0.47	$0.29	$0.52	$0.31	$0.95	$2.08
56	5,024	482	241	241	$0.15	7,777	$0.27	$0.16	$0.50	4,815	462	231	231	$0.15	7,453	$0.26	$0.16	$0.47	$0.30	$0.53	$0.32	$0.97	$2.12
57	5,097	489	245	245	$0.15	7,891	$0.27	$0.17	$0.50	4,872	468	234	234	$0.15	7,541	$0.26	$0.16	$0.48	$0.30	$0.54	$0.32	$0.98	$2.15
58	5,150	494	247	247	$0.16	7,972	$0.28	$0.17	$0.51	4,907	471	235	235	$0.15	7,595	$0.26	$0.16	$0.48	$0.31	$0.54	$0.33	$0.99	$2.17
59	5,183	497	249	249	$0.16	8,024	$0.28	$0.17	$0.51	4,921	472	236	236	$0.15	7,618	$0.27	$0.16	$0.49	$0.31	$0.55	$0.33	$1.00	$2.18
60	5,199	499	249	249	$0.16	8,048	$0.28	$0.17	$0.51	4,916	472	236	236	$0.15	7,610	$0.27	$0.16	$0.48	$0.31	$0.55	$0.33	$1.00	$2.18
61	5,198	499	249	249	$0.16	8,047	$0.28	$0.17	$0.51	4,894	470	235	235	$0.15	7,575	$0.26	$0.16	$0.48	$0.31	$0.54	$0.33	$1.00	$2.17
62	5,182	497	249	249	$0.16	8,022	$0.28	$0.17	$0.51	4,855	466	233	233	$0.15	7,515	$0.26	$0.16	$0.48	$0.30	$0.54	$0.33	$0.99	$2.16
63	5,152	494	247	247	$0.16	7,976	$0.28	$0.17	$0.51	4,799	461	230	230	$0.15	7,430	$0.26	$0.16	$0.47	$0.30	$0.54	$0.32	$0.98	$2.14
64	5,109	490	245	245	$0.16	7,909	$0.28	$0.17	$0.50	4,730	454	227	227	$0.14	7,321	$0.26	$0.15	$0.47	$0.30	$0.53	$0.32	$0.97	$2.12
65	5,072	487	243	243	$0.15	7,851	$0.27	$0.16	$0.50	4,663	448	224	224	$0.14	7,218	$0.25	$0.15	$0.46	$0.30	$0.53	$0.32	$0.96	$2.10
66	5,038	484	242	242	$0.15	7,799	$0.27	$0.16	$0.50	4,597	441	221	221	$0.14	7,116	$0.25	$0.15	$0.45	$0.29	$0.52	$0.31	$0.95	$2.08
67	5,007	481	240	240	$0.15	7,751	$0.27	$0.16	$0.49	4,531	435	217	217	$0.14	7,014	$0.24	$0.15	$0.45	$0.29	$0.51	$0.31	$0.94	$2.05
68	4,977	478	239	239	$0.15	7,704	$0.27	$0.16	$0.49	4,463	428	214	214	$0.14	6,909	$0.24	$0.14	$0.44	$0.29	$0.51	$0.31	$0.93	$2.03
69	4,946	475	237	237	$0.15	7,656	$0.27	$0.16	$0.49	4,392	421	211	211	$0.13	6,798	$0.24	$0.14	$0.43	$0.28	$0.50	$0.30	$0.92	$2.01
70	4,913	472	236	236	$0.15	7,606	$0.27	$0.16	$0.48	4,315	414	207	207	$0.13	6,680	$0.23	$0.14	$0.43	$0.28	$0.50	$0.30	$0.91	$1.99
71	4,878	468	234	234	$0.15	7,551	$0.26	$0.16	$0.48	4,233	406	203	203	$0.13	6,552	$0.23	$0.14	$0.42	$0.28	$0.49	$0.30	$0.90	$1.96
72	4,839	464	232	232	$0.15	7,491	$0.26	$0.16	$0.48	4,143	398	199	199	$0.13	6,413	$0.22	$0.13	$0.41	$0.27	$0.48	$0.29	$0.89	$1.93
73	4,795	460	230	230	$0.15	7,423	$0.26	$0.16	$0.47	4,045	388	194	194	$0.12	6,261	$0.22	$0.13	$0.40	$0.27	$0.48	$0.29	$0.87	$1.90
74	4,746	456	228	228	$0.14	7,347	$0.26	$0.15	$0.47	3,938	378	189	189	$0.12	6,095	$0.21	$0.13	$0.39	$0.26	$0.47	$0.28	$0.86	$1.87
75	4,691	450	225	225	$0.14	7,262	$0.25	$0.15	$0.46	3,821	367	183	183	$0.12	5,915	$0.21	$0.12	$0.38	$0.26	$0.46	$0.28	$0.84	$1.83
Total	*166,225*	*15,954*	*7,977*	*7,977*	*$5.04*	*257,315*	*$8.97*	*$5.40*	*$16.39*	*155,132*	*14,889*	*7,444*	*7,444*	*$4.71*	*240,143*	*$8.37*	*$5.04*	*$15.30*	*$9.75*	*$17.34*	*$10.44*	*$31.69*	*$69.21*

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	7,587	728	11,744	$0.70	$0.32	7,447	715	11,527	$0.68	$0.32	$1.38	$0.64	$2.02
46	7,216	693	11,171	$0.66	$0.31	7,075	679	10,951	$0.65	$0.30	$1.31	$0.61	$1.92
47	6,863	659	10,624	$0.63	$0.29	6,719	645	10,401	$0.62	$0.29	$1.25	$0.58	$1.83
48	6,527	626	10,103	$0.60	$0.28	6,380	612	9,876	$0.59	$0.27	$1.19	$0.55	$1.74
49	6,205	596	9,606	$0.57	$0.27	6,055	581	9,374	$0.56	$0.26	$1.13	$0.52	$1.65
50	5,899	566	9,132	$0.54	$0.25	5,745	551	8,893	$0.53	$0.25	$1.07	$0.50	$1.57
51	5,607	538	8,679	$0.52	$0.24	5,448	523	8,433	$0.50	$0.23	$1.02	$0.47	$1.49
52	5,328	511	8,247	$0.49	$0.23	5,163	496	7,993	$0.47	$0.22	$0.96	$0.45	$1.41
53	5,061	486	7,835	$0.47	$0.22	4,890	469	7,570	$0.45	$0.21	$0.91	$0.43	$1.34
54	4,807	461	7,441	$0.44	$0.21	4,629	444	7,165	$0.43	$0.20	$0.87	$0.40	$1.27
55	4,928	473	7,628	$0.45	$0.21	4,734	454	7,329	$0.44	$0.20	$0.89	$0.41	$1.30
56	5,024	482	7,777	$0.46	$0.21	4,815	462	7,453	$0.44	$0.21	$0.90	$0.42	$1.32
57	5,097	489	7,891	$0.47	$0.22	4,872	468	7,541	$0.45	$0.21	$0.92	$0.43	$1.34
58	5,150	494	7,972	$0.47	$0.22	4,907	471	7,595	$0.45	$0.21	$0.92	$0.43	$1.35
59	5,183	497	8,024	$0.48	$0.22	4,921	472	7,618	$0.45	$0.21	$0.93	$0.43	$1.36
60	5,199	499	8,048	$0.48	$0.22	4,916	472	7,610	$0.45	$0.21	$0.93	$0.43	$1.36
61	5,198	499	8,047	$0.48	$0.22	4,894	470	7,575	$0.45	$0.21	$0.93	$0.43	$1.36
62	5,182	497	8,022	$0.48	$0.22	4,855	466	7,515	$0.45	$0.21	$0.92	$0.43	$1.35
63	5,152	494	7,976	$0.47	$0.22	4,799	461	7,430	$0.44	$0.21	$0.91	$0.43	$1.34
64	5,109	490	7,909	$0.47	$0.22	4,730	454	7,321	$0.43	$0.20	$0.90	$0.42	$1.32
65	5,072	487	7,851	$0.47	$0.22	4,663	448	7,218	$0.43	$0.20	$0.89	$0.42	$1.31
66	5,038	484	7,799	$0.46	$0.22	4,597	441	7,116	$0.42	$0.20	$0.89	$0.41	$1.30
67	5,007	481	7,751	$0.46	$0.21	4,531	435	7,014	$0.42	$0.19	$0.88	$0.41	$1.28
68	4,977	478	7,704	$0.46	$0.21	4,463	428	6,909	$0.41	$0.19	$0.87	$0.40	$1.27
69	4,946	475	7,656	$0.45	$0.21	4,392	421	6,798	$0.40	$0.19	$0.86	$0.40	$1.26
70	4,913	472	7,606	$0.45	$0.21	4,315	414	6,680	$0.40	$0.18	$0.85	$0.39	$1.24
71	4,878	468	7,551	$0.45	$0.21	4,233	406	6,552	$0.39	$0.18	$0.84	$0.39	$1.23
72	4,839	464	7,491	$0.44	$0.21	4,143	398	6,413	$0.38	$0.18	$0.83	$0.38	$1.21
73	4,795	460	7,423	$0.44	$0.20	4,045	388	6,261	$0.37	$0.17	$0.81	$0.38	$1.19
74	4,746	456	7,347	$0.44	$0.20	3,938	378	6,095	$0.36	$0.17	$0.80	$0.37	$1.17
75	4,691	450	7,262	$0.43	$0.20	3,821	367	5,915	$0.35	$0.16	$0.78	$0.36	$1.15
Total	***166,225***	***15,954***	***257,315***	***$15.28***	***$7.10***	***155,132***	***14,889***	***240,143***	***$14.26***	***$6.63***	***$29.54***	***$13.74***	***$43.27***

Cost of Harms

- Based on data from Ontario, the cost of a bleeding complication following a colonoscopy is $3,521 (in 2013$ or $3,676 in 2017$).[406]
- Based on data from Ontario, the cost of a perforation complication following a colonoscopy is $34,412 (in 2013$ or $35,923).[407]
- Over the lifetime of the BC birth cohort, the healthcare costs associated with treating bleeding and perforations resulting from colonoscopies is estimated at $804,903 (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	$5,139	0.4	$13,863	1.4	$5,044	0.4	$13,607	$10,183	$27,471	$37,654
46	1.3	$4,888	0.4	$13,186	1.3	$4,792	0.4	$12,927	$9,681	$26,114	$35,794
47	1.3	$4,649	0.3	$12,541	1.2	$4,552	0.3	$12,278	$9,201	$24,819	$34,020
48	1.2	$4,421	0.3	$11,926	1.2	$4,322	0.3	$11,658	$8,743	$23,584	$32,326
49	1.1	$4,204	0.3	$11,339	1.1	$4,102	0.3	$11,065	$8,305	$22,404	$30,710
50	1.1	$3,996	0.3	$10,780	1.1	$3,892	0.3	$10,498	$7,888	$21,277	$29,165
51	1.0	$3,798	0.3	$10,245	1.0	$3,690	0.3	$9,955	$7,488	$20,200	$27,688
52	1.0	$3,609	0.3	$9,735	1.0	$3,497	0.3	$9,435	$7,106	$19,170	$26,277
53	0.9	$3,428	0.3	$9,249	0.9	$3,313	0.2	$8,936	$6,741	$18,185	$24,926
54	0.9	$3,256	0.2	$8,783	0.9	$3,135	0.2	$8,458	$6,391	$17,241	$23,633
55	0.9	$3,338	0.3	$9,004	0.9	$3,207	0.2	$8,651	$6,545	$17,655	$24,200
56	0.9	$3,403	0.3	$9,180	0.9	$3,262	0.2	$8,798	$6,665	$17,978	$24,643
57	0.9	$3,453	0.3	$9,314	0.9	$3,300	0.2	$8,902	$6,753	$18,216	$24,969
58	0.9	$3,488	0.3	$9,410	0.9	$3,324	0.2	$8,966	$6,812	$18,376	$25,188
59	1.0	$3,511	0.3	$9,471	0.9	$3,333	0.3	$8,992	$6,845	$18,464	$25,308
60	1.0	$3,522	0.3	$9,500	0.9	$3,330	0.3	$8,984	$6,852	$18,483	$25,335
61	1.0	$3,521	0.3	$9,498	0.9	$3,315	0.2	$8,942	$6,836	$18,441	$25,277
62	1.0	$3,510	0.3	$9,469	0.9	$3,288	0.2	$8,871	$6,799	$18,340	$25,139
63	0.9	$3,490	0.3	$9,415	0.9	$3,251	0.2	$8,770	$6,741	$18,185	$24,926
64	0.9	$3,461	0.3	$9,336	0.9	$3,204	0.2	$8,642	$6,665	$17,979	$24,643
65	0.9	$3,436	0.3	$9,268	0.9	$3,159	0.2	$8,520	$6,594	$17,788	$24,383
66	0.9	$3,413	0.3	$9,207	0.8	$3,114	0.2	$8,401	$6,527	$17,607	$24,134
67	0.9	$3,392	0.3	$9,149	0.8	$3,069	0.2	$8,280	$6,461	$17,429	$23,890
68	0.9	$3,371	0.3	$9,094	0.8	$3,023	0.2	$8,155	$6,394	$17,249	$23,644
69	0.9	$3,350	0.3	$9,037	0.8	$2,975	0.2	$8,025	$6,325	$17,062	$23,387
70	0.9	$3,328	0.2	$8,978	0.8	$2,923	0.2	$7,885	$6,251	$16,863	$23,114
71	0.9	$3,304	0.2	$8,914	0.8	$2,867	0.2	$7,734	$6,172	$16,648	$22,820
72	0.9	$3,278	0.2	$8,843	0.8	$2,806	0.2	$7,570	$6,084	$16,413	$22,497
73	0.9	$3,248	0.2	$8,763	0.7	$2,740	0.2	$7,391	$5,988	$16,154	$22,142
74	0.9	$3,215	0.2	$8,673	0.7	$2,667	0.2	$7,195	$5,882	$15,868	$21,750
75	0.9	$3,178	0.2	$8,572	0.7	$2,588	0.2	$6,982	$5,766	$15,554	$21,320
Total	**30.6**	**$112,600**	**8.5**	**$303,744**	**28.6**	**$105,085**	**7.9**	**$283,474**	**$217,685**	**$587,218**	**$804,903**

[406] 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.
[407] 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:[408]
    - Females
        - Initial 6 months - $24,765 (in 2009$, $28,264 in 2017 $)
        - Continuing care (annual) - $5,349 ($6,105)
        - Terminal care (12 months) - $31,120 ($36,658)
    - Males
        - Initial 6 months - $25,138 ($28,690)
        - Continuing care (annual) - $5,446 ($6,215)
        - Terminal care (12 months) - $32,408 ($36,987)
- Based on data from Ontario, *first year* healthcare costs associated with a CRC survivor are $47,823 (in 2017$). The mean costs for females / males are $45,236 and $49,633, respectively. The costs by stage are $25,145 for Stage I, $41,438 for Stage II, $63,373 for Stage III and $83,140 for Stage IV.[409]
- 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:[410]
    - Stage I - $28,981 (in 2013 $, $30,253 in 2017$)
    - Stage II - $43,348 ($45,251)
    - Stage III - $62,259 ($64,992)
    - Stage IV – $83,440 ($87,103)
- 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 215 new CRC cases avoided (314 new CRCs minus 99 that died in Year 1) are associated with costs avoided of $16.55 million during the first year following diagnosis (see Table 22).

[408] 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.
[409] 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.
[410] 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	$0.09	-0.7	1.0	0.7	0.6	1.6	$0.12
46	-0.2	0.3	0.2	0.2	0.5	$0.04	-0.5	0.7	0.5	0.4	1.1	$0.09	-0.7	1.0	0.7	0.6	1.6	$0.12
47	-0.2	0.3	0.2	0.2	0.5	$0.04	-0.5	0.7	0.5	0.4	1.1	$0.09	-0.7	1.0	0.7	0.6	1.6	$0.12
48	-0.2	0.3	0.2	0.2	0.5	$0.04	-0.5	0.7	0.5	0.4	1.1	$0.09	-0.7	1.0	0.7	0.6	1.6	$0.12
49	-0.2	0.3	0.2	0.2	0.5	$0.04	-0.5	0.7	0.5	0.4	1.1	$0.09	-0.7	1.0	0.7	0.6	1.6	$0.12
50	-0.6	0.8	0.6	0.5	1.3	$0.10	-0.7	0.9	0.7	0.5	1.4	$0.11	-1.3	1.7	1.3	1.0	2.7	$0.21
51	-0.6	0.8	0.6	0.5	1.3	$0.10	-0.7	0.9	0.7	0.5	1.4	$0.11	-1.3	1.7	1.3	1.0	2.7	$0.21
52	-0.6	0.8	0.6	0.5	1.3	$0.10	-0.7	0.9	0.7	0.5	1.4	$0.11	-1.3	1.7	1.3	1.0	2.7	$0.21
53	-0.6	0.8	0.6	0.5	1.3	$0.10	-0.7	0.9	0.7	0.5	1.4	$0.11	-1.3	1.7	1.3	1.0	2.7	$0.21
54	-0.6	0.8	0.6	0.5	1.3	$0.10	-0.7	0.9	0.7	0.5	1.4	$0.11	-1.3	1.7	1.3	1.0	2.7	$0.21
55	-0.8	1.0	0.7	0.6	1.5	$0.12	-1.3	1.7	1.2	0.9	2.5	$0.20	-2.0	2.7	2.0	1.5	4.1	$0.32
56	-0.8	1.0	0.7	0.6	1.5	$0.12	-1.3	1.6	1.2	0.9	2.5	$0.20	-2.0	2.7	2.0	1.5	4.1	$0.32
57	-0.8	1.0	0.7	0.6	1.5	$0.12	-1.2	1.6	1.2	0.9	2.5	$0.19	-2.0	2.6	2.0	1.5	4.1	$0.31
58	-0.8	1.0	0.7	0.6	1.5	$0.12	-1.2	1.6	1.2	0.9	2.5	$0.19	-2.0	2.6	1.9	1.5	4.0	$0.31
59	-0.8	1.0	0.7	0.6	1.5	$0.12	-1.2	1.6	1.2	0.9	2.5	$0.19	-2.0	2.6	1.9	1.5	4.0	$0.31
60	-1.3	1.7	1.2	0.9	2.6	$0.20	-2.0	2.6	2.0	1.5	4.1	$0.31	-3.3	4.3	3.2	2.4	6.6	$0.51
61	-1.3	1.7	1.2	0.9	2.5	$0.20	-2.0	2.6	1.9	1.5	4.0	$0.31	-3.3	4.3	3.2	2.4	6.6	$0.51
62	-1.3	1.7	1.2	0.9	2.5	$0.20	-2.0	2.6	1.9	1.5	4.0	$0.31	-3.2	4.3	3.2	2.4	6.5	$0.51
63	-1.3	1.6	1.2	0.9	2.5	$0.20	-2.0	2.6	1.9	1.4	4.0	$0.31	-3.2	4.2	3.1	2.4	6.5	$0.50
64	-1.2	1.6	1.2	0.9	2.5	$0.19	-1.9	2.6	1.9	1.4	3.9	$0.30	-3.2	4.2	3.1	2.3	6.5	$0.50
65	-1.7	2.2	1.7	1.3	3.5	$0.27	-2.3	3.0	2.2	1.7	4.7	$0.36	-4.0	5.3	3.9	2.9	8.1	$0.63
66	-1.7	2.2	1.7	1.2	3.4	$0.27	-2.3	3.0	2.2	1.7	4.6	$0.36	-4.0	5.2	3.9	2.9	8.1	$0.62
67	-1.7	2.2	1.7	1.2	3.4	$0.26	-2.3	3.0	2.2	1.7	4.6	$0.35	-3.9	5.2	3.8	2.9	8.0	$0.62
68	-1.7	2.2	1.6	1.2	3.4	$0.26	-2.2	2.9	2.2	1.6	4.5	$0.35	-3.9	5.1	3.8	2.9	7.9	$0.61
69	-1.7	2.2	1.6	1.2	3.4	$0.26	-2.2	2.9	2.1	1.6	4.4	$0.34	-3.9	5.1	3.8	2.8	7.8	$0.60
70	-2.4	3.1	2.2	1.1	4.0	$0.31	-3.3	4.3	3.0	1.6	5.6	$0.43	-5.7	7.3	5.2	2.7	9.6	$0.74
71	-2.4	3.1	2.2	1.1	4.0	$0.31	-3.3	4.2	3.0	1.6	5.5	$0.42	-5.6	7.2	5.2	2.7	9.5	$0.73
72	-2.4	3.0	2.2	1.1	4.0	$0.31	-3.2	4.1	2.9	1.5	5.4	$0.41	-5.6	7.1	5.1	2.7	9.3	$0.72
73	-2.3	3.0	2.2	1.1	3.9	$0.30	-3.1	4.0	2.9	1.5	5.3	$0.40	-5.5	7.0	5.0	2.6	9.2	$0.71
74	-2.3	3.0	2.1	1.1	3.9	$0.30	-3.1	3.9	2.8	1.5	5.1	$0.39	-5.4	6.9	4.9	2.6	9.0	$0.69
75	-3.0	3.9	2.8	1.4	5.1	$0.39	-3.7	4.8	3.4	1.8	6.2	$0.48	-6.7	8.6	6.2	3.2	11.3	$0.87
76	-3.0	3.8	2.7	1.4	5.0	$0.38	-3.6	4.6	3.3	1.7	6.0	$0.46	-6.6	8.4	6.0	3.1	11.0	$0.85
77	-2.9	3.8	2.7	1.4	4.9	$0.38	-3.5	4.5	3.2	1.7	5.8	$0.45	-6.4	8.3	5.9	3.1	10.8	$0.83
78	-2.9	3.7	2.7	1.4	4.9	$0.37	-3.4	4.3	3.1	1.6	5.6	$0.43	-6.3	8.0	5.7	3.0	10.5	$0.81
79	-2.9	3.7	2.6	1.4	4.8	$0.37	-3.2	4.1	3.0	1.5	5.4	$0.42	-6.1	7.8	5.6	2.9	10.2	$0.78
Total	**-49.3**	**64.1**	**46.6**	**29.5**	**90.8**	**$7.00**	**-66.7**	**86.8**	**63.2**	**40.6**	**123.9**	**$9.55**	**-116.1**	**150.9**	**109.7**	**70.1**	**214.6**	**$16.55**

- Based on data from Ontario, the *ongoing annual* healthcare costs associated with a CRC survivor by stage was as follows:[411]
    - Stage I - $7,442 (in 2013 $, $7,769 in 2017$)
    - Stage II - $10,435 ($10,893)
    - Stage III - $13,344 ($13,930)
    - Stage IV – $42,551 ($44,419)
- 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 $36.55 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	$0.01	-0.5	0.7	0.5	0.4	1.1	$0.03	-0.7	1.0	0.7	0.6	1.6	$0.04
46	-0.4	0.6	0.4	0.3	0.9	$0.02	-1.0	1.4	1.0	0.8	2.1	$0.05	-1.5	1.9	1.4	1.1	2.9	$0.08
47	-0.6	0.8	0.6	0.4	1.2	$0.03	-1.5	2.0	1.4	1.0	2.9	$0.07	-2.2	2.8	2.0	1.4	4.1	$0.10
48	-0.8	1.1	0.8	0.5	1.5	$0.04	-2.0	2.6	1.8	1.1	3.5	$0.09	-2.9	3.7	2.6	1.6	5.0	$0.12
49	-1.0	1.3	0.9	0.5	1.7	$0.04	-2.5	3.1	2.2	1.2	4.1	$0.10	-3.5	4.5	3.2	1.8	5.9	$0.14
50	-1.6	2.1	1.5	0.9	2.8	$0.07	-3.1	3.9	2.8	1.4	5.0	$0.12	-4.7	6.0	4.3	2.3	7.8	$0.19
51	-2.2	2.8	2.0	1.1	3.7	$0.09	-3.7	4.7	3.3	1.6	5.9	$0.14	-5.9	7.5	5.3	2.7	9.6	$0.23
52	-2.8	3.5	2.5	1.3	4.5	$0.11	-4.3	5.4	3.8	1.7	6.6	$0.16	-7.1	9.0	6.3	3.0	11.2	$0.26
53	-3.4	4.2	3.0	1.4	5.2	$0.12	-4.9	6.2	4.3	1.9	7.4	$0.17	-8.3	10.4	7.3	3.3	12.6	$0.30
54	-3.9	4.9	3.4	1.5	5.9	$0.14	-5.5	6.9	4.8	2.0	8.1	$0.19	-9.4	11.8	8.2	3.5	14.0	$0.33
55	-4.6	5.7	4.0	1.7	6.9	$0.16	-6.7	8.3	5.8	2.6	10.0	$0.23	-11.3	14.1	9.8	4.3	16.9	$0.39
56	-5.3	6.5	4.5	1.9	7.8	$0.18	-7.9	9.8	6.8	3.0	11.7	$0.27	-13.1	16.3	11.3	4.9	19.5	$0.45
57	-5.9	7.4	5.1	2.1	8.6	$0.20	-9.0	11.1	7.7	3.3	13.2	$0.31	-14.9	18.5	12.8	5.4	21.8	$0.50
58	-6.6	8.2	5.6	2.3	9.5	$0.22	-10.1	12.5	8.6	3.6	14.6	$0.34	-16.7	20.6	14.3	5.8	24.0	$0.55
59	-7.3	8.9	6.2	2.4	10.3	$0.23	-11.1	13.7	9.5	3.8	15.9	$0.36	-18.4	22.7	15.7	6.2	26.2	$0.60
60	-8.4	10.4	7.2	2.9	12.1	$0.28	-13.0	16.1	11.1	4.6	18.8	$0.43	-21.4	26.5	18.3	7.5	30.9	$0.71
61	-9.6	11.8	8.2	3.3	13.7	$0.32	-14.8	18.3	12.7	5.2	21.4	$0.49	-24.4	30.1	20.9	8.5	35.1	$0.81
62	-10.7	13.2	9.1	3.6	15.2	$0.35	-16.6	20.5	14.2	5.7	23.7	$0.54	-27.3	33.6	23.3	9.3	39.0	$0.89
63	-11.8	14.5	10.0	3.9	16.6	$0.38	-18.3	22.5	15.6	6.1	25.9	$0.59	-30.1	37.1	25.6	10.0	42.6	$0.97
64	-12.9	15.8	10.9	4.1	18.0	$0.41	-20.0	24.6	16.9	6.4	28.0	$0.63	-32.9	40.4	27.9	10.6	45.9	$1.04
65	-14.4	17.7	12.2	4.7	20.2	$0.46	-22.0	27.1	18.7	7.1	30.7	$0.70	-36.5	44.8	30.9	11.8	51.0	$1.16
66	-16.0	19.6	13.5	5.2	22.3	$0.51	-24.1	29.5	20.3	7.6	33.4	$0.76	-40.0	49.1	33.8	12.8	55.7	$1.26
67	-17.5	21.4	14.8	5.5	24.3	$0.55	-26.0	31.9	21.9	8.1	35.8	$0.81	-43.5	53.3	36.7	13.6	60.1	$1.36
68	-18.9	23.2	16.0	5.9	26.1	$0.59	-28.0	34.2	23.5	8.5	38.2	$0.86	-46.9	57.4	39.5	14.4	64.4	$1.45
69	-20.4	25.0	17.2	6.2	27.9	$0.63	-29.9	36.5	25.0	8.9	40.5	$0.91	-50.3	61.4	42.2	15.1	68.4	$1.54
70	-22.6	27.6	18.9	6.4	30.3	$0.67	-32.9	40.1	27.5	9.2	43.9	$0.97	-55.5	67.7	46.4	15.7	74.3	$1.65
71	-24.7	30.1	20.5	6.6	32.5	$0.72	-35.8	43.6	29.7	9.5	47.0	$1.03	-60.6	73.7	50.2	16.2	79.5	$1.75
72	-26.8	32.6	22.0	6.8	34.5	$0.75	-38.7	46.9	31.7	9.7	49.7	$1.08	-65.5	79.5	53.7	16.5	84.2	$1.84
73	-28.9	34.9	23.5	6.9	36.4	$0.79	-41.4	50.1	33.6	9.9	52.2	$1.13	-70.3	85.0	57.1	16.9	88.7	$1.92
74	-30.9	37.2	24.9	7.1	38.4	$0.83	-44.1	53.1	35.5	10.2	54.7	$1.18	-75.0	90.3	60.4	17.3	93.0	$2.01
75	-33.6	40.5	27.0	7.7	41.5	$0.90	-47.4	56.9	37.9	10.7	58.2	$1.26	-81.0	97.4	64.9	18.4	99.7	$2.15
76	-36.3	43.6	28.9	8.1	44.3	$0.96	-50.5	60.6	40.2	11.2	61.5	$1.32	-86.8	104.2	69.2	19.3	105.8	$2.28
77	-38.9	46.6	30.8	8.4	46.9	$1.01	-53.6	64.1	42.4	11.5	64.4	$1.38	-92.5	110.7	73.2	19.8	111.2	$2.39
78	-41.5	49.5	32.6	8.7	49.3	$1.06	-56.5	67.5	44.4	11.7	67.1	$1.43	-98.0	117.0	77.0	20.4	116.4	$2.49
79	-43.9	52.4	34.3	8.9	51.6	$1.10	-59.3	70.6	46.3	11.9	69.6	$1.48	-103.2	123.0	80.6	20.8	121.2	$2.59
Total						$14.91						$21.64						$36.55

[411] 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:[412]
    - Stage I - $302,484 (in 2013 $, $315,762 in 2017$)
    - Stage II - $202,540 ($211,431)
    - Stage III - $134,354 ($140,252)
    - Stage IV - $117,128 ($122,270)
- 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 (729 with no screening program [Table 8] minus 537 with a coordinated screening program [Table 12], or a reduction of 193 deaths) are associated with costs avoided of $24.60 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	$0.01	0.0	0.0	0.0	0.2	0.3	$0.03	0.0	0.0	0.0	0.3	0.4	$0.05
46	0.0	0.0	0.0	0.1	0.2	$0.02	0.0	0.1	0.1	0.3	0.4	$0.05	0.0	0.1	0.1	0.5	0.6	$0.08
47	0.0	0.0	0.0	0.2	0.3	$0.03	0.0	0.1	0.1	0.4	0.6	$0.08	0.0	0.1	0.1	0.6	0.8	$0.11
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	$0.12
49	0.0	0.1	0.1	0.2	0.3	$0.04	-0.1	0.2	0.2	0.5	0.8	$0.10	-0.1	0.2	0.2	0.7	1.1	$0.14
50	0.0	0.1	0.1	0.5	0.6	$0.08	-0.1	0.2	0.2	0.7	1.0	$0.12	-0.1	0.3	0.3	1.1	1.6	$0.20
51	-0.1	0.1	0.1	0.5	0.7	$0.09	-0.1	0.2	0.2	0.7	1.0	$0.13	-0.1	0.3	0.3	1.2	1.7	$0.22
52	-0.1	0.2	0.2	0.6	0.9	$0.11	-0.1	0.2	0.2	0.7	1.1	$0.14	-0.2	0.4	0.4	1.3	1.9	$0.25
53	-0.1	0.2	0.2	0.6	0.9	$0.12	-0.1	0.2	0.2	0.7	1.1	$0.14	-0.2	0.4	0.4	1.4	2.0	$0.26
54	-0.1	0.2	0.2	0.7	1.0	$0.13	-0.1	0.2	0.2	0.7	1.1	$0.14	-0.2	0.4	0.4	1.4	2.1	$0.27
55	-0.1	0.2	0.2	0.7	1.1	$0.14	-0.1	0.3	0.3	1.0	1.4	$0.18	-0.2	0.5	0.5	1.8	2.5	$0.32
56	-0.1	0.2	0.2	0.8	1.1	$0.14	-0.1	0.3	0.3	1.1	1.6	$0.21	-0.2	0.5	0.5	1.9	2.7	$0.35
57	-0.1	0.2	0.2	0.8	1.2	$0.15	-0.1	0.3	0.3	1.2	1.8	$0.23	-0.2	0.6	0.6	2.0	3.0	$0.38
58	-0.1	0.2	0.2	0.8	1.2	$0.15	-0.2	0.4	0.4	1.3	1.9	$0.24	-0.3	0.6	0.6	2.1	3.1	$0.39
59	-0.1	0.3	0.3	0.8	1.2	$0.15	-0.2	0.4	0.4	1.3	2.0	$0.25	-0.3	0.7	0.7	2.1	3.2	$0.40
60	-0.1	0.3	0.3	1.1	1.5	$0.19	-0.2	0.5	0.5	1.7	2.4	$0.31	-0.3	0.8	0.7	2.8	4.0	$0.50
61	-0.1	0.3	0.3	1.2	1.7	$0.21	-0.2	0.5	0.5	1.9	2.7	$0.34	-0.4	0.8	0.8	3.0	4.3	$0.55
62	-0.1	0.4	0.4	1.3	1.8	$0.23	-0.2	0.6	0.6	2.0	2.9	$0.37	-0.4	0.9	0.9	3.3	4.7	$0.60
63	-0.2	0.4	0.4	1.3	1.9	$0.24	-0.3	0.6	0.6	2.0	3.0	$0.38	-0.4	1.0	1.0	3.3	4.9	$0.63
64	-0.2	0.4	0.4	1.3	2.0	$0.25	-0.3	0.7	0.7	2.1	3.1	$0.40	-0.5	1.1	1.1	3.4	5.1	$0.65
65	-0.2	0.5	0.4	1.6	2.3	$0.29	-0.3	0.7	0.7	2.2	3.3	$0.42	-0.5	1.1	1.1	3.8	5.6	$0.71
66	-0.2	0.5	0.5	1.6	2.4	$0.31	-0.3	0.7	0.7	2.3	3.4	$0.43	-0.5	1.2	1.2	4.0	5.8	$0.74
67	-0.2	0.5	0.5	1.7	2.5	$0.32	-0.3	0.7	0.7	2.4	3.5	$0.44	-0.5	1.2	1.2	4.1	6.0	$0.77
68	-0.2	0.5	0.5	1.8	2.6	$0.33	-0.3	0.7	0.7	2.4	3.5	$0.45	-0.6	1.3	1.3	4.1	6.1	$0.78
69	-0.2	0.6	0.6	1.8	2.7	$0.34	-0.3	0.8	0.7	2.3	3.5	$0.45	-0.6	1.3	1.3	4.1	6.2	$0.79
70	-0.4	0.8	0.8	2.9	4.2	$0.53	-0.5	1.1	1.1	3.9	5.7	$0.72	-0.8	2.0	2.0	6.8	9.9	$1.26
71	-0.4	0.9	0.9	2.9	4.4	$0.56	-0.5	1.2	1.3	4.0	5.9	$0.76	-0.9	2.1	2.2	6.9	10.3	$1.32
72	-0.4	1.0	1.0	2.9	4.5	$0.58	-0.5	1.3	1.4	4.0	6.2	$0.79	-0.9	2.3	2.5	6.9	10.7	$1.37
73	-0.4	1.0	1.1	2.9	4.5	$0.58	-0.6	1.3	1.4	3.9	6.1	$0.78	-1.0	2.3	2.5	6.7	10.6	$1.36
74	-0.4	1.0	1.1	2.8	4.5	$0.58	-0.6	1.4	1.5	3.7	6.0	$0.77	-1.0	2.4	2.5	6.6	10.5	$1.34
75	-0.5	1.1	1.2	3.4	5.2	$0.67	-0.6	1.5	1.5	4.2	6.6	$0.85	-1.1	2.6	2.7	7.6	11.8	$1.52
76	-0.5	1.2	1.2	3.5	5.4	$0.69	-0.6	1.5	1.6	4.2	6.7	$0.85	-1.1	2.7	2.8	7.7	12.1	$1.54
77	-0.5	1.2	1.3	3.5	5.5	$0.71	-0.6	1.5	1.6	4.2	6.7	$0.86	-1.1	2.7	2.9	7.8	12.2	$1.57
78	-0.5	1.3	1.3	3.5	5.6	$0.71	-0.6	1.5	1.6	4.1	6.6	$0.84	-1.2	2.8	2.9	7.6	12.1	$1.55
79	-0.5	1.3	1.3	3.5	5.6	$0.71	-0.6	1.5	1.6	4.0	6.4	$0.82	-1.2	2.8	2.9	7.5	12.0	$1.53
Total	**-7.3**	**17.3**	**17.8**	**54.0**	**81.8**	**$10.45**	**-10.0**	**23.6**	**24.1**	**73.0**	**110.8**	**$14.15**	**-17.3**	**40.9**	**41.9**	**127.0**	**192.6**	**$24.60**

[412] 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 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 colorectal cancer in adults ages 45-75 in a British Columbia birth cohort of 40,000 is $14,639 (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)	$9.75	Table 19
b	Physician visit costs (in millions)	$17.34	Table 19
c	Cost of FIT kit & processing (in millions)	$10.44	Table 19
d	Cost of colonoscopies (in millions)	$31.69	Table 19
e	**Subtotal Program Costs (in millions)**	**$69.21**	= a + b + c + d
f	Patient time costs for physician visits (in millions)	$29.54	Table 20
g	Patient time costs for colonoscopies (in millions)	$13.74	Table 20
h	**Subtotal Patient Time Costs (in millions)**	**$43.27**	=f+g
i	Cost of complications due to colonoscopy - Bleeding (in millions)	$0.22	Table 21
j	Cost of complications due to colonoscopy - Perforations (in millions)	$0.59	Table 21
k	**Subtotal Cost of Harms (in millions)**	**$0.80**	= i + j
l	**Total Cost of Screening Program**	**$113.29**	= e + h + k
	Treatment Costs Avoided with a Screening Program		
m	Cost of treating new CRCs avoided (in millions)	$16.55	Table 22
n	Cost of treating those living with CRC avoided (in millions)	$36.55	Table 23
o	Cost of treating those who die due to CRC avoided (in millions)	$24.60	Table 24
p	**Total Treatment Costs Avoided**	**$77.70**	= m + n + o
	CE per QALY Gained		
q	Net cost of screening and treatment (in millions)	$35.59	= l - p
r	Total QALYs gained	3,588	Table 16
s	CE ($/QALY gained)	$9,921	=(q/r)*1,000,000
t	Net cost of screening and treatment (in millions, 1.5% discount)	$38.18	Calculated
u	Total QALYs gained, 1.5% Discount	2,608	Calculated
v	**CE ($/QALY gained), 1.5% Discount**	$14,639	=(t/u)*1,000,000

√ = 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 = $21,284
- Assume that the effectiveness of screening in reducing the incidence of CRC is increased from 22% to 26%: CE = $10,480
- 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 = $15,195
- 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 = $14,068
- Screening rate reduced from 77% to 50% (Table 16, row *t*): CE = $17,719

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 $22,166 (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)	$5.04	Table 19
b	Physician visit costs (in millions)	$8.97	Table 19
c	Cost of FIT kit & processing (in millions)	$5.40	Table 19
d	Cost of colonoscopies (in millions)	$16.39	Table 19
e	**Subtotal Program Costs (in millions)**	**$35.80**	= a + b + c + d
f	Patient time costs for physician visits (in millions)	$15.28	Table 20
g	Patient time costs for colonoscopies (in millions)	$7.10	Table 20
h	**Subtotal Patient Time Costs (in millions)**	**$22.38**	=f+g
i	Cost of complications due to colonoscopy - Bleeding (in millions)	$0.11	Table 21
j	Cost of complications due to colonoscopy - Perforations (in millions)	$0.30	Table 21
k	**Subtotal Cost of Harms (in millions)**	**$0.42**	= i + j
l	**Total Cost of Screening Program**	**$58.60**	= e + h + k
	Treatment Costs Avoided with a Screening Program		
m	Cost of treating new CRCs avoided (in millions)	$7.00	Table 22
n	Cost of treating those living with CRC avoided (in millions)	$14.91	Table 23
o	Cost of treating those who die due to CRC avoided (in millions)	$10.45	Table 24
p	**Total Treatment Costs Avoided**	**$32.36**	= m + n + o
	CE per QALY Gained		
q	Net cost of screening and treatment (in millions)	$26.25	= l - p
r	Total QALYs gained	1,582	Table 17
s	CE ($/QALY gained)	$16,588	=(q/r)*1,000,000
t	Net cost of screening and treatment (in millions, 1.5% discount)	$25.26	Calculated
u	Total QALYs gained, 1.5% Discount	1,139	Calculated
v	**CE ($/QALY gained), 1.5% Discount**	$22,166	=(t/u)*1,000,000

√ = Estimates from the literature

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 = $29,780
- Assume that the effectiveness of screening in reducing the incidence of CRC is increased from 22% to 26%: CE = $17,409
- 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 = $22,970
- 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 = $21,338
- Screening rate reduced from 77% to 50% (Table 17, row *t*): CE = $26,726

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 $8,800 (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)	$4.71	Table 19
b	Physician visit costs (in millions)	$8.37	Table 19
c	Cost of FIT kit & processing (in millions)	$5.04	Table 19
d	Cost of colonoscopies (in millions)	$15.30	Table 19
e	**Subtotal Program Costs (in millions)**	**$33.41**	= a + b + c + d
f	Patient time costs for physician visits (in millions)	$14.26	Table 20
g	Patient time costs for colonoscopies (in millions)	$6.63	Table 20
h	**Subtotal Patient Time Costs (in millions)**	**$20.89**	=f+g
i	Cost of complications due to colonoscopy - Bleeding (in millions)	$0.11	Table 21
j	Cost of complications due to colonoscopy - Perforations (in millions)	$0.28	Table 21
k	**Subtotal Cost of Harms (in millions)**	**$0.39**	= i + j
l	**Total Cost of Screening Program**	**$54.69**	= e + h + k
	Treatment Costs Avoided with a Screening Program		
m	Cost of treating new CRCs avoided (in millions)	$9.55	Table 22
n	Cost of treating those living with CRC avoided (in millions)	$21.64	Table 23
o	Cost of treating those who die due to CRC avoided (in millions)	$14.15	Table 24
p	**Total Treatment Costs Avoided**	**$45.34**	= m + n + o
	CE per QALY Gained		
q	Net cost of screening and treatment (in millions)	$9.35	= l - p
r	Total QALYs gained	2,006	Table 18
s	CE ($/QALY gained)	$4,661	=(q/r)*1,000,000
t	Net cost of screening and treatment (in millions, 1.5% discount)	$12.93	Calculated
u	Total QALYs gained, 1.5% Discount	1,469	Calculated
v	**CE ($/QALY gained), 1.5% Discount**	$8,800	=(t/u)*1,000,000

√ = Estimates from the literature

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 = $14,707
- Assume that the effectiveness of screening in reducing the incidence of CRC is increased from 22% to 26%: CE = $5,097
- 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 = $9,146
- 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 = $8,446
- Screening rate reduced from 77% to 50% (Table 18, row *t*): CE = $11,120.

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 2,608 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $14,639 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	**2,608**	**2,259**	**2,887**
3% Discount Rate	1,937	1,678	2,144
0% Discount Rate	3,588	3,108	3,972
Assume 50% Current Service			
1.5% Discount Rate	**914**	**792**	**1,012**
3% Discount Rate	679	588	752
0% Discount Rate	1,258	1,090	1,393
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$14,639**	**$10,480**	**$21,284**
3% Discount Rate	$19,852	$15,290	$27,140
0% Discount Rate	$9,921	$6,115	$16,000
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	**$1,016**	**-$1,827**	**$5,557**
3% Discount Rate	$4,478	$1,403	$9,392
0% Discount Rate	-$2,141	-$4,780	$2,076

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 1,139 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $22,166 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	**1,139**	**986**	**1,262**
3% Discount Rate	838	724	928
0% Discount Rate	1,582	1,369	1,752
Assume 50% Current Service			
1.5% Discount Rate	**400**	**346**	**443**
3% Discount Rate	294	254	326
0% Discount Rate	555	480	615
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$22,166**	**$17,409**	**$29,780**
3% Discount Rate	$28,437	$23,148	$36,909
0% Discount Rate	$16,588	$12,293	$23,460
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	**$6,084**	**$2,893**	**$11,192**
3% Discount Rate	$10,156	$6,651	$15,770
0% Discount Rate	$2,440	-$481	$7,113

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 1,469 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $8,800 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	**1,469**	**1,274**	**1,625**
3% Discount Rate	1,099	953	1,216
0% Discount Rate	2,006	1,739	2,220
Assume 50% Current Service			
1.5% Discount Rate	**515**	**446**	**569**
3% Discount Rate	385	334	426
0% Discount Rate	703	609	778
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$8,800**	**$5,097**	**$14,707**
3% Discount Rate	$13,310	$9,291	$19,716
0% Discount Rate	$4,661	$1,238	$10,124
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	**-$2,915**	**-$5,493**	**$1,195**
3% Discount Rate	$152	-$2,604	$4,545
0% Discount Rate	-$5,754	-$8,174	-$1,892

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.) [413]

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) [414]

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).[415] 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).

[413] Canadian Task Force on Preventive Health Care. Recommendations on screening for lung cancer. *Canadian Medical Association Journal*. 2016: 1-8.
[414] Moyer VA. Screening for lung cancer: US Preventive Services Task Force recommendation statement. *Annals of Internal Medicine*. 2014; 160(5): 330-8.
[415] 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.[416]

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 2010 to 2012, a total of 8,909 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 5,117 deaths between the ages of 45 and 64 in BC in 2012, with 544 (10.6%) of these deaths due to lung cancer (ICD-10 codes C34). There were also 8,674 deaths between the ages of 65 and 79 that year, with 1,102 (12.7%) of these deaths due to lung cancer.[417] This suggests that 1,098 of the 8,909 (12.3%) of the deaths in the BC birth cohort between the ages of 55 and 79 would be due to lung cancer (see Table 2).

[416] Goffin JR, Flanagan WM, Miller AB et al. Cost-effectiveness of lung cancer screening in Canada. *JAMA Oncology*. 2015; 1(6): 807-13.
[417] British Columbia Vital Statistics Agency. *Selected Vital Statistics and Health Status Indicators: One Hundred and Forty-First Annual Report*. Apendix 2. 2012. British Colubmia Ministry of Health. Available at https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2012/pdf/annual-report-2012.pdf. Accessed December 2017.

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	*Mean Survival Rate*		*Individuals in Birth Cohort*			*Life Years Lived*	*Deaths in Birth Cohort*		Deaths due to Lung Cancer		*Life Years Lost*	
	Males	Females	Males	Females	Total		%	#	%	#	Per Death	Total
50-54	0.950	0.969	19,003	19,375	38,378	191,890						
55-59	0.931	0.956	18,619	19,118	37,737	188,686	1.7%	641	10.6%	68	27.7	1,882
60-64	0.902	0.936	18,041	18,726	36,767	183,834	2.6%	970	10.6%	103	23.4	2,407
65-69	0.858	0.906	17,164	18,113	35,277	176,387	4.2%	1,489	12.7%	189	19.2	3,632
70-74	0.792	0.857	15,837	17,144	32,981	164,903	7.0%	2,297	12.7%	292	15.3	4,463
75-79	0.693	0.780	13,861	15,608	29,469	147,346	11.9%	3,511	12.7%	446	11.8	5,262
								8,909	**12.3%**	**1,098**	**16.1**	**17,645**

- 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*).[418]

- 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).[419]

- 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).[420,421]

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.

[418] 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.
[419] 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.
[420] Ibid.
[421] 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.

- 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).[422] 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.[423]

- **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."[424] 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*).

- "**Overdiagnosis** refers to the detection of a lung cancer that will not otherwise cause symptoms throughout the person's lifetime or result in death."[425] Based upon a review of four studies, the CTFPHC found an overdiagnosis 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) initiated as a result of screening."[426] 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."[427] 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

[422] 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.
[423] 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.
[424] Ibid.
[425] Ibid.
[426] Ibid.
[427] Ibid.

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. [428]

- We have assumed a disutility of 0.05 associated with a false positive screen (see Table 4, row *q*).[429,430]
- 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.[431] 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.[432] 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.
- 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.[433] 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).[434]

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[428] 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.
[429] 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.
[430] 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.
[431] 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.
[432] 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.
[433] 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.
[434] Tammemagi MC and Lam S. Screening for lung cancer using low dose computed tomography. *BMJ* 2014; 348: g2253-63.

- The PAN-CAN lung cancer risk model has been validated in at least two studies.[435,436] 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.[437]
- 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.[438,439]

Based on the above assumptions drawn from the NLST and the CTFPHC, the CPB is 1,745 quality-adjusted life years saved (see Table 4, row *z*). The CPB of 1,745 represents the gap between the existing coverage (no coverage) and 60%.

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[435] 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.
[436] 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.
[437] Tammemagi MC and Lam S. Screening for lung cancer using low dose computed tomography. *BMJ* 2014; 348: g2253-63.
[438] 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.
[439] 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	37,737	Table 2
b	Age 55-59: % of individuals eligible for screening	10.5%	Table 1
c	Age 60-64: # of individuals alive in cohort	36,767	Table 2
d	Age 60-64: % of individuals eligible for screening	8.6%	Table 1
e	Age 65-69: # of individuals alive in cohort	35,277	Table 2
f	Age 65-69: % of individuals eligible for screening	8.7%	Table 1
g	Age 70-74: # of individuals alive in cohort	32,981	Table 2
h	Age 70-74: % of individuals eligible for screening	5.2%	Table 1
i	# of individuals eligible for screening	2,977	= ((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	5,359	= i * j * k
m	Proportion of screens positive	24.2%	√
n	# of positive screens	1,297	= l * m
o	Proportion of screens false positive	96.4%	√
p	# of false positive screens	1,250	= n * o
q	QALYs lost per false positive test	0.05	√
r	QALYs lost due to false positive test	63	= 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	17	= p * s
u	Lung cancer deaths ages 55-79	1,098	Table 2
v	Remaining life expectancy at death from lung cancer (in years)	16.08	Table 2
w	Effectiveness of screening in reducing LC deaths	19.6%	√
x	LC deaths avoided due to LC screening	129	= u * w * k
y	Net deaths avoided due to LC screening	112	= x - t
z	Potential QALYs saved (CPB) - Utilization increasing from 0% to 60%	1,745	= (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 = 485.
- 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 = 2,846.
- Assume the adherence rate is reduced from 60% to 50% (Table 4, row *k*): CPB = 1,454.
- Assume the adherence rate is increased from 60% to 70% (Table 4, row *k*): CPB = 2,036.

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 37,737 individuals in a BC birth cohort of 40,000 who are expected to survive to age 55 (see Table 2). Each of the 37,737 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 $198 (2017 CAD) (see Table 6, row *i*).[440]
- **Physician visits -** LDCT screening results in an additional 14 physician visits per 100 persons screened (see Table 6, row *j*).[441]
- Positive findings on the screening CT result in the **ensuing follow-up procedures** (Table 5 rows *c* to *k*):[442]
    - 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, overdiagnosis, 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*):[443]
    - Follow-up chest radiograph – $67
    - Follow-up chest CT – $164
    - Follow-up PET/CT scan – $1,399
    - Percutaneous biopsy – CT-guided = $1,083, US-guided = $682
    - Bronchoscopy without biopsy – $747
    - Bronchoscopy with biopsy – $804
    - Mediastinoscopy – $976
    - Thoracoscopy – $16,814
    - Thoracotomy – $18,689
- **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*).

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440 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.
441 Ibid.
442 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.
443 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.

Table 5. Calculation of Costs Associated with Follow-up Procedures			
Row Label	**Variable**	**Base Case**	**Data Source**
a	Number of positive screens	1,297	Table 4, row n
b	Number of false positive screens	1,250	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	187	= a * c
m	Follow-up chest radiograph	646	= a * d
n	Follow-up PET/CT scan	108	= a * e
o	Percutaneous biopsy	23	= a * f
p	Bronchoscopy without biopsy	23	= a * g
q	Bronchoscopy with biopsy	23	= 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	$67	√
v	Follow-up chest CT	$164	√
w	Follow-up PET/CT scan	$1,399	√
x	Percutaneous biopsy	$883	√
y	Bronchoscopy without biopsy	$747	√
z	Bronchoscopy with biopsy	$804	√
aa	Mediastinoscopy	$976	√
ab	Thoracoscopy	$16,814	√
ac	Thoracotomy	$18,689	√
ad	Follow-up costs of positive screens	**$1,283,108**	= 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	12,101	= 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	$29.69	√
ap	Total cost of patient time for follow-up procedures	**$359,290**	= ao * ap
aq	**Cost of follow-up procedures**	**$1,642,398**	= 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 $34,267 (95% CI of $32,426 - $35,902).[444] This increases to $49,115 (95% CI of $44,451 - $53,645) 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 $43,119 for the usual care group and $37,288 for the CT group, resulting in costs avoided of $5,831 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 $2,204 (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	$34.85	Ref Doc
e	Value of patient time and travel for office visit	$59.38	Ref Doc
f	Portion of 10-minute office visit for screen	50%	Assumed
g	Cost of primary care provider screening	$1,511,290	=(b*c) * ((d+e) * f)
	Screening for Lung Cancer		
h	Potential screens with 60% adherence	5,359	=Table 4, row l
i	Cost per screen	$198	√
j	Additional physician visits per screening exam	0.14	√
k	Cost of screening	$1,131,712	=(i*h) + ((h*j) * (d+e))
l	Costs Asspociated with Follow-up Procedures	$1,642,398	=Table 5, row aq
m	Total Costs of Screening and Follow-up	$4,285,400	= g + k + l
	Costs Avoided		
n	Treatment costs avoided with earlier detection, per cancer	-$5,831	√
o	Number of incident lung cancers detected earlier	112	= Table 4, row y
p	Treatment costs avoided with earlier detection	-$655,691	= n * o
q	Net screening and patient costs (undiscounted)	$3,629,710	= m + p
r	QALYs saved (undiscounted)	1,745	Table 4, row z
s	Net screening and patient costs (1.5% discount)	$3,140,279	Calculated
t	QALYs saved (1.5% discount)	1,402	Calculated
u	**CE ($/QALY saved)**	$2,240	= s / t

√ = Estimates from the literature

[444] 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 = $9,026.
- 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 = $1,228.
- Assume the adherence rate is reduced from 60% to 50% (Table 4, row *k*): CE = $2,425.
- Assume the adherence rate is increased from 60% to 70% (Table 4, row *k*): CE = $2,107.
- Assume the adherence rate with the assessment of patient risk is reduced from 85% to 75% (Table 6, row *c*): CE = $2,131.
- Assume the adherence rate with the assessment of patient risk is increased from 85% to 95% (Table 6, row *c*): CE = $2,349.
- 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 = $1,924.
- 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 = $2,555.

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 1,402 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $2,240 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	**1,402**	390	2,287
3% Discount Rate	1,303	362	2,125
0% Discount Rate	1,745	485	2,846
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$2,240**	$1,228	$9,206
3% Discount Rate	$2,296	$1,261	$9,239
0% Discount Rate	$2,080	$1,135	$8,419
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$1,408	$718	$6,035
3% Discount Rate	$1,445	$739	$6,180
0% Discount Rate	$1,303	$658	$5,625

Hypertension Screening and Treatment

United States Preventive Services Task Force Recommendations (2021)[445]

> *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)*

Canadian Task Force on Preventive Health Care (2013)[446]

> *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[447] 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)*

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." [448]
- 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.[449]

Best in the World

- Canada has become a world leader in the identification and management of hypertension.[450,451] Based on data from the Canadian Primary Care Sentinel

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[445] US Preventive Services Task Force. Screening for hypertension in adults: US Preventive Services Task Force Recommendation statement. *JAMA*. 2021; 325(16): 1650-6.
[446] 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.
[447] Canadian Hypertension Education Program
[448] US Preventive Services Task Force. Screening for hypertension in adults: US Preventive Services Task Force Recommendation statement. *JAMA*. 2021; 325(16): 1650-6.
[449] 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.
[450] Schiffrin E, Campbell N, Feldman R et al. Hypertension in Canada: past, present, and future. *Annals of Global Health*. 2016; 82(2): 288-99.
[451] 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.[452]

- 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).[453]

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%.

[452] 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.

[453] 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[454] in BC by age and sex.[455] 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

- The age-standardized[456] 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).[457]

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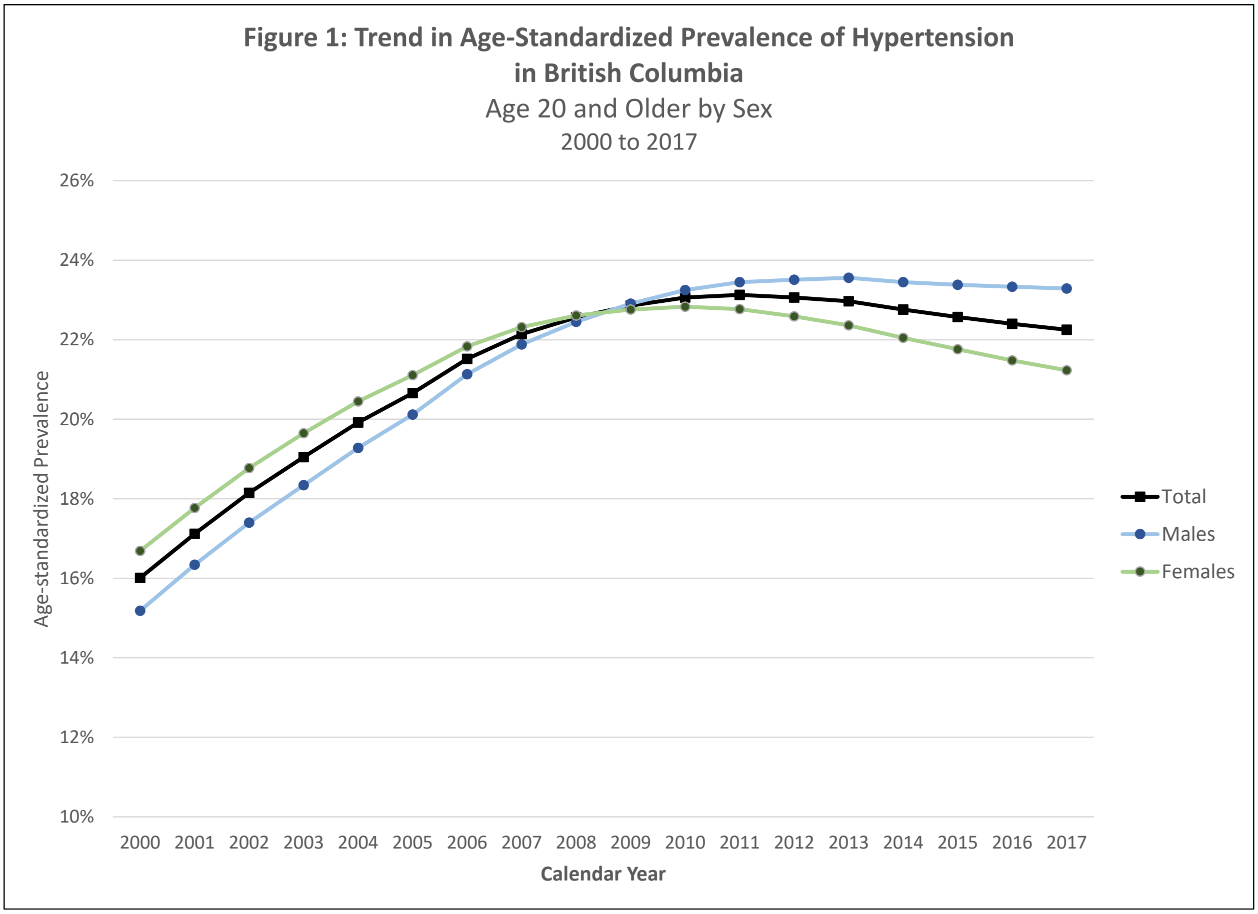
[454] Based on linked health data indicating one or more hospital separation records, or two or more physician claims within two years with ICD-10 codes I10, I11, I12, I13, I15.
[455] Public Health Agency of Canada. *Canadian Chronic Disease Surveillance System (CCDSS)*. Available at https://health-infobase.canada.ca/ccdss/data-tool/Index. Accessed January 2022.
[456] Rates are age-standardized to the 2011 Canadian population
[457] 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.



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,[458] 19.7% in 2009[459] and 23.2% in 2015.[460] 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.

[458] 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.
[459] Ibid.
[460] 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.[461,462] 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.[463]
- 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.[464]

[461] 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.
[462] 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.
[463] Ibid.
[464] 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					
	Average Blood Pressure		**Males**		
Age Group	**Pressure**	Prevalence	Awareness	Treatment	Control
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		
		Prevalence	Awareness	Treatment	Control
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		
		Prevalence	Awareness	Treatment	Control
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.[465] 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.[466] 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.[467] 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.

[465] 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.
[466] 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.
[467] 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".[468] 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 589,746 life years lived with hypertension in a BC birth cohort of 40,000. Of these 589,746 life years lived with hypertension, 348,746 (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 334,099 (56.7%) life years and hypertension would be under control during 273,259 life yea,rs, or just under half (46.3%) of the 589,746 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 589,746 life years lived with hypertension in a BC birth cohort of 40,000. Of these 589,746 life years lived with hypertension, however, 506,039 (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 485,047 (82.2%) life years and hypertension would be under control during 396,720 life years, or 67.3% of the 589,746 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 123,461 life years lived would be ones in which the individual's hypertension was under control.

[468] Leung A, Williams J, Tran K et al. Epidemiology of resultant 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	19,871	4.4%	869	42.6%	370	32.7%	284	30.8%	267	39,765	1,551	690	591	545
19	19,887	3.4%	682	46.9%	320	44.9%	306	40.7%	278	19,862	4.4%	868	42.6%	370	32.7%	284	30.8%	267	39,749	1,550	690	590	545
20	19,881	3.4%	682	46.9%	320	44.9%	306	40.7%	278	19,850	4.4%	868	42.6%	369	32.7%	284	30.8%	267	39,731	1,550	689	590	545
21	19,874	3.4%	682	46.9%	320	44.9%	306	40.7%	278	19,837	4.4%	867	42.6%	369	32.7%	284	30.8%	267	39,711	1,549	689	590	545
22	19,868	3.4%	681	46.9%	320	44.9%	306	40.7%	277	19,821	4.4%	866	42.6%	369	32.7%	284	30.8%	267	39,689	1,548	689	590	544
23	19,861	3.4%	681	46.9%	320	44.9%	306	40.7%	277	19,805	4.4%	866	42.6%	369	32.7%	283	30.8%	267	39,666	1,547	688	589	544
24	19,855	3.4%	681	46.9%	319	44.9%	306	40.7%	277	19,788	4.4%	865	42.6%	368	32.7%	283	30.8%	266	39,643	1,546	688	589	544
25	19,848	3.4%	681	46.9%	319	44.9%	306	40.7%	277	19,772	4.4%	864	42.6%	368	32.7%	283	30.8%	266	39,620	1,545	687	589	543
26	19,842	3.4%	681	46.9%	319	44.9%	306	40.7%	277	19,756	4.4%	864	42.6%	368	32.7%	283	30.8%	266	39,599	1,544	687	588	543
27	19,836	3.4%	680	46.9%	319	44.9%	306	40.7%	277	19,742	4.4%	863	42.6%	367	32.7%	282	30.8%	266	39,578	1,543	687	588	543
28	19,829	3.4%	680	46.9%	319	44.9%	305	40.7%	277	19,727	4.4%	862	42.6%	367	32.7%	282	30.8%	266	39,556	1,542	686	588	542
29	19,822	3.4%	680	46.9%	319	44.9%	305	40.7%	277	19,713	4.4%	862	42.6%	367	32.7%	282	30.8%	265	39,535	1,542	686	587	542
30	19,815	3.4%	680	46.9%	319	44.9%	305	40.7%	277	19,698	4.4%	861	42.6%	367	32.7%	282	30.8%	265	39,513	1,541	685	587	542
31	19,808	3.4%	679	46.9%	319	44.9%	305	40.7%	277	19,683	4.4%	860	42.6%	366	32.7%	282	30.8%	265	39,490	1,540	685	587	542
32	19,799	3.4%	679	46.9%	319	44.9%	305	40.7%	276	19,666	4.4%	860	42.6%	366	32.7%	281	30.8%	265	39,466	1,539	685	586	541
33	19,791	3.4%	679	46.9%	318	44.9%	305	40.7%	276	19,649	4.4%	859	42.6%	366	32.7%	281	30.8%	264	39,440	1,538	684	586	541
34	19,781	3.4%	678	46.9%	318	44.9%	305	40.7%	276	19,631	4.4%	858	42.6%	365	32.7%	281	30.8%	264	39,412	1,537	684	586	540
35	19,771	3.4%	678	46.9%	318	44.9%	305	40.7%	276	19,612	4.4%	857	42.6%	365	32.7%	281	30.8%	264	39,383	1,535	683	585	540
36	19,760	3.4%	678	46.9%	318	44.9%	304	40.7%	276	19,592	4.4%	856	42.6%	365	32.7%	280	30.8%	264	39,352	1,534	683	585	540
37	19,748	3.4%	677	46.9%	318	44.9%	304	40.7%	276	19,571	4.4%	856	42.6%	364	32.7%	280	30.8%	263	39,318	1,533	682	584	539
38	19,735	3.4%	677	46.9%	318	44.9%	304	40.7%	276	19,548	4.4%	855	42.6%	364	32.7%	280	30.8%	263	39,283	1,531	681	584	539
39	19,721	3.4%	676	46.9%	317	44.9%	304	40.7%	275	19,524	4.4%	854	42.6%	363	32.7%	279	30.8%	263	39,245	1,530	681	583	538
40	19,706	14.8%	2,918	53.9%	1,572	51.5%	1,504	44.3%	1,292	19,499	18.4%	3,593	55.8%	2,005	48.6%	1,745	38.1%	1,369	39,204	6,511	3,577	3,248	2,661
41	19,689	14.8%	2,916	53.9%	1,571	51.5%	1,502	44.3%	1,291	19,471	18.4%	3,588	55.8%	2,002	48.6%	1,742	38.1%	1,367	39,161	6,503	3,573	3,245	2,658
42	19,672	14.8%	2,913	53.9%	1,569	51.5%	1,501	44.3%	1,290	19,442	18.4%	3,582	55.8%	1,999	48.6%	1,740	38.1%	1,365	39,114	6,495	3,568	3,241	2,655
43	19,653	14.8%	2,910	53.9%	1,568	51.5%	1,500	44.3%	1,289	19,411	18.4%	3,577	55.8%	1,996	48.6%	1,737	38.1%	1,363	39,064	6,487	3,563	3,237	2,652
44	19,632	14.8%	2,907	53.9%	1,566	51.5%	1,498	44.3%	1,288	19,378	18.4%	3,571	55.8%	1,992	48.6%	1,734	38.1%	1,360	39,010	6,478	3,558	3,232	2,648
45	19,610	14.8%	2,904	53.9%	1,564	51.5%	1,496	44.3%	1,286	19,342	18.4%	3,564	55.8%	1,989	48.6%	1,731	38.1%	1,358	38,952	6,468	3,553	3,227	2,644
46	19,586	14.8%	2,900	53.9%	1,562	51.5%	1,494	44.3%	1,285	19,304	18.4%	3,557	55.8%	1,985	48.6%	1,727	38.1%	1,355	38,890	6,457	3,547	3,222	2,640
47	19,560	14.8%	2,896	53.9%	1,560	51.5%	1,492	44.3%	1,283	19,263	18.4%	3,549	55.8%	1,981	48.6%	1,724	38.1%	1,352	38,823	6,446	3,541	3,216	2,635
48	19,532	14.8%	2,892	53.9%	1,558	51.5%	1,490	44.3%	1,281	19,218	18.4%	3,541	55.8%	1,976	48.6%	1,720	38.1%	1,349	38,750	6,434	3,534	3,210	2,630
49	19,502	14.8%	2,888	53.9%	1,556	51.5%	1,488	44.3%	1,279	19,171	18.4%	3,532	55.8%	1,971	48.6%	1,716	38.1%	1,346	38,673	6,420	3,527	3,204	2,625
50	19,469	14.8%	2,883	53.9%	1,553	51.5%	1,485	44.3%	1,277	19,119	18.4%	3,523	55.8%	1,966	48.6%	1,711	38.1%	1,342	38,588	6,406	3,519	3,196	2,619
51	19,434	14.8%	2,878	53.9%	1,550	51.5%	1,483	44.3%	1,275	19,064	18.4%	3,513	55.8%	1,960	48.6%	1,706	38.1%	1,338	38,497	6,390	3,510	3,189	2,613
52	19,395	14.8%	2,872	53.9%	1,547	51.5%	1,480	44.3%	1,272	19,003	18.4%	3,502	55.8%	1,954	48.6%	1,701	38.1%	1,334	38,399	6,374	3,501	3,180	2,606
53	19,354	14.8%	2,866	53.9%	1,544	51.5%	1,477	44.3%	1,269	18,938	18.4%	3,490	55.8%	1,947	48.6%	1,695	38.1%	1,329	38,292	6,356	3,491	3,171	2,599
54	19,309	14.8%	2,859	53.9%	1,540	51.5%	1,473	44.3%	1,266	18,868	18.4%	3,477	55.8%	1,940	48.6%	1,688	38.1%	1,324	38,177	6,336	3,480	3,162	2,591
55	19,260	14.8%	2,852	53.9%	1,536	51.5%	1,470	44.3%	1,263	18,792	18.4%	3,463	55.8%	1,932	48.6%	1,682	38.1%	1,319	38,052	6,315	3,468	3,151	2,582
56	19,207	14.8%	2,844	53.9%	1,532	51.5%	1,466	44.3%	1,260	18,709	18.4%	3,447	55.8%	1,924	48.6%	1,674	38.1%	1,313	37,916	6,292	3,456	3,140	2,573
57	19,150	14.8%	2,836	53.9%	1,528	51.5%	1,461	44.3%	1,256	18,619	18.4%	3,431	55.8%	1,914	48.6%	1,666	38.1%	1,307	37,769	6,266	3,442	3,127	2,563
58	19,087	14.8%	2,826	53.9%	1,523	51.5%	1,456	44.3%	1,252	18,522	18.4%	3,413	55.8%	1,904	48.6%	1,657	38.1%	1,300	37,609	6,239	3,427	3,114	2,552
59	19,019	14.8%	2,816	53.9%	1,517	51.5%	1,451	44.3%	1,247	18,416	18.4%	3,393	55.8%	1,893	48.6%	1,648	38.1%	1,293	37,434	6,210	3,411	3,099	2,540
60	18,944	42.6%	8,069	61.7%	4,980	57.7%	4,658	48.8%	3,935	18,301	43.3%	7,918	60.7%	4,805	59.4%	4,702	52.8%	4,183	37,245	15,987	9,786	9,360	8,119
61	18,863	42.6%	8,035	61.7%	4,959	57.7%	4,638	48.8%	3,919	18,176	43.3%	7,864	60.7%	4,772	59.4%	4,670	52.8%	4,155	37,039	15,898	9,732	9,308	8,073
62	18,774	42.6%	7,997	61.7%	4,936	57.7%	4,616	48.8%	3,900	18,041	43.3%	7,805	60.7%	4,737	59.4%	4,635	52.8%	4,124	36,815	15,802	9,673	9,251	8,024
63	18,678	42.6%	7,956	61.7%	4,910	57.7%	4,592	48.8%	3,880	17,893	43.3%	7,741	60.7%	4,698	59.4%	4,597	52.8%	4,090	36,571	15,697	9,609	9,189	7,970
64	18,572	42.6%	7,910	61.7%	4,882	57.7%	4,566	48.8%	3,858	17,733	43.3%	7,672	60.7%	4,656	59.4%	4,556	52.8%	4,054	36,305	15,583	9,539	9,122	7,912
65	18,456	42.6%	7,861	61.7%	4,852	57.7%	4,538	48.8%	3,834	17,559	43.3%	7,597	60.7%	4,610	59.4%	4,511	52.8%	4,014	36,015	15,458	9,462	9,049	7,848
66	18,329	42.6%	7,807	61.7%	4,819	57.7%	4,507	48.8%	3,808	17,370	43.3%	7,515	60.7%	4,561	59.4%	4,462	52.8%	3,971	35,699	15,322	9,379	8,969	7,778
67	18,190	42.6%	7,748	61.7%	4,782	57.7%	4,472	48.8%	3,779	17,164	43.3%	7,426	60.7%	4,507	59.4%	4,409	52.8%	3,924	35,354	15,174	9,289	8,882	7,702
68	18,037	42.6%	7,683	61.7%	4,742	57.7%	4,435	48.8%	3,747	16,940	43.3%	7,329	60.7%	4,448	59.4%	4,352	52.8%	3,872	34,978	15,012	9,190	8,787	7,619
69	17,870	42.6%	7,612	61.7%	4,698	57.7%	4,394	48.8%	3,712	16,697	43.3%	7,224	60.7%	4,384	59.4%	4,290	52.8%	3,817	34,567	14,836	9,082	8,684	7,529
70	17,687	61.6%	10,899	60.3%	6,577	59.5%	6,487	43.7%	4,760	16,434	63.9%	10,505	63.1%	6,634	62.7%	6,590	52.3%	5,491	34,120	21,405	13,211	13,077	10,251
71	17,486	61.6%	10,775	60.3%	6,502	59.5%	6,413	43.7%	4,706	16,147	63.9%	10,322	63.1%	6,518	62.7%	6,475	52.3%	5,395	33,633	21,098	13,020	12,889	10,101
72	17,265	61.6%	10,639	60.3%	6,420	59.5%	6,332	43.7%	4,647	15,837	63.9%	10,124	63.1%	6,393	62.7%	6,351	52.3%	5,291	33,102	20,763	12,813	12,683	9,938
73	17,023	61.6%	10,490	60.3%	6,330	59.5%	6,244	43.7%	4,582	15,500	63.9%	9,909	63.1%	6,257	62.7%	6,216	52.3%	5,179	32,523	20,399	12,587	12,459	9,760
74	16,758	61.6%	10,327	60.3%	6,232	59.5%	6,146	43.7%	4,510	15,136	63.9%	9,676	63.1%	6,110	62.7%	6,070	52.3%	5,057	31,894	20,003	12,341	12,216	9,567
75	16,467	61.6%	10,148	60.3%	6,123	59.5%	6,040	43.7%	4,432	14,743	63.9%	9,424	63.1%	5,951	62.7%	5,912	52.3%	4,926	31,209	19,572	12,074	11,952	9,357
76	16,148	61.6%	9,951	60.3%	6,005	59.5%	5,923	43.7%	4,346	14,318	63.9%	9,153	63.1%	5,780	62.7%	5,742	52.3%	4,784	30,466	19,104	11,784	11,664	9,130
77	15,799	61.6%	9,736	60.3%	5,875	59.5%	5,795	43.7%	4,252	13,861	63.9%	8,861	63.1%	5,595	62.7%	5,558	52.3%	4,631	29,660	18,597	11,470	11,353	8,883
78	15,418	61.6%	9,501	60.3%	5,733	59.5%	5,655	43.7%	4,149	13,370	63.9%	8,547	63.1%	5,397	62.7%	5,362	52.3%	4,467	28,788	18,048	11,130	11,016	8,617
79	15,001	61.6%	9,244	60.3%	5,578	59.5%	5,502	43.7%	4,037	12,844	63.9%	8,211	63.1%	5,185	62.7%	5,151	52.3%	4,291	27,845	17,455	10,763	10,653	8,329
80	14,547	61.6%	8,965	60.3%	5,410	59.5%	5,335	43.7%	3,915	12,283	63.9%	7,852	63.1%	4,958	62.7%	4,926	52.3%	4,104	26,830	16,817	10,368	10,261	8,019
81	14,053	61.6%	8,660	60.3%	5,226	59.5%	5,154	43.7%	3,782	11,686	63.9%	7,470	63.1%	4,717	62.7%	4,686	52.3%	3,904	25,739	16,130	9,943	9,841	7,687
82	13,517	61.6%	8,330	60.3%	5,027	59.5%	4,958	43.7%	3,638	11,053	63.9%	7,066	63.1%	4,462	62.7%	4,433	52.3%	3,693	24,571	15,396	9,488	9,390	7,331
83	12,938	61.6%	7,973	60.3%	4,811	59.5%	4,745	43.7%	3,482	10,386	63.9%	6,640	63.1%	4,193	62.7%	4,165	52.3%	3,470	23,325	14,613	9,004	8,911	6,952
84	12,314	61.6%	7,589	60.3%	4,579	59.5%	4,517	43.7%	3,314	9,688	63.9%	6,193	63.1%	3,910	62.7%	3,885	52.3%	3,237	22,002	13,782	8,490	8,401	6,551
Total	*1,241,983*	*23.7%*	*294,437*	*58.8%*	*173,022*	*56.7%*	*167,047*	*45.0%*	*132,516*	*1,194,429*	*24.7%*	*295,309*	*59.4%*	*175,537*	*56.6%*	*167,051*	*47.7%*	*140,743*	*2,436,412*	*589,746*	*348,559*	*334,099*	*273,259*

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	19,871	4.4%	869	61.8%	537	47.5%	413	44.7%	388	39,765	1,551	1,002	857	792
19	19,887	3.4%	682	68.1%	465	65.2%	445	59.1%	403	19,862	4.4%	868	61.8%	537	47.5%	412	44.7%	388	39,749	1,550	1,001	857	791
20	19,881	3.4%	682	68.1%	464	65.2%	445	59.1%	403	19,850	4.4%	868	61.8%	536	47.5%	412	44.7%	388	39,731	1,550	1,001	857	791
21	19,874	3.4%	682	68.1%	464	65.2%	444	59.1%	403	19,837	4.4%	867	61.8%	536	47.5%	412	44.7%	388	39,711	1,549	1,000	856	790
22	19,868	3.4%	681	68.1%	464	65.2%	444	59.1%	403	19,821	4.4%	866	61.8%	535	47.5%	412	44.7%	387	39,689	1,548	1,000	856	790
23	19,861	3.4%	681	68.1%	464	65.2%	444	59.1%	403	19,805	4.4%	866	61.8%	535	47.5%	411	44.7%	387	39,666	1,547	999	855	790
24	19,855	3.4%	681	68.1%	464	65.2%	444	59.1%	402	19,788	4.4%	865	61.8%	535	47.5%	411	44.7%	387	39,643	1,546	998	855	789
25	19,848	3.4%	681	68.1%	464	65.2%	444	59.1%	402	19,772	4.4%	864	61.8%	534	47.5%	411	44.7%	386	39,620	1,545	998	854	789
26	19,842	3.4%	681	68.1%	463	65.2%	444	59.1%	402	19,756	4.4%	864	61.8%	534	47.5%	410	44.7%	386	39,599	1,544	997	854	788
27	19,836	3.4%	680	68.1%	463	65.2%	444	59.1%	402	19,742	4.4%	863	61.8%	533	47.5%	410	44.7%	386	39,578	1,543	997	854	788
28	19,829	3.4%	680	68.1%	463	65.2%	443	59.1%	402	19,727	4.4%	862	61.8%	533	47.5%	410	44.7%	385	39,556	1,542	996	853	787
29	19,822	3.4%	680	68.1%	463	65.2%	443	59.1%	402	19,713	4.4%	862	61.8%	533	47.5%	409	44.7%	385	39,535	1,542	996	853	787
30	19,815	3.4%	680	68.1%	463	65.2%	443	59.1%	402	19,698	4.4%	861	61.8%	532	47.5%	409	44.7%	385	39,513	1,541	995	852	787
31	19,808	3.4%	679	68.1%	463	65.2%	443	59.1%	402	19,683	4.4%	860	61.8%	532	47.5%	409	44.7%	385	39,490	1,540	994	852	786
32	19,799	3.4%	679	68.1%	462	65.2%	443	59.1%	401	19,666	4.4%	860	61.8%	531	47.5%	408	44.7%	384	39,466	1,539	994	851	786
33	19,791	3.4%	679	68.1%	462	65.2%	443	59.1%	401	19,649	4.4%	859	61.8%	531	47.5%	408	44.7%	384	39,440	1,538	993	851	785
34	19,781	3.4%	678	68.1%	462	65.2%	442	59.1%	401	19,631	4.4%	858	61.8%	530	47.5%	408	44.7%	384	39,412	1,537	992	850	785
35	19,771	3.4%	678	68.1%	462	65.2%	442	59.1%	401	19,612	4.4%	857	61.8%	530	47.5%	407	44.7%	383	39,383	1,535	992	849	784
36	19,760	3.4%	678	68.1%	462	65.2%	442	59.1%	401	19,592	4.4%	856	61.8%	529	47.5%	407	44.7%	383	39,352	1,534	991	849	783
37	19,748	3.4%	677	68.1%	461	65.2%	442	59.1%	400	19,571	4.4%	856	61.8%	529	47.5%	406	44.7%	382	39,318	1,533	990	848	783
38	19,735	3.4%	677	68.1%	461	65.2%	441	59.1%	400	19,548	4.4%	855	61.8%	528	47.5%	406	44.7%	382	39,283	1,531	989	847	782
39	19,721	3.4%	676	68.1%	461	65.2%	441	59.1%	400	19,524	4.4%	854	61.8%	527	47.5%	405	44.7%	382	39,245	1,530	988	846	781
40	19,706	14.8%	2,918	78.2%	2,282	74.8%	2,183	64.3%	1,876	19,499	18.4%	3,593	81.0%	2,910	70.5%	2,533	55.3%	1,987	39,204	6,511	5,192	4,716	3,863
41	19,689	14.8%	2,916	78.2%	2,280	74.8%	2,181	64.3%	1,875	19,471	18.4%	3,588	81.0%	2,906	70.5%	2,529	55.3%	1,984	39,161	6,503	5,186	4,710	3,859
42	19,672	14.8%	2,913	78.2%	2,278	74.8%	2,179	64.3%	1,873	19,442	18.4%	3,582	81.0%	2,902	70.5%	2,526	55.3%	1,981	39,114	6,495	5,180	4,705	3,854
43	19,653	14.8%	2,910	78.2%	2,276	74.8%	2,177	64.3%	1,871	19,411	18.4%	3,577	81.0%	2,897	70.5%	2,522	55.3%	1,978	39,064	6,487	5,173	4,698	3,849
44	19,632	14.8%	2,907	78.2%	2,273	74.8%	2,175	64.3%	1,869	19,378	18.4%	3,571	81.0%	2,892	70.5%	2,517	55.3%	1,975	39,010	6,478	5,166	4,692	3,844
45	19,610	14.8%	2,904	78.2%	2,271	74.8%	2,172	64.3%	1,867	19,342	18.4%	3,564	81.0%	2,887	70.5%	2,513	55.3%	1,971	38,952	6,468	5,158	4,685	3,838
46	19,586	14.8%	2,900	78.2%	2,268	74.8%	2,169	64.3%	1,865	19,304	18.4%	3,557	81.0%	2,881	70.5%	2,508	55.3%	1,967	38,890	6,457	5,149	4,677	3,832
47	19,560	14.8%	2,896	78.2%	2,265	74.8%	2,167	64.3%	1,862	19,263	18.4%	3,549	81.0%	2,875	70.5%	2,502	55.3%	1,963	38,823	6,446	5,140	4,669	3,825
48	19,532	14.8%	2,892	78.2%	2,262	74.8%	2,163	64.3%	1,860	19,218	18.4%	3,541	81.0%	2,868	70.5%	2,497	55.3%	1,958	38,750	6,434	5,130	4,660	3,818
49	19,502	14.8%	2,888	78.2%	2,258	74.8%	2,160	64.3%	1,857	19,171	18.4%	3,532	81.0%	2,861	70.5%	2,490	55.3%	1,953	38,673	6,420	5,120	4,650	3,810
50	19,469	14.8%	2,883	78.2%	2,254	74.8%	2,156	64.3%	1,854	19,119	18.4%	3,523	81.0%	2,854	70.5%	2,484	55.3%	1,948	38,588	6,406	5,108	4,640	3,802
51	19,434	14.8%	2,878	78.2%	2,250	74.8%	2,153	64.3%	1,850	19,064	18.4%	3,513	81.0%	2,845	70.5%	2,476	55.3%	1,943	38,497	6,390	5,096	4,629	3,793
52	19,395	14.8%	2,872	78.2%	2,246	74.8%	2,148	64.3%	1,847	19,003	18.4%	3,502	81.0%	2,836	70.5%	2,469	55.3%	1,936	38,399	6,374	5,082	4,617	3,783
53	19,354	14.8%	2,866	78.2%	2,241	74.8%	2,144	64.3%	1,843	18,938	18.4%	3,490	81.0%	2,827	70.5%	2,460	55.3%	1,930	38,292	6,356	5,068	4,604	3,773
54	19,309	14.8%	2,859	78.2%	2,236	74.8%	2,139	64.3%	1,839	18,868	18.4%	3,477	81.0%	2,816	70.5%	2,451	55.3%	1,923	38,177	6,336	5,052	4,590	3,761
55	19,260	14.8%	2,852	78.2%	2,230	74.8%	2,133	64.3%	1,834	18,792	18.4%	3,463	81.0%	2,805	70.5%	2,441	55.3%	1,915	38,052	6,315	5,035	4,574	3,749
56	19,207	14.8%	2,844	78.2%	2,224	74.8%	2,127	64.3%	1,829	18,709	18.4%	3,447	81.0%	2,792	70.5%	2,430	55.3%	1,906	37,916	6,292	5,017	4,558	3,735
57	19,150	14.8%	2,836	78.2%	2,217	74.8%	2,121	64.3%	1,823	18,619	18.4%	3,431	81.0%	2,779	70.5%	2,419	55.3%	1,897	37,769	6,266	4,996	4,540	3,721
58	19,087	14.8%	2,826	78.2%	2,210	74.8%	2,114	64.3%	1,817	18,522	18.4%	3,413	81.0%	2,764	70.5%	2,406	55.3%	1,887	37,609	6,239	4,975	4,520	3,705
59	19,019	14.8%	2,816	78.2%	2,202	74.8%	2,107	64.3%	1,811	18,416	18.4%	3,393	81.0%	2,749	70.5%	2,392	55.3%	1,877	37,434	6,210	4,951	4,499	3,687
60	18,944	42.6%	8,069	89.6%	7,230	83.8%	6,762	70.8%	5,713	18,301	43.3%	7,918	88.1%	6,976	86.2%	6,825	76.7%	6,073	37,245	15,987	14,206	13,587	11,786
61	18,863	42.6%	8,035	89.6%	7,199	83.8%	6,733	70.8%	5,688	18,176	43.3%	7,864	88.1%	6,928	86.2%	6,779	76.7%	6,032	37,039	15,898	14,127	13,512	11,720
62	18,774	42.6%	7,997	89.6%	7,165	83.8%	6,701	70.8%	5,662	18,041	43.3%	7,805	88.1%	6,876	86.2%	6,728	76.7%	5,987	36,815	15,802	14,042	13,429	11,648
63	18,678	42.6%	7,956	89.6%	7,128	83.8%	6,667	70.8%	5,633	17,893	43.3%	7,741	88.1%	6,820	86.2%	6,673	76.7%	5,938	36,571	15,697	13,948	13,340	11,570
64	18,572	42.6%	7,910	89.6%	7,088	83.8%	6,629	70.8%	5,601	17,733	43.3%	7,672	88.1%	6,759	86.2%	6,613	76.7%	5,885	36,305	15,583	13,847	13,242	11,485
65	18,456	42.6%	7,861	89.6%	7,043	83.8%	6,588	70.8%	5,566	17,559	43.3%	7,597	88.1%	6,693	86.2%	6,549	76.7%	5,827	36,015	15,458	13,736	13,136	11,392
66	18,329	42.6%	7,807	89.6%	6,995	83.8%	6,542	70.8%	5,527	17,370	43.3%	7,515	88.1%	6,621	86.2%	6,478	76.7%	5,764	35,699	15,322	13,616	13,020	11,291
67	18,190	42.6%	7,748	89.6%	6,942	83.8%	6,493	70.8%	5,485	17,164	43.3%	7,426	88.1%	6,542	86.2%	6,401	76.7%	5,696	35,354	15,174	13,484	12,894	11,181
68	18,037	42.6%	7,683	89.6%	6,884	83.8%	6,438	70.8%	5,439	16,940	43.3%	7,329	88.1%	6,457	86.2%	6,318	76.7%	5,621	34,978	15,012	13,341	12,756	11,061
69	17,870	42.6%	7,612	89.6%	6,820	83.8%	6,378	70.8%	5,389	16,697	43.3%	7,224	88.1%	6,364	86.2%	6,227	76.7%	5,541	34,567	14,836	13,184	12,606	10,930
70	17,687	61.6%	10,899	87.6%	9,548	86.4%	9,417	63.4%	6,910	16,434	63.9%	10,505	91.7%	9,633	91.1%	9,570	75.9%	7,974	34,120	21,405	19,181	18,987	14,884
71	17,486	61.6%	10,775	87.6%	9,439	86.4%	9,310	63.4%	6,832	16,147	63.9%	10,322	91.7%	9,465	91.1%	9,404	75.9%	7,835	33,633	21,098	18,905	18,714	14,666
72	17,265	61.6%	10,639	87.6%	9,320	86.4%	9,193	63.4%	6,745	15,837	63.9%	10,124	91.7%	9,283	91.1%	9,223	75.9%	7,684	33,102	20,763	18,604	18,415	14,429
73	17,023	61.6%	10,490	87.6%	9,190	86.4%	9,064	63.4%	6,651	15,500	63.9%	9,909	91.7%	9,086	91.1%	9,027	75.9%	7,521	32,523	20,399	18,276	18,090	14,172
74	16,758	61.6%	10,327	87.6%	9,046	86.4%	8,922	63.4%	6,547	15,136	63.9%	9,676	91.7%	8,873	91.1%	8,815	75.9%	7,344	31,894	20,003	17,919	17,737	13,891
75	16,467	61.6%	10,148	87.6%	8,889	86.4%	8,768	63.4%	6,434	14,743	63.9%	9,424	91.7%	8,642	91.1%	8,586	75.9%	7,153	31,209	19,572	17,531	17,353	13,587
76	16,148	61.6%	9,951	87.6%	8,717	86.4%	8,598	63.4%	6,309	14,318	63.9%	9,153	91.7%	8,393	91.1%	8,338	75.9%	6,947	30,466	19,104	17,110	16,936	13,256
77	15,799	61.6%	9,736	87.6%	8,529	86.4%	8,412	63.4%	6,173	13,861	63.9%	8,861	91.7%	8,125	91.1%	8,072	75.9%	6,725	29,660	18,597	16,654	16,484	12,898
78	15,418	61.6%	9,501	87.6%	8,323	86.4%	8,209	63.4%	6,024	13,370	63.9%	8,547	91.7%	7,838	91.1%	7,786	75.9%	6,487	28,788	18,048	16,160	15,995	12,511
79	15,001	61.6%	9,244	87.6%	8,098	86.4%	7,987	63.4%	5,861	12,844	63.9%	8,211	91.7%	7,529	91.1%	7,480	75.9%	6,232	27,845	17,455	15,627	15,467	12,093
80	14,547	61.6%	8,965	87.6%	7,853	86.4%	7,745	63.4%	5,684	12,283	63.9%	7,852	91.7%	7,200	91.1%	7,153	75.9%	5,960	26,830	16,817	15,053	14,899	11,643
81	14,053	61.6%	8,660	87.6%	7,586	86.4%	7,482	63.4%	5,491	11,686	63.9%	7,470	91.7%	6,850	91.1%	6,805	75.9%	5,670	25,739	16,130	14,437	14,288	11,160
82	13,517	61.6%	8,330	87.6%	7,297	86.4%	7,197	63.4%	5,281	11,053	63.9%	7,066	91.7%	6,479	91.1%	6,437	75.9%	5,363	24,571	15,396	13,776	13,634	10,644
83	12,938	61.6%	7,973	87.6%	6,984	86.4%	6,889	63.4%	5,055	10,386	63.9%	6,640	91.7%	6,088	91.1%	6,049	75.9%	5,039	23,325	14,613	13,073	12,937	10,094
84	12,314	61.6%	7,589	87.6%	6,648	86.4%	6,557	63.4%	4,811	9,688	63.9%	6,193	91.7%	5,679	91.1%	5,642	75.9%	4,700	22,002	13,782	12,327	12,198	9,512
Total	***1,241,983***	***23.7%***	***294,437***	***85.3%***	***251,172***	***82.4%***	***242,498***	***65.3%***	***192,370***	***1,194,429***	***24.7%***	***295,309***	***86.3%***	***254,868***	***82.1%***	***242,549***	***69.2%***	***204,350***	***2,436,412***	***589,746***	***506,039***	***485,047***	***396,720***

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	294,437	173,022	167,047	132,516
After	294,437	251,172	242,498	192,370
Difference	**0**	**78,150**	**75,451**	**59,854**
		Males		
Before	295,309	175,537	167,051	140,743
After	295,309	254,868	242,549	204,350
Difference	**0**	**79,330**	**75,497**	**63,607**
		Total Population		
Before	589,746	348,559	334,099	273,259
After	589,746	506,039	485,047	396,720
Difference	**0**	**157,480**	**150,948**	**123,461**

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 123,461 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.[469]
- 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.[470] 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.[471,472]

- 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

[469] 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.
[470] Ibid.
[471] 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.
[472] Ibid.

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."[473]

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.[474,475] 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).

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473 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.
474 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.
475 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			
	Number of Cardiovascular Events		
Outcomes	**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.[476] 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.

[476] 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).[477] 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 19,640 non-fatal cardiovascular events (Table 10). With 100% antihypertensive drug therapy, we would expect 3,820 fatal and 12,979 non-fatal cardiovascular events (Table 11).

[477] 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	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				19,871				39,765			
19	19,887	19.5	0.6	18.9	19,862	17.0	1.4	15.5	39,749	36.4	2.0	34.5
20	19,881	19.5	0.6	18.9	19,850	16.9	1.4	15.5	39,731	36.4	2.0	34.5
21	19,874	19.5	0.6	18.9	19,837	16.9	1.4	15.5	39,711	36.4	2.0	34.4
22	19,868	19.5	0.6	18.9	19,821	16.9	1.4	15.5	39,689	36.4	2.0	34.4
23	19,861	19.5	0.6	18.9	19,805	16.9	1.4	15.5	39,666	36.4	2.0	34.4
24	19,855	19.5	0.6	18.9	19,788	16.9	1.4	15.5	39,643	36.3	2.0	34.4
25	19,848	19.5	0.6	18.9	19,772	16.9	1.4	15.5	39,620	36.3	2.0	34.4
26	19,842	19.4	0.6	18.9	19,756	16.9	1.4	15.5	39,599	36.3	2.0	34.4
27	19,836	19.4	0.6	18.9	19,742	16.9	1.4	15.5	39,578	36.3	2.0	34.3
28	19,829	19.4	0.6	18.9	19,727	16.8	1.4	15.4	39,556	36.3	2.0	34.3
29	19,822	19.4	0.6	18.9	19,713	16.8	1.4	15.4	39,535	36.3	2.0	34.3
30	19,815	19.4	0.6	18.9	19,698	16.8	1.4	15.4	39,513	36.2	2.0	34.3
31	19,808	19.4	0.6	18.9	19,683	16.8	1.4	15.4	39,490	36.2	2.0	34.3
32	19,799	19.4	0.6	18.8	19,666	16.8	1.4	15.4	39,466	36.2	2.0	34.2
33	19,791	19.4	0.6	18.8	19,649	16.8	1.4	15.4	39,440	36.2	2.0	34.2
34	19,781	19.4	0.6	18.8	19,631	16.8	1.4	15.4	39,412	36.1	1.9	34.2
35	19,771	19.4	0.6	18.8	19,612	16.7	1.4	15.4	39,383	36.1	1.9	34.2
36	19,760	19.4	0.6	18.8	19,592	16.7	1.4	15.3	39,352	36.1	1.9	34.1
37	19,748	19.4	0.6	18.8	19,571	16.7	1.4	15.3	39,318	36.1	1.9	34.1
38	19,735	19.3	0.6	18.8	19,548	16.7	1.4	15.3	39,283	36.0	1.9	34.1
39	19,721	19.3	0.6	18.8	19,524	16.7	1.4	15.3	39,245	36.0	1.9	34.1
40	19,706	19.3	0.6	18.8	19,499	16.6	1.4	15.3	39,204	36.0	1.9	34.0
41	19,689	19.3	0.6	18.7	19,471	16.6	1.4	15.2	39,161	35.9	1.9	34.0
42	19,672	19.3	0.6	18.7	19,442	16.6	1.4	15.2	39,114	35.9	1.9	33.9
43	19,653	19.3	0.6	18.7	19,411	16.6	1.4	15.2	39,064	35.8	1.9	33.9
44	19,632	19.2	0.6	18.7	19,378	16.5	1.4	15.2	39,010	35.8	1.9	33.9
45	19,610	107	3.1	104	19,342	111	9	102	38,952	218	12	206
46	19,586	107	3.1	104	19,304	111	9	102	38,890	218	12	206
47	19,560	107	3.1	104	19,263	111	9	101	38,823	218	12	205
48	19,532	107	3.1	104	19,218	110	9	101	38,750	217	12	205
49	19,502	107	3.1	104	19,171	110	9	101	38,673	217	12	204
50	19,469	106	5.2	101	19,119	110	11	99	38,588	216	16	200
51	19,434	106	5.2	101	19,064	109	11	98	38,497	216	16	200
52	19,395	106	5.2	101	19,003	109	11	98	38,399	215	16	199
53	19,354	106	5.2	101	18,938	109	11	98	38,292	215	16	198
54	19,309	106	5.2	100	18,868	108	11	97	38,177	214	16	198
55	19,260	105	6.0	99	18,792	108	11	96	38,052	213	17	196
56	19,207	105	6.0	99	18,709	107	11	96	37,916	212	17	195
57	19,150	105	6.0	99	18,619	107	11	95	37,769	212	17	194
58	19,087	104	5.9	98	18,522	106	11	95	37,609	211	17	193
59	19,019	104	5.9	98	18,416	106	11	94	37,434	210	17	193
60	18,944	499	54	444	18,301	482	70	412	37,245	980	124	856
61	18,863	496	54	442	18,176	478	69	409	37,039	975	123	851
62	18,774	494	54	440	18,041	475	69	406	36,815	969	123	846
63	18,678	492	54	438	17,893	471	68	403	36,571	962	122	841
64	18,572	489	53	436	17,733	467	68	399	36,305	955	121	835
65	18,456	486	75	411	17,559	462	104	358	36,015	948	179	769
66	18,329	482	75	408	17,370	457	103	354	35,699	939	177	762
67	18,190	479	74	405	17,164	452	102	350	35,354	930	176	755
68	18,037	475	73	401	16,940	446	100	346	34,978	920	174	747
69	17,870	470	73	398	16,697	439	99	341	34,567	910	172	738
70	17,687	465	108	357	16,434	432	154	278	34,120	898	262	636
71	17,486	460	107	353	16,147	425	151	273	33,633	885	258	627
72	17,265	454	106	349	15,837	417	149	268	33,102	871	254	617
73	17,023	448	104	344	15,500	408	145	262	32,523	856	250	606
74	16,758	441	102	339	15,136	398	142	256	31,894	839	245	595
75	16,467	433	131	302	14,743	388	151	237	31,209	821	282	539
76	16,148	425	129	296	14,318	377	147	230	30,466	802	275	526
77	15,799	416	126	290	13,861	365	142	223	29,660	781	268	513
78	15,418	406	123	283	13,370	352	137	215	28,788	758	260	498
79	15,001	395	120	275	12,844	338	132	206	27,845	733	251	482
80	14,547	383	116	267	12,283	323	126	197	26,830	706	242	464
81	14,053	370	112	258	11,686	308	120	188	25,739	677	232	446
82	13,517	356	108	248	11,053	291	113	178	24,571	647	221	426
83	12,938	340	103	237	10,386	273	106	167	23,325	614	210	404
84	12,314	324	98	226	9,688	255	99	156	22,002	579	197	382
Total		13,070	2,418	10,653		12,046	3,058	8,987		26,056	5,476	19,640

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				19,871				39,765			
19	19,887	9.0	0.3	8.7	19,862	7.8	0.6	7.2	39,749	16.8	0.9	15.9
20	19,881	9.0	0.3	8.7	19,850	7.8	0.6	7.2	39,731	16.8	0.9	15.9
21	19,874	9.0	0.3	8.7	19,837	7.8	0.6	7.2	39,711	16.8	0.9	15.9
22	19,868	9.0	0.3	8.7	19,821	7.8	0.6	7.2	39,689	16.8	0.9	15.9
23	19,861	9.0	0.3	8.7	19,805	7.8	0.6	7.2	39,666	16.8	0.9	15.9
24	19,855	9.0	0.3	8.7	19,788	7.8	0.6	7.1	39,643	16.8	0.9	15.9
25	19,848	9.0	0.3	8.7	19,772	7.8	0.6	7.1	39,620	16.8	0.9	15.9
26	19,842	9.0	0.3	8.7	19,756	7.8	0.6	7.1	39,599	16.8	0.9	15.9
27	19,836	9.0	0.3	8.7	19,742	7.8	0.6	7.1	39,578	16.7	0.9	15.8
28	19,829	9.0	0.3	8.7	19,727	7.8	0.6	7.1	39,556	16.7	0.9	15.8
29	19,822	9.0	0.3	8.7	19,713	7.8	0.6	7.1	39,535	16.7	0.9	15.8
30	19,815	9.0	0.3	8.7	19,698	7.8	0.6	7.1	39,513	16.7	0.9	15.8
31	19,808	9.0	0.3	8.7	19,683	7.8	0.6	7.1	39,490	16.7	0.9	15.8
32	19,799	9.0	0.3	8.7	19,666	7.7	0.6	7.1	39,466	16.7	0.9	15.8
33	19,791	9.0	0.3	8.7	19,649	7.7	0.6	7.1	39,440	16.7	0.9	15.8
34	19,781	8.9	0.3	8.7	19,631	7.7	0.6	7.1	39,412	16.7	0.9	15.8
35	19,771	8.9	0.3	8.7	19,612	7.7	0.6	7.1	39,383	16.7	0.9	15.8
36	19,760	8.9	0.3	8.7	19,592	7.7	0.6	7.1	39,352	16.7	0.9	15.8
37	19,748	8.9	0.3	8.7	19,571	7.7	0.6	7.1	39,318	16.6	0.9	15.7
38	19,735	8.9	0.3	8.7	19,548	7.7	0.6	7.1	39,283	16.6	0.9	15.7
39	19,721	8.9	0.3	8.7	19,524	7.7	0.6	7.1	39,245	16.6	0.9	15.7
40	19,706	8.9	0.3	8.7	19,499	7.7	0.6	7.0	39,204	16.6	0.9	15.7
41	19,689	8.9	0.3	8.6	19,471	7.7	0.6	7.0	39,161	16.6	0.9	15.7
42	19,672	8.9	0.3	8.6	19,442	7.7	0.6	7.0	39,114	16.6	0.9	15.7
43	19,653	8.9	0.3	8.6	19,411	7.6	0.6	7.0	39,064	16.5	0.9	15.6
44	19,632	8.9	0.3	8.6	19,378	7.6	0.6	7.0	39,010	16.5	0.9	15.6
45	19,610	50	1.4	48	19,342	51	4.2	47	38,952	101	5.7	95
46	19,586	49	1.4	48	19,304	51	4.2	47	38,890	101	5.7	95
47	19,560	49	1.4	48	19,263	51	4.2	47	38,823	100	5.7	95
48	19,532	49	1.4	48	19,218	51	4.2	47	38,750	100	5.6	95
49	19,502	49	1.4	48	19,171	51	4.2	47	38,673	100	5.6	94
50	19,469	49	2.4	47	19,119	51	5.1	46	38,588	100	7.5	92
51	19,434	49	2.4	47	19,064	50	5.0	45	38,497	100	7.4	92
52	19,395	49	2.4	47	19,003	50	5.0	45	38,399	99	7.4	92
53	19,354	49	2.4	46	18,938	50	5.0	45	38,292	99	7.4	92
54	19,309	49	2.4	46	18,868	50	5.0	45	38,177	99	7.4	91
55	19,260	49	2.8	46	18,792	50	5.3	44	38,052	98	8.1	90
56	19,207	48	2.8	46	18,709	50	5.3	44	37,916	98	8.0	90
57	19,150	48	2.7	46	18,619	49	5.2	44	37,769	98	8.0	90
58	19,087	48	2.7	45	18,522	49	5.2	44	37,609	97	8.0	89
59	19,019	48	2.7	45	18,416	49	5.2	44	37,434	97	7.9	89
60	18,944	354	39	315	18,301	342	50	292	37,245	696	88	608
61	18,863	352	38	314	18,176	340	49	290	37,039	692	88	604
62	18,774	351	38	313	18,041	337	49	288	36,815	688	87	601
63	18,678	349	38	311	17,893	334	48	286	36,571	683	86	597
64	18,572	347	38	309	17,733	331	48	283	36,305	678	86	593
65	18,456	345	53	291	17,559	328	74	254	36,015	673	127	546
66	18,329	342	53	289	17,370	325	73	252	35,699	667	126	541
67	18,190	340	53	287	17,164	321	72	249	35,354	661	125	536
68	18,037	337	52	285	16,940	317	71	245	34,978	654	123	530
69	17,870	334	52	282	16,697	312	70	242	34,567	646	122	524
70	17,687	330	77	254	16,434	307	110	198	34,120	638	186	451
71	17,486	327	76	251	16,147	302	108	194	33,633	628	184	445
72	17,265	323	75	248	15,837	296	106	190	33,102	618	181	438
73	17,023	318	74	244	15,500	290	103	186	32,523	608	177	430
74	16,758	313	73	240	15,136	283	101	182	31,894	596	174	422
75	16,467	308	93	214	14,743	275	107	168	31,209	583	200	383
76	16,148	302	91	210	14,318	268	104	163	30,466	569	196	374
77	15,799	295	89	206	13,861	259	101	158	29,660	554	190	364
78	15,418	288	87	201	13,370	250	97	153	28,788	538	185	353
79	15,001	280	85	195	12,844	240	93	147	27,845	520	178	342
80	14,547	272	82	189	12,283	229	89	140	26,830	501	172	330
81	14,053	263	80	183	11,686	218	85	133	25,739	481	165	316
82	13,517	253	77	176	11,053	207	80	126	24,571	459	157	302
83	12,938	242	73	168	10,386	194	76	119	23,325	436	149	287
84	12,314	230	70	160	9,688	181	70	111	22,002	411	140	271
Total		**8,760**	**1,695**	**7,064**		**7,084**	**2,124**	**5,915**		**16,799**	**3,820**	**12,979**

- Tables 10 and 11 suggest the possibility of a reduction of 1,656 fatal (5,476 from Table 10 minus 3,820 from Table 11) and 6,661 non-fatal (19,640 from Table 10 minus 12,979 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 882 cardiovascular events (147 fatal and 736 non-fatal) (Table 12). For males, this improved control of hypertension is expected to result in a reduction of 872 cardiovascular events (214 fatal and 658 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					
	Total Life	Prevalence		Control (No Screening)		Control (With Screening)		100% Control			Moving from % Control without Screening to % Control with Screening		
Age	**Years**	%	#	%	#	%	#	Fatal	Non-Fatal	Total	Fatal	Non-Fatal	Total
18	19,894	3.4%	682	40.7%	278	59.1%	403						
19	19,887	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	19,868	3.4%	681	40.7%	277	59.1%	403	0.3	10.2	10.5	0.1	1.9	1.9
23	19,861	3.4%	681	40.7%	277	59.1%	403	0.3	10.2	10.5	0.1	1.9	1.9
24	19,855	3.4%	681	40.7%	277	59.1%	402	0.3	10.2	10.5	0.1	1.9	1.9
25	19,848	3.4%	681	40.7%	277	59.1%	402	0.3	10.2	10.5	0.1	1.9	1.9
26	19,842	3.4%	681	40.7%	277	59.1%	402	0.3	10.2	10.5	0.1	1.9	1.9
27	19,836	3.4%	680	40.7%	277	59.1%	402	0.3	10.2	10.5	0.1	1.9	1.9
28	19,829	3.4%	680	40.7%	277	59.1%	402	0.3	10.2	10.5	0.1	1.9	1.9
29	19,822	3.4%	680	40.7%	277	59.1%	402	0.3	10.2	10.5	0.1	1.9	1.9
30	19,815	3.4%	680	40.7%	277	59.1%	402	0.3	10.2	10.5	0.1	1.9	1.9
31	19,808	3.4%	679	40.7%	277	59.1%	402	0.3	10.2	10.5	0.1	1.9	1.9
32	19,799	3.4%	679	40.7%	276	59.1%	401	0.3	10.1	10.4	0.1	1.9	1.9
33	19,791	3.4%	679	40.7%	276	59.1%	401	0.3	10.1	10.4	0.1	1.9	1.9
34	19,781	3.4%	678	40.7%	276	59.1%	401	0.3	10.1	10.4	0.1	1.9	1.9
35	19,771	3.4%	678	40.7%	276	59.1%	401	0.3	10.1	10.4	0.1	1.9	1.9
36	19,760	3.4%	678	40.7%	276	59.1%	401	0.3	10.1	10.4	0.1	1.9	1.9
37	19,748	3.4%	677	40.7%	276	59.1%	400	0.3	10.1	10.4	0.1	1.9	1.9
38	19,735	3.4%	677	40.7%	276	59.1%	400	0.3	10.1	10.4	0.1	1.9	1.9
39	19,721	3.4%	676	40.7%	275	59.1%	400	0.3	10.1	10.4	0.1	1.9	1.9
40	19,706	14.8%	2,918	44.3%	1,292	64.3%	1,876	0.3	10.1	10.4	0.1	2.0	2.1
41	19,689	14.8%	2,916	44.3%	1,291	64.3%	1,875	0.3	10.1	10.4	0.1	2.0	2.1
42	19,672	14.8%	2,913	44.3%	1,290	64.3%	1,873	0.3	10.1	10.4	0.1	2.0	2.1
43	19,653	14.8%	2,910	44.3%	1,289	64.3%	1,871	0.3	10.1	10.4	0.1	2.0	2.1
44	19,632	14.8%	2,907	44.3%	1,288	64.3%	1,869	0.3	10.1	10.4	0.1	2.0	2.1
45	19,610	14.8%	2,904	44.3%	1,286	64.3%	1,867	2	56	58	0.3	11	12
46	19,586	14.8%	2,900	44.3%	1,285	64.3%	1,865	2	56	58	0.3	11	12
47	19,560	14.8%	2,896	44.3%	1,283	64.3%	1,862	2	56	58	0.3	11	12
48	19,532	14.8%	2,892	44.3%	1,281	64.3%	1,860	2	56	58	0.3	11	12
49	19,502	14.8%	2,888	44.3%	1,279	64.3%	1,857	2	56	57	0.3	11	11
50	19,469	14.8%	2,883	44.3%	1,277	64.3%	1,854	3	55	57	0.6	11	11
51	19,434	14.8%	2,878	44.3%	1,275	64.3%	1,850	3	54	57	0.6	11	11
52	19,395	14.8%	2,872	44.3%	1,272	64.3%	1,847	3	54	57	0.6	11	11
53	19,354	14.8%	2,866	44.3%	1,269	64.3%	1,843	3	54	57	0.6	11	11
54	19,309	14.8%	2,859	44.3%	1,266	64.3%	1,839	3	54	57	0.6	11	11
55	19,260	14.8%	2,852	44.3%	1,263	64.3%	1,834	3	53	57	0.6	11	11
56	19,207	14.8%	2,844	44.3%	1,260	64.3%	1,829	3	53	57	0.6	11	11
57	19,150	14.8%	2,836	44.3%	1,256	64.3%	1,823	3	53	56	0.6	11	11
58	19,087	14.8%	2,826	44.3%	1,252	64.3%	1,817	3	53	56	0.6	11	11
59	19,019	14.8%	2,816	44.3%	1,247	64.3%	1,811	3	53	56	0.6	11	11
60	18,944	42.6%	8,069	48.8%	3,935	70.8%	5,713	16	129	145	3	28	32
61	18,863	42.6%	8,035	48.8%	3,919	70.8%	5,688	16	128	144	3	28	32
62	18,774	42.6%	7,997	48.8%	3,900	70.8%	5,662	16	128	143	3	28	32
63	18,678	42.6%	7,956	48.8%	3,880	70.8%	5,633	16	127	143	3	28	31
64	18,572	42.6%	7,910	48.8%	3,858	70.8%	5,601	15	126	142	3	28	31
65	18,456	42.6%	7,861	48.8%	3,834	70.8%	5,566	22	119	141	5	26	31
66	18,329	42.6%	7,807	48.8%	3,808	70.8%	5,527	22	118	140	5	26	31
67	18,190	42.6%	7,748	48.8%	3,779	70.8%	5,485	21	117	139	5	26	31
68	18,037	42.6%	7,683	48.8%	3,747	70.8%	5,439	21	116	138	5	26	30
69	17,870	42.6%	7,612	48.8%	3,712	70.8%	5,389	21	115	136	5	25	30
70	17,687	61.6%	10,899	43.7%	4,760	63.4%	6,910	31	104	135	6	20	27
71	17,486	61.6%	10,775	43.7%	4,706	63.4%	6,832	31	102	133	6	20	26
72	17,265	61.6%	10,639	43.7%	4,647	63.4%	6,745	31	101	132	6	20	26
73	17,023	61.6%	10,490	43.7%	4,582	63.4%	6,651	30	100	130	6	20	26
74	16,758	61.6%	10,327	43.7%	4,510	63.4%	6,547	30	98	128	6	19	25
75	16,467	61.6%	10,148	43.7%	4,432	63.4%	6,434	38	88	126	8	17	25
76	16,148	61.6%	9,951	43.7%	4,346	63.4%	6,309	37	86	123	7	17	24
77	15,799	61.6%	9,736	43.7%	4,252	63.4%	6,173	37	84	121	7	17	24
78	15,418	61.6%	9,501	43.7%	4,149	63.4%	6,024	36	82	118	7	16	23
79	15,001	61.6%	9,244	43.7%	4,037	63.4%	5,861	35	80	114	7	16	23
80	14,547	61.6%	8,965	43.7%	3,915	63.4%	5,684	34	77	111	7	15	22
81	14,053	61.6%	8,660	43.7%	3,782	63.4%	5,491	32	75	107	6	15	21
82	13,517	61.6%	8,330	43.7%	3,638	63.4%	5,281	31	72	103	6	14	20
83	12,938	61.6%	7,973	43.7%	3,482	63.4%	5,055	30	69	99	6	14	19
84	12,314	61.6%	7,589	43.7%	3,314	63.4%	4,811	28	66	94	6	13	19
Total	***1,241,983***	***23.7%***	***294,437***	***45.0%***	***132,516***	***65.3%***	***192,370***	***722***	***3,588***	***4,310***	***147***	***736***	***882***

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					
	Total Life	Prevalence		Control (No Screening)		Control (With Screening)		100% Control			Moving from % Control without Screening to % Control with Screening		
Age	**Years**	%	#	%	#	%	#	Fatal	Non-Fatal	Total	Fatal	Non-Fatal	Total
18	19,871	4.4%	869	30.8%	267	44.7%	388						
19	19,862	4.4%	868	30.8%	267	44.7%	388	0.8	8.4	9.1	0.1	1.2	1.3
20	19,850	4.4%	868	30.8%	267	44.7%	388	0.8	8.4	9.1	0.1	1.2	1.3
21	19,837	4.4%	867	30.8%	267	44.7%	388	0.8	8.4	9.1	0.1	1.2	1.3
22	19,821	4.4%	866	30.8%	267	44.7%	387	0.8	8.4	9.1	0.1	1.2	1.3
23	19,805	4.4%	866	30.8%	267	44.7%	387	0.8	8.3	9.1	0.1	1.2	1.3
24	19,788	4.4%	865	30.8%	266	44.7%	387	0.8	8.3	9.1	0.1	1.2	1.3
25	19,772	4.4%	864	30.8%	266	44.7%	386	0.8	8.3	9.1	0.1	1.2	1.3
26	19,756	4.4%	864	30.8%	266	44.7%	386	0.8	8.3	9.1	0.1	1.2	1.3
27	19,742	4.4%	863	30.8%	266	44.7%	386	0.8	8.3	9.1	0.1	1.2	1.3
28	19,727	4.4%	862	30.8%	266	44.7%	385	0.8	8.3	9.1	0.1	1.2	1.3
29	19,713	4.4%	862	30.8%	265	44.7%	385	0.8	8.3	9.1	0.1	1.2	1.3
30	19,698	4.4%	861	30.8%	265	44.7%	385	0.8	8.3	9.1	0.1	1.2	1.3
31	19,683	4.4%	860	30.8%	265	44.7%	385	0.7	8.3	9.0	0.1	1.2	1.3
32	19,666	4.4%	860	30.8%	265	44.7%	384	0.7	8.3	9.0	0.1	1.2	1.3
33	19,649	4.4%	859	30.8%	264	44.7%	384	0.7	8.3	9.0	0.1	1.2	1.3
34	19,631	4.4%	858	30.8%	264	44.7%	384	0.7	8.3	9.0	0.1	1.2	1.3
35	19,612	4.4%	857	30.8%	264	44.7%	383	0.7	8.3	9.0	0.1	1.1	1.3
36	19,592	4.4%	856	30.8%	264	44.7%	383	0.7	8.3	9.0	0.1	1.1	1.3
37	19,571	4.4%	856	30.8%	263	44.7%	382	0.7	8.2	9.0	0.1	1.1	1.3
38	19,548	4.4%	855	30.8%	263	44.7%	382	0.7	8.2	9.0	0.1	1.1	1.2
39	19,524	4.4%	854	30.8%	263	44.7%	382	0.7	8.2	9.0	0.1	1.1	1.2
40	19,499	18.4%	3,593	38.1%	1,369	55.3%	1,987	0.7	8.2	9.0	0.1	1.4	1.5
41	19,471	18.4%	3,588	38.1%	1,367	55.3%	1,984	0.7	8.2	8.9	0.1	1.4	1.5
42	19,442	18.4%	3,582	38.1%	1,365	55.3%	1,981	0.7	8.2	8.9	0.1	1.4	1.5
43	19,411	18.4%	3,577	38.1%	1,363	55.3%	1,978	0.7	8.2	8.9	0.1	1.4	1.5
44	19,378	18.4%	3,571	38.1%	1,360	55.3%	1,975	0.7	8.2	8.9	0.1	1.4	1.5
45	19,342	18.4%	3,564	38.1%	1,358	55.3%	1,971	5	55	60	0.9	9	10
46	19,304	18.4%	3,557	38.1%	1,355	55.3%	1,967	5	55	60	0.9	9	10
47	19,263	18.4%	3,549	38.1%	1,352	55.3%	1,963	5	55	60	0.8	9	10
48	19,218	18.4%	3,541	38.1%	1,349	55.3%	1,958	5	54	59	0.8	9	10
49	19,171	18.4%	3,532	38.1%	1,346	55.3%	1,953	5	54	59	0.8	9	10
50	19,119	18.4%	3,523	38.1%	1,342	55.3%	1,948	6	53	59	1.0	9	10
51	19,064	18.4%	3,513	38.1%	1,338	55.3%	1,943	6	53	59	1.0	9	10
52	19,003	18.4%	3,502	38.1%	1,334	55.3%	1,936	6	53	59	1.0	9	10
53	18,938	18.4%	3,490	38.1%	1,329	55.3%	1,930	6	53	59	1.0	9	10
54	18,868	18.4%	3,477	38.1%	1,324	55.3%	1,923	6	52	58	1.0	9	10
55	18,792	18.4%	3,463	38.1%	1,319	55.3%	1,915	6	52	58	1.1	9	10
56	18,709	18.4%	3,447	38.1%	1,313	55.3%	1,906	6	52	58	1.1	9	10
57	18,619	18.4%	3,431	38.1%	1,307	55.3%	1,897	6	51	58	1.1	9	10
58	18,522	18.4%	3,413	38.1%	1,300	55.3%	1,887	6	51	57	1.0	9	10
59	18,416	18.4%	3,393	38.1%	1,293	55.3%	1,877	6	51	57	1.0	9	10
60	18,301	43.3%	7,918	52.8%	4,183	76.7%	6,073	20	119	140	5	28	33
61	18,176	43.3%	7,864	52.8%	4,155	76.7%	6,032	20	119	139	5	28	33
62	18,041	43.3%	7,805	52.8%	4,124	76.7%	5,987	20	118	138	5	28	33
63	17,893	43.3%	7,741	52.8%	4,090	76.7%	5,938	20	117	137	5	28	33
64	17,733	43.3%	7,672	52.8%	4,054	76.7%	5,885	20	116	135	5	28	32
65	17,559	43.3%	7,597	52.8%	4,014	76.7%	5,827	30	104	134	7	25	32
66	17,370	43.3%	7,515	52.8%	3,971	76.7%	5,764	30	103	133	7	25	32
67	17,164	43.3%	7,426	52.8%	3,924	76.7%	5,696	29	102	131	7	24	31
68	16,940	43.3%	7,329	52.8%	3,872	76.7%	5,621	29	100	129	7	24	31
69	16,697	43.3%	7,224	52.8%	3,817	76.7%	5,541	29	99	127	7	24	30
70	16,434	63.9%	10,505	52.3%	5,491	75.9%	7,974	45	81	125	11	19	30
71	16,147	63.9%	10,322	52.3%	5,395	75.9%	7,835	44	79	123	10	19	29
72	15,837	63.9%	10,124	52.3%	5,291	75.9%	7,684	43	78	121	10	18	29
73	15,500	63.9%	9,909	52.3%	5,179	75.9%	7,521	42	76	118	10	18	28
74	15,136	63.9%	9,676	52.3%	5,057	75.9%	7,344	41	74	116	10	18	27
75	14,743	63.9%	9,424	52.3%	4,926	75.9%	7,153	44	69	113	10	16	27
76	14,318	63.9%	9,153	52.3%	4,784	75.9%	6,947	42	67	109	10	16	26
77	13,861	63.9%	8,861	52.3%	4,631	75.9%	6,725	41	65	106	10	15	25
78	13,370	63.9%	8,547	52.3%	4,467	75.9%	6,487	40	62	102	9	15	24
79	12,844	63.9%	8,211	52.3%	4,291	75.9%	6,232	38	60	98	9	14	23
80	12,283	63.9%	7,852	52.3%	4,104	75.9%	5,960	36	57	94	9	14	22
81	11,686	63.9%	7,470	52.3%	3,904	75.9%	5,670	35	54	89	8	13	21
82	11,053	63.9%	7,066	52.3%	3,693	75.9%	5,363	33	52	84	8	12	20
83	10,386	63.9%	6,640	52.3%	3,470	75.9%	5,039	31	48	79	7	11	19
84	9,688	63.9%	6,193	52.3%	3,237	75.9%	4,700	29	45	74	7	11	17
Total	***1,194,429***	***24.7%***	***295,309***	***47.7%***	***140,743***	***69.2%***	***204,350***	***934***	***3,073***	***4,007***	***214***	***658***	***872***

- 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 1,755 fewer cardiovascular events (361 of which would be fatal and 1,394 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.[478]

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.

[478] 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.[479]
- 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).[480]

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 6,206 life years would be gained associated with screening for and treatment of hypertension in females (Table 16) and 5,934 in males (Table 17).

[479] Krueger H, Lindsay P, Cote R et al. Cost avoidance associated with optimal stroke care in Canada. *Stroke*. 2012; 43(8): 2198-206.
[480] 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	3.4	1.9	1.9				3.4
24	0.06	61	3.4	1.9	1.9				3.4
25	0.06	60	3.3	1.9	1.9				3.3
26	0.06	59	3.3	1.9	1.9				3.3
27	0.06	58	3.2	1.9	1.9				3.2
28	0.06	57	3.2	1.9	1.9				3.2
29	0.06	56	3.1	1.9	1.9				3.1
30	0.06	55	3.1	1.9	1.9				3.1
31	0.06	54	3.0	1.9	1.9				3.0
32	0.06	53	2.9	1.9	1.9				2.9
33	0.06	52	2.9	1.9	1.9				2.9
34	0.06	51	2.8	1.9	1.9				2.8
35	0.06	50	2.8	1.9	1.9				2.8
36	0.06	49	2.7	1.9	1.9				2.7
37	0.06	48	2.7	1.9	1.9				2.7
38	0.06	47	2.6	1.9	1.9				2.6
39	0.06	46	2.5	1.9	1.9				2.5
40	0.06	45	2.7	2.0	2.0				2.7
41	0.06	44	2.7	2.0	2.0				2.7
42	0.06	43	2.6	2.0	2.0				2.6
43	0.06	42	2.5	2.0	2.0				2.5
44	0.06	41	2.5	2.0	2.0				2.5
45	0.33	40	13	11	11				13
46	0.33	39	13	11	11				13
47	0.33	39	13	11	11				13
48	0.33	38	12	11	11				12
49	0.33	37	12	11	11				12
50	0.56	36	20	11	11	106			126
51	0.56	35	19	11	11	103			123
52	0.56	34	19	11	11	101			119
53	0.56	33	18	11	11	97			116
54	0.56	32	18	11	11	94			112
55	0.65	31	20	11	11	91			111
56	0.64	30	19	11	11	88			107
57	0.64	29	19	11	11	85			104
58	0.64	28	18	11	11	82			100
59	0.64	27	17	11	11	79			97
60	3.47	27	92	28	14	106	15		198
61	3.45	26	88	28	14	102	15		190
62	3.44	25	85	28	13	98	15		183
63	3.42	24	81	28	13	94	15		175
64	3.40	23	78	28	13	90	14		167
65	4.80	22	106	26	13	82	14	139	327
66	4.77	21	101	26	12	78	14	133	311
67	4.73	20	96	26	12	74	13	127	297
68	4.69	20	92	26	12	71	13	121	283
69	4.65	19	87	25	12	67	13	114	268
70	6.18	18	111	20	10	53	11	90	253
71	6.11	17	105	20	10	50	11	85	239
72	6.04	16	98	20	10	47	10	80	225
73	5.95	16	93	20	9	44	10	75	212
74	5.86	15	87	19	9	42	10	70	198
75	7.51	14	106	17	8	35	9	61	202
76	7.36	13	98	17	8	33	9	56	187
77	7.20	13	91	17	8	30	9	52	173
78	7.03	12	84	16	8	28	8	48	160
79	6.84	11	77	16	8	26	8	44	146
80	6.63	11	70	15	7	23	8	42	135
81	6.41	10	63	15	7	21	8	38	122
82	6.16	9	57	14	7	19	7	34	110
83	5.90	9	51	14	7	17	7	30	99
84	5.61	8	45	13	6	15	7	27	87
Total	*147*	*16.9*	*2,473*	*736*	*463*	*2,269*	*272*	*1,464*	*6,206*

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	62	6.5	1.2	1.2				6.5
20	0.11	61	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	0.10	58	6.1	1.2	1.2				6.1
24	0.10	57	6.0	1.2	1.2				6.0
25	0.10	56	5.9	1.2	1.2				5.9
26	0.10	55	5.8	1.2	1.2				5.8
27	0.10	54	5.7	1.2	1.2				5.7
28	0.10	53	5.5	1.2	1.2				5.5
29	0.10	52	5.5	1.2	1.2				5.5
30	0.10	51	5.3	1.2	1.2				5.3
31	0.10	50	5.2	1.2	1.2				5.2
32	0.10	49	5.1	1.2	1.2				5.1
33	0.10	48	5.0	1.2	1.2				5.0
34	0.10	47	4.9	1.2	1.2				4.9
35	0.10	46	4.8	1.1	1.1				4.8
36	0.10	46	4.7	1.1	1.1				4.7
37	0.10	45	4.6	1.1	1.1				4.6
38	0.10	44	4.5	1.1	1.1				4.5
39	0.10	43	4.4	1.1	1.1				4.4
40	0.13	42	5.3	1.4	1.4				5.3
41	0.13	41	5.2	1.4	1.4				5.2
42	0.13	40	5.1	1.4	1.4				5.1
43	0.13	39	4.9	1.4	1.4				4.9
44	0.13	38	4.8	1.4	1.4				4.8
45	0.85	37	32	9	9				32
46	0.85	36	31	9	9				31
47	0.85	35	30	9	9				30
48	0.85	34	29	9	9				29
49	0.84	33	28	9	9				28
50	1.02	32	33	9	9	85			118
51	1.01	32	32	9	9	82			114
52	1.01	31	31	9	9	80			111
53	1.01	30	30	9	9	77			107
54	1.00	29	29	9	9	74			103
55	1.06	28	30	9	9	71			101
56	1.06	27	29	9	9	69			97
57	1.05	26	28	9	9	66			94
58	1.05	25	26	9	9	64			90
59	1.04	24	25	9	9	61			87
60	4.83	24	114	28	14	97	15		211
61	4.80	23	109	28	14	92	15		201
62	4.76	22	104	28	13	88	15		193
63	4.73	21	100	28	13	85	15		184
64	4.68	20	95	28	13	81	14		176
65	7.18	20	140	25	12	70	13	73	283
66	7.11	19	133	25	12	66	13	69	268
67	7.02	18	126	24	12	62	13	66	254
68	6.93	17	119	24	11	59	12	62	239
69	6.83	16	112	24	11	56	12	59	226
70	10.57	16	165	19	9	39	10	50	254
71	10.37	15	155	19	9	37	10	47	238
72	10.17	14	144	18	9	34	10	44	222
73	9.96	14	134	18	9	32	9	41	207
74	9.73	13	124	18	8	29	9	38	192
75	10.33	12	125	16	8	26	8	38	188
76	10.04	12	115	16	8	24	8	35	174
77	9.72	11	105	15	7	22	8	31	158
78	9.38	10	96	15	7	20	8	29	144
79	9.01	10	87	14	7	18	7	26	130
80	8.62	9	78	14	6	16	7	27	121
81	8.20	8	69	13	6	14	7	24	107
82	7.76	8	61	12	6	13	6	21	95
83	7.29	7	54	11	5	11	6	19	84
84	6.80	7	47	11	5	10	6	16	73
Total	*214*	*15.4*	*3,291*	*658*	*403*	*1,829*	*255*	*814*	*5,934*

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.[481] 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.[482] 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.[483] 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.
- Based on this approach, a total of 2,512 QALYs would be gained associated with screening for and treatment of hypertension in females and 1,864 QALYs in males (Table 18).

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[481] 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.
[482] Krueger H, Lindsay P, Cote R et al. Cost avoidance associated with optimal stroke care in Canada. *Stroke*. 2012; 43(8): 2198-206.
[483] 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.

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	QALYs Gained	# AMI	QALYs Gained	# Stroke	QALYs Gained
18								
19			2	27			1	16
20			2	27			1	15
21			2	26			1	15
22			2	26			1	15
23			2	25			1	15
24			2	25			1	14
25			2	24			1	14
26			2	24			1	14
27			2	24			1	14
28			2	23			1	13
29			2	23			1	13
30			2	23			1	13
31			2	23			1	13
32			2	22			1	13
33			2	22			1	13
34			2	21			1	12
35			2	21			1	12
36			2	21			1	12
37			2	20			1	11
38			2	20			1	11
39			2	19			1	11
40			2	21			1	14
41			2	21			1	13
42			2	20			1	13
43			2	20			1	13
44			2	19			1	12
45			11	106			9	82
46			11	103			9	80
47			11	101			9	77
48			11	98			9	75
49			11	96			9	73
50			11	69			9	52
51			11	67			9	50
52			11	65			9	48
53			11	63			9	47
54			11	61			9	45
55			11	59			9	43
56			11	57			9	42
57			11	55			9	40
58			11	53			9	39
59			11	51			9	37
60	15	0.15	14	64	15	0.15	14	56
61	15	0.15	14	61	15	0.15	14	54
62	15	0.15	13	59	15	0.15	13	52
63	15	0.15	13	56	15	0.15	13	49
64	14	0.15	13	54	14	0.15	13	47
65	14	0.14	13	49	13	0.13	12	41
66	14	0.14	12	47	13	0.13	12	38
67	13	0.14	12	45	13	0.13	12	36
68	13	0.14	12	43	12	0.13	11	34
69	13	0.14	12	40	12	0.13	11	32
70	11	0.11	10	32	10	0.11	9	27
71	11	0.11	10	30	10	0.11	9	26
72	10	0.11	10	29	10	0.10	9	24
73	10	0.11	9	27	9	0.10	9	22
74	10	0.11	9	25	9	0.10	8	21
75	9	0.10	8	22	8	0.09	8	18
76	9	0.10	8	20	8	0.09	8	17
77	9	0.09	8	18	8	0.09	7	15
78	8	0.09	8	17	8	0.08	7	14
79	8	0.09	8	16	7	0.08	7	13
80	8	0.09	7	16	7	0.08	6	12
81	8	0.09	7	14	7	0.08	6	11
82	7	0.09	7	13	6	0.07	6	10
83	7	0.08	7	11	6	0.07	5	8
84	7	0.08	6	10	6	0.07	5	7
	272	**2.9**	**463**	**2,509**	**255**	**2.7**	**403**	**1,861**

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%).[484, 485, 486] 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[487] or 2.88 per 100 person-years of treatment.[488]
    - 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.[489]
- 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.[490] Each SAE was associated with a disutility of 0.0096 (0.5 / 52 weeks[491]). 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 260 QALYs lost for both females and males (see Table 19).

[484] 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.

[485] 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.

[486] 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.

[487] The SPRINT Research Group. A randomized trial of intensive versus standard blood-pressure control. *New England Journal of Medicine*. 2015; 373(22): 2103-16.

[488] 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.

[489] Richman I, Fairley M, Jorgensen M et al. Cost-effectiveness of intensive blood pressure management. *JAMA Cardiology*. 2016; 8: 872-9.

[490] 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.

[491] 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	128	4	0.04	0.3
27	138	4	0.04	0.4	128	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	127	4	0.04	0.3
33	138	4	0.04	0.4	127	4	0.04	0.3
34	138	4	0.04	0.4	127	4	0.04	0.3
35	138	4	0.04	0.4	127	4	0.04	0.3
36	137	4	0.04	0.4	127	4	0.04	0.3
37	137	4	0.04	0.4	126	4	0.04	0.3
38	137	4	0.04	0.4	126	4	0.04	0.3
39	137	4	0.04	0.4	126	4	0.04	0.3
40	679	20	0.22	1.9	788	23	0.26	2.2
41	679	20	0.22	1.9	787	23	0.26	2.2
42	678	20	0.22	1.9	786	23	0.25	2.2
43	677	20	0.22	1.9	785	23	0.25	2.2
44	677	19	0.22	1.9	783	23	0.25	2.2
45	676	19	0.22	1.9	782	23	0.25	2.2
46	675	19	0.22	1.9	780	22	0.25	2.2
47	674	19	0.22	1.9	779	22	0.25	2.2
48	673	19	0.22	1.9	777	22	0.25	2.2
49	672	19	0.22	1.9	775	22	0.25	2.2
50	671	19	0.23	2.0	773	22	0.26	2.3
51	670	19	0.23	2.0	771	22	0.26	2.3
52	668	19	0.23	2.0	768	22	0.26	2.2
53	667	19	0.23	2.0	765	22	0.26	2.2
54	665	19	0.22	1.9	763	22	0.26	2.2
55	664	19	0.22	1.9	760	22	0.26	2.2
56	662	19	0.22	1.9	756	22	0.26	2.2
57	660	19	0.22	1.9	753	22	0.25	2.2
58	658	19	0.22	1.9	749	22	0.25	2.2
59	655	19	0.22	1.9	744	21	0.25	2.2
60	2,104	61	0.73	6.3	2,124	61	0.74	6.4
61	2,095	60	0.73	6.3	2,109	61	0.73	6.3
62	2,085	60	0.72	6.3	2,093	60	0.73	6.3
63	2,074	60	0.72	6.2	2,076	60	0.72	6.2
64	2,063	59	0.71	6.2	2,058	59	0.71	6.2
65	2,050	59	0.71	6.2	2,038	59	0.71	6.1
66	2,036	59	0.71	6.1	2,016	58	0.70	6.1
67	2,020	58	0.70	6.1	1,992	57	0.69	6.0
68	2,003	58	0.69	6.0	1,966	57	0.68	5.9
69	1,985	57	0.69	6.0	1,938	56	0.67	5.8
70	2,930	84	1.07	9.3	2,980	86	1.09	9.4
71	2,897	83	1.06	9.2	2,928	84	1.07	9.3
72	2,860	82	1.05	9.1	2,872	83	1.05	9.1
73	2,820	81	1.03	8.9	2,811	81	1.03	8.9
74	2,776	80	1.02	8.8	2,745	79	1.00	8.7
75	2,728	79	1.00	8.6	2,674	77	0.98	8.5
76	2,675	77	0.98	8.5	2,597	75	0.95	8.2
77	2,617	75	0.96	8.3	2,514	72	0.92	8.0
78	2,554	74	0.93	8.1	2,425	70	0.89	7.7
79	2,485	72	0.91	7.9	2,329	67	0.85	7.4
80	2,410	69	0.96	8.3	2,227	64	0.89	7.7
81	2,328	67	0.92	8.0	2,119	61	0.84	7.3
82	2,239	64	0.89	7.7	2,004	58	0.80	6.9
83	2,143	62	0.85	7.4	1,884	54	0.75	6.5
84	2,040	59	0.81	7.0	1,757	51	0.70	6.0
	75,451	**2,173**	**27**	**233**	**75,497**	**2,174**	**27**	**233**

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 15,995 QALYs (Table 20, row ab). The CPB of 15,995 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	24.2%	= e/d
d	Life years lived in cohort	2,436,412	Table 5
e	Life years lived with hypertension	589,746	Table 5
	Without a Screening Program		
f	Life years lived **aware** of hypertension	348,559	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	334,099	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**	273,259	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	506,039	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	485,047	Table 6
o	% of life years lived with hypertension and **on treatment** for hypertension	82.2%	= n/e
p	Life years lived with hypertension **under control**	396,720	Table 6
q	% of life years lived with hypertension and hypertension **controlled**	67.3%	= p/e
r	Life years gained - avoid fatal CV events (females)	2,473	Table 16
s	QALYs gained - avoid non-fatal AMI (females)	1,466	Tables 16 & 18
t	QALYs gained - avoid non-fatal stroke (females)	4,778	Tables 16 & 18
u	**Total QALYs gained - Females**	**8,717**	= r + s + t
v	Life years gained - avoid fatal CV (males)	3,291	Table 17
w	QALYs gained - avoid non-fatal AMI (males)	817	Tables 17 & 18
x	QALYs gained - avoid non-fatal stroke (males)	3,690	Tables 17 & 18
y	**Total QALYs gained - Males**	**7,797**	= v + w + x
	Harms		
z	QALYs lost due to harms - Females	260	Table 19
aa	QALYs lost due to harms - Males	259	Table 19
	Net QALYs Gained With Screening		
ab	**Net QALYs gained (CPB) -** No screening to 88.1%	**15,995**	= 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 = 19,473
- 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 = 9,851
- The average disutility of living with a stroke is increased from 0.200 to 0.265. CPB = 17,416
- The average disutility of living with a stroke is decreased from 0.200 to 0.134. CPB = 14,553
- The disutility associated with taking preventive medication is increased from 0.0024 to 0.0033. CPB = 15,821
- The disutility associated with taking preventive medication is reduced from 0.0024 to 0.0. CPB = 16,461

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 8,457 QALYs (Table 21, row ab). The CPB of 8,457 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	23.7%	= e/d
d	Life years lived in cohort	1,241,983	Table 5
e	Life years lived with hypertension	294,437	Table 5
	Without a Screening Program		
f	Life years lived **aware** of hypertension	173,022	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	167,047	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**	132,516	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	251,172	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	242,498	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**	192,370	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)	2,473	Table 16
s	QALYs gained - avoid non-fatal AMI (females)	1,466	Tables 16 & 18
t	QALYs gained - avoid non-fatal stroke (females)	4,778	Tables 16 & 18
u	**Total QALYs gained - Females**	**8,717**	= 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	260	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%	**8,457**	= 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 = 10,283
- 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 = 5,207
- The average disutility of living with a stroke is increased from 0.200 to 0.265. CPB = 9,273.
- The average disutility of living with a stroke is decreased from 0.200 to 0.134. CPB = 7,629
- The disutility associated with taking preventive medication is increased from 0.0024 to 0.0033. CPB = 8,370
- The disutility associated with taking preventive medication is reduced from 0.0024 to 0.0. CPB = 8,691

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 7,538 QALYs (Table 22, row ab). The CPB of 7,538 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	1,194,429	Table 5
e	Life years lived with hypertension	295,309	Table 5
	Without a Screening Program		
f	Life years lived **aware** of hypertension	175,537	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	167,051	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**	140,743	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	254,868	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	242,549	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**	204,350	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**	**0**	= r + s + t
v	Life years gained - avoid fatal CV (males)	3,291	Table 17
w	QALYs gained - avoid non-fatal AMI (males)	817	Tables 17 & 18
x	QALYs gained - avoid non-fatal stroke (males)	3,690	Tables 17 & 18
y	**Total QALYs gained - Males**	**7,797**	= v + w + x
	Harms		
z	QALYs lost due to harms - Females		Table 19
aa	QALYs lost due to harms - Males	259	Table 19
	Net QALYs Gained With Screening		
ab	**Net QALYs gained (CPB) -** No screening to 88.1%	**7,538**	= 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 = 9,190
- 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 = 4,644
- The average disutility of living with a stroke is increased from 0.200 to 0.265. CPB = 8,143.
- The average disutility of living with a stroke is decreased from 0.200 to 0.134. CPB = 6,924
- The disutility associated with taking preventive medication is increased from 0.0024 to 0.0033. CPB = 7,451
- The disutility associated with taking preventive medication is reduced from 0.0024 to 0.0. CPB = 7,771

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.[492]
- 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.[493]
- 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

[492] 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.
[493] Ibid.

≥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.[494]

- 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.[495]
- 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.[496]
- 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. [497]
- 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 cost of an office visit to a General Practitioner (GP) in BC is estimated at $34.85.[498]
- 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 2017 ($25.16[499]) plus 18% benefits for an average cost per hour of $29.69. In the absence of specific data on the amount of time required, we assume two hours per service.
- Patient time costs are truncated at $222.67 per day (7.5 hours times $29.69). If, for example, we are valuing a patient's time costs while in hospital, each day would be assessed a value of $222.67 (rather than 24 hours times $29.69 or $712.56).

[494] 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.
[495] Ibid
[496] 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.
[497] Leung A, Williams J, Tran K et al. Epidemiology of resultant hypertension in Canada. *Canadian Journal of Cardiology*. 2022; 38: 681-7.
[498] Ministry of Health. *Medical Services Commission Payment Schedule*. 2016. Available at http://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msc-payment-schedule-december-2016.pdf. Accessed July 2017.
[499] Statistics Canada. *Average Hourly Wages of Employees by Selected Characteristics and Occupation, Unadjusted Data, by Province (monthly) (British Columbia)*. 2017. Available at http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/labr69k-eng.htm. Accessed July 2017.

- The BC Hypertension Guidelines state the following tests should be ordered twice a year for monitoring purposes:[500]
    - 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:

    - 12-lead ECG - $24.29[501]
    - Urinalysis (fee item 92385) - $2.05[502]
    - 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 - $98.57**

- 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.[503]

- Average annual cost of antihypertensive medication – Calculated based on an estimated average cost per day of treatment for antihypertensive medication in Canada of $0.53 (365 * $0.53 = $193.45).[504]

- Capital cost of equipment for automated office blood pressure (AOBP) measurement and ambulatory blood pressure monitoring (ABPM) are not included. ABPM

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500 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.

501 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 August 2022. 2017/18 average FFS for fee item 33016 (ECG and Interpretaion – Office – Cardiology).

502 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.

503 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.

504 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 February 2018.

machines cost approximately $2,000[505] each while AOBP machines cost approximately $400 - $900 each.[506,507]

- 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 $77.3 million in females (see Tables 23) and $74.7 million in males (see Table 24).

505 See https://www.cardiacdirect.com/product-category/24-hour-abp-monitors/. Accessed July 2022.
506 See https://medical.andonline.com/product/professional-office-blood-pressure-monitor-um-211/. Accessed July 2022.
507 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	Costs Total
18	19,894	3.4%	682	58.8%	11,379	6,195	208	277	$223,142	$27,288	$26,777	$380,206	**$657,413**
19	19,887	3.4%	682	58.8%	11,230	5,615	208	277	$202,920	$27,279	$26,769	$345,751	**$602,719**
20	19,881	3.4%	682	68.2%	13,100	6,550	207	277	$235,491	$27,270	$26,760	$401,247	**$690,769**
21	19,874	3.4%	682	68.2%	13,095	6,548	207	277	$235,413	$27,261	$26,751	$401,114	**$690,539**
22	19,868	3.4%	681	68.2%	13,091	6,545	207	276	$235,335	$27,252	$26,742	$400,980	**$690,310**
23	19,861	3.4%	681	68.2%	13,087	6,543	207	276	$235,259	$27,244	$26,734	$400,851	**$690,088**
24	19,855	3.4%	681	68.2%	13,082	6,541	207	276	$235,181	$27,235	$26,725	$400,718	**$689,858**
25	19,848	3.4%	681	77.8%	14,985	7,492	207	276	$268,329	$27,226	$26,716	$457,199	**$779,470**
26	19,842	3.4%	681	77.8%	14,980	7,490	207	276	$268,246	$27,217	$26,708	$457,057	**$779,227**
27	19,836	3.4%	680	77.8%	14,975	7,488	207	276	$268,159	$27,208	$26,699	$456,909	**$778,976**
28	19,829	3.4%	680	77.8%	14,970	7,485	207	276	$268,070	$27,199	$26,690	$456,757	**$778,716**
29	19,822	3.4%	680	77.8%	14,965	7,483	207	276	$267,978	$27,190	$26,681	$456,600	**$778,449**
30	19,815	3.4%	680	75.5%	14,492	7,246	207	276	$259,737	$27,180	$26,672	$442,558	**$756,147**
31	19,808	3.4%	679	75.5%	14,487	7,243	207	276	$259,637	$27,170	$26,661	$442,388	**$755,857**
32	19,799	3.4%	679	75.5%	14,481	7,240	207	276	$259,526	$27,159	$26,650	$442,200	**$755,535**
33	19,791	3.4%	679	75.5%	14,474	7,237	207	275	$259,411	$27,146	$26,638	$442,003	**$755,199**
34	19,781	3.4%	678	75.5%	14,467	7,234	206	275	$259,285	$27,133	$26,625	$441,788	**$754,832**
35	19,771	3.4%	678	76.5%	14,668	7,334	206	275	$262,781	$27,119	$26,612	$447,745	**$764,257**
36	19,760	3.4%	678	76.5%	14,660	7,330	206	275	$262,631	$27,104	$26,597	$447,491	**$763,822**
37	19,748	3.4%	677	76.5%	14,651	7,325	206	275	$262,472	$27,087	$26,580	$447,218	**$763,358**
38	19,735	3.4%	677	76.5%	14,641	7,321	206	275	$262,298	$27,070	$26,563	$446,923	**$762,854**
39	19,721	3.4%	676	76.5%	14,631	7,315	206	274	$262,112	$27,050	$26,544	$446,605	**$762,312**
40	19,706	14.8%	2,918	80.6%	15,428	9,698	1,019	1,358	$373,460	$133,881	$131,375	$636,329	**$1,275,044**
41	19,689	14.8%	2,916	80.6%	13,594	6,797	1,018	1,357	$272,346	$133,769	$131,265	$464,043	**$1,001,423**
42	19,672	14.8%	2,913	80.6%	13,582	6,791	1,017	1,356	$272,100	$133,650	$131,148	$463,624	**$1,000,521**
43	19,653	14.8%	2,910	80.6%	13,568	6,784	1,016	1,355	$271,834	$133,520	$131,021	$463,171	**$999,547**
44	19,632	14.8%	2,907	80.6%	13,554	6,777	1,015	1,353	$271,549	$133,382	$130,885	$462,686	**$998,502**
45	19,610	14.8%	2,904	82.7%	13,950	6,975	1,014	1,352	$278,402	$133,231	$130,737	$474,362	**$1,016,733**
46	19,586	14.8%	2,900	82.7%	13,932	6,966	1,012	1,350	$278,058	$133,068	$130,577	$473,776	**$1,015,479**
47	19,560	14.8%	2,896	82.7%	13,914	6,957	1,011	1,348	$277,685	$132,891	$130,404	$473,140	**$1,014,120**
48	19,532	14.8%	2,892	82.7%	13,894	6,947	1,010	1,346	$277,283	$132,701	$130,217	$472,455	**$1,012,657**
49	19,502	14.8%	2,888	82.7%	13,872	6,936	1,008	1,344	$276,850	$132,496	$130,016	$471,717	**$1,011,079**
50	19,469	14.8%	2,883	79.9%	13,291	6,646	1,006	1,342	$266,677	$132,273	$129,797	$454,383	**$983,130**
51	19,434	14.8%	2,878	79.9%	13,267	6,633	1,005	1,339	$266,186	$132,033	$129,561	$453,548	**$981,328**
52	19,395	14.8%	2,872	79.9%	13,240	6,620	1,003	1,337	$265,657	$131,773	$129,307	$452,647	**$979,384**
53	19,354	14.8%	2,866	79.9%	13,212	6,606	1,000	1,334	$265,081	$131,490	$129,029	$451,664	**$977,264**
54	19,309	14.8%	2,859	79.9%	13,181	6,590	998	1,331	$264,460	$131,186	$128,731	$450,607	**$974,984**
55	19,260	14.8%	2,852	90.0%	15,096	7,548	996	1,328	$297,740	$130,854	$128,405	$507,311	**$1,064,311**
56	19,207	14.8%	2,844	90.0%	15,054	7,527	993	1,324	$296,912	$130,494	$128,052	$505,900	**$1,061,358**
57	19,150	14.8%	2,836	90.0%	15,008	7,504	990	1,320	$296,012	$130,103	$127,668	$504,367	**$1,058,150**
58	19,087	14.8%	2,826	90.0%	14,958	7,479	987	1,316	$295,034	$129,678	$127,250	$502,700	**$1,054,662**
59	19,019	14.8%	2,816	90.0%	14,904	7,452	983	1,311	$293,964	$129,213	$126,794	$500,878	**$1,050,850**
60	18,944	42.6%	8,069	88.4%	14,549	6,257	3,156	4,208	$328,043	$414,763	$407,000	$558,944	**$1,708,751**
61	18,863	42.6%	8,035	88.4%	9,450	4,725	3,142	4,190	$274,172	$412,986	$405,255	$467,155	**$1,559,569**
62	18,774	42.6%	7,997	88.4%	9,402	4,701	3,128	4,170	$272,833	$411,046	$403,352	$464,873	**$1,552,103**
63	18,678	42.6%	7,956	88.4%	9,351	4,675	3,111	4,149	$271,369	$408,926	$401,272	$462,378	**$1,543,945**
64	18,572	42.6%	7,910	88.4%	9,294	4,647	3,094	4,125	$269,764	$406,606	$398,995	$459,643	**$1,535,008**
65	18,456	42.6%	7,861	91.2%	9,752	4,876	3,074	4,099	$277,072	$404,066	$396,503	$472,096	**$1,549,738**
66	18,329	42.6%	7,807	91.2%	9,681	4,840	3,053	4,071	$275,092	$401,290	$393,779	$468,721	**$1,538,882**
67	18,190	42.6%	7,748	91.2%	9,602	4,801	3,030	4,040	$272,914	$398,242	$390,788	$465,010	**$1,526,954**
68	18,037	42.6%	7,683	91.2%	9,516	4,758	3,005	4,006	$270,531	$394,906	$387,514	$460,951	**$1,513,902**
69	17,870	42.6%	7,612	91.2%	9,422	4,711	2,977	3,969	$267,916	$391,245	$383,922	$456,495	**$1,499,577**
70	17,687	61.6%	10,899	91.7%	9,393	7,667	4,395	5,860	$420,372	$577,627	$566,815	$716,262	**$2,281,076**
71	17,486	61.6%	10,775	91.7%	6,481	3,240	4,345	5,793	$264,354	$571,056	$560,367	$450,426	**$1,846,203**
72	17,265	61.6%	10,639	91.7%	6,387	3,194	4,290	5,720	$260,813	$563,851	$553,297	$444,392	**$1,822,353**
73	17,023	61.6%	10,490	91.7%	6,285	3,142	4,230	5,640	$256,926	$555,948	$545,542	$437,770	**$1,796,187**
74	16,758	61.6%	10,327	91.7%	6,172	3,086	4,164	5,552	$252,665	$547,280	$537,037	$430,510	**$1,767,492**
75	16,467	61.6%	10,148	95.0%	6,589	3,295	4,092	5,456	$257,424	$537,783	$527,717	$438,617	**$1,761,541**
76	16,148	61.6%	9,951	95.0%	6,444	3,222	4,013	5,350	$252,123	$527,372	$517,501	$429,587	**$1,726,582**
77	15,799	61.6%	9,736	95.0%	6,284	3,142	3,926	5,235	$246,326	$515,974	$506,316	$419,708	**$1,688,323**
78	15,418	61.6%	9,501	95.0%	6,111	3,055	3,831	5,108	$239,995	$503,518	$494,093	$408,921	**$1,646,527**
79	15,001	61.6%	9,244	95.0%	5,921	2,961	3,728	4,970	$233,082	$489,912	$480,742	$397,142	**$1,600,879**
80	14,547	61.6%	8,965	93.2%	5,454	2,727	3,615	4,820	$221,020	$475,085	$466,193	$376,591	**$1,538,889**
81	14,053	61.6%	8,660	93.2%	5,239	2,620	3,492	4,656	$212,998	$458,958	$450,368	$362,922	**$1,485,247**
82	13,517	61.6%	8,330	93.2%	5,007	2,503	3,359	4,479	$204,305	$441,460	$433,197	$348,110	**$1,427,072**
83	12,938	61.6%	7,973	93.2%	4,757	2,378	3,215	4,287	$194,927	$422,544	$414,635	$332,131	**$1,364,237**
84	12,314	61.6%	7,589	93.2%	4,488	2,244	3,060	4,080	$184,847	$402,172	$394,644	$314,955	**$1,296,617**
Total	***1,241,983***	***23.7%***	***294,437***		***780,118***	***394,502***	***113,176***	***150,902***	**$17,692,585**	**$14,874,392**	**$14,595,978**	**$30,145,930**	**$77,308,884**

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	Costs Total
18	19,871	4.4%	869	46.7%	8,912	5,041	193	257	$182,374	$25,309	$28,587	$310,742	**$547,012**
19	19,862	4.4%	868	46.7%	8,741	4,370	192	257	$159,011	$25,298	$28,574	$270,935	**$483,818**
20	19,850	4.4%	868	54.2%	10,213	5,106	192	256	$184,665	$25,283	$28,557	$314,646	**$553,150**
21	19,837	4.4%	867	54.2%	10,206	5,103	192	256	$184,537	$25,265	$28,537	$314,428	**$552,769**
22	19,821	4.4%	866	54.2%	10,198	5,099	192	256	$184,391	$25,246	$28,515	$314,180	**$552,331**
23	19,805	4.4%	866	54.2%	10,189	5,095	192	256	$184,236	$25,224	$28,491	$313,916	**$551,868**
24	19,788	4.4%	865	54.2%	10,181	5,090	192	256	$184,080	$25,203	$28,467	$313,649	**$551,399**
25	19,772	4.4%	864	59.2%	11,175	5,587	192	255	$201,398	$25,182	$28,444	$343,156	**$598,180**
26	19,756	4.4%	864	59.2%	11,166	5,583	191	255	$201,243	$25,163	$28,422	$342,893	**$597,721**
27	19,742	4.4%	863	59.2%	11,158	5,579	191	255	$201,095	$25,144	$28,401	$342,640	**$597,280**
28	19,727	4.4%	862	59.2%	11,150	5,575	191	255	$200,946	$25,126	$28,380	$342,387	**$596,838**
29	19,713	4.4%	862	59.2%	11,142	5,571	191	255	$200,799	$25,108	$28,359	$342,137	**$596,403**
30	19,698	4.4%	861	62.6%	11,802	5,901	191	255	$212,310	$25,089	$28,338	$361,750	**$627,486**
31	19,683	4.4%	860	62.6%	11,793	5,897	191	254	$212,144	$25,069	$28,316	$361,466	**$626,995**
32	19,666	4.4%	860	62.6%	11,783	5,892	191	254	$211,969	$25,048	$28,292	$361,168	**$626,478**
33	19,649	4.4%	859	62.6%	11,773	5,887	190	254	$211,785	$25,027	$28,268	$360,855	**$625,935**
34	19,631	4.4%	858	62.6%	11,762	5,881	190	254	$211,591	$25,004	$28,242	$360,524	**$625,360**
35	19,612	4.4%	857	67.4%	12,695	6,348	190	253	$227,842	$24,980	$28,215	$388,215	**$669,251**
36	19,592	4.4%	856	67.4%	12,682	6,341	190	253	$227,607	$24,954	$28,186	$387,814	**$668,561**
37	19,571	4.4%	856	67.4%	12,668	6,334	190	253	$227,358	$24,927	$28,155	$387,389	**$667,829**
38	19,548	4.4%	855	67.4%	12,654	6,327	189	253	$227,095	$24,898	$28,122	$386,941	**$667,056**
39	19,524	4.4%	854	67.4%	12,638	6,319	189	252	$226,815	$24,867	$28,088	$386,465	**$666,235**
40	19,499	18.4%	3,593	77.2%	14,524	9,857	1,182	1,576	$384,717	$155,368	$175,489	$655,509	**$1,371,083**
41	19,471	18.4%	3,588	77.2%	12,121	6,060	1,181	1,574	$252,344	$155,152	$175,244	$429,963	**$1,012,703**
42	19,442	18.4%	3,582	77.2%	12,102	6,051	1,179	1,572	$251,961	$154,919	$174,981	$429,309	**$1,011,170**
43	19,411	18.4%	3,577	77.2%	12,083	6,041	1,177	1,569	$251,554	$154,672	$174,702	$428,616	**$1,009,545**
44	19,378	18.4%	3,571	77.2%	12,061	6,031	1,175	1,566	$251,115	$154,406	$174,402	$427,868	**$1,007,791**
45	19,342	18.4%	3,564	77.3%	12,051	6,026	1,173	1,564	$250,863	$154,122	$174,081	$427,439	**$1,006,506**
46	19,304	18.4%	3,557	77.3%	12,027	6,014	1,170	1,560	$250,358	$153,816	$173,736	$426,578	**$1,004,487**
47	19,263	18.4%	3,549	77.3%	12,001	6,001	1,168	1,557	$249,819	$153,490	$173,367	$425,660	**$1,002,335**
48	19,218	18.4%	3,541	77.3%	11,973	5,986	1,165	1,554	$249,234	$153,136	$172,967	$424,663	**$1,000,000**
49	19,171	18.4%	3,532	77.3%	11,943	5,971	1,162	1,550	$248,608	$152,756	$172,539	$423,597	**$997,500**
50	19,119	18.4%	3,523	81.3%	12,679	6,339	1,159	1,546	$261,325	$152,345	$172,074	$445,265	**$1,031,010**
51	19,064	18.4%	3,513	81.3%	12,641	6,321	1,156	1,541	$260,554	$151,902	$171,574	$443,952	**$1,027,982**
52	19,003	18.4%	3,502	81.3%	12,601	6,300	1,152	1,536	$259,719	$151,423	$171,032	$442,529	**$1,024,702**
53	18,938	18.4%	3,490	81.3%	12,557	6,278	1,148	1,531	$258,818	$150,905	$170,447	$440,993	**$1,021,162**
54	18,868	18.4%	3,477	81.3%	12,509	6,255	1,144	1,525	$257,841	$150,344	$169,813	$439,328	**$1,017,327**
55	18,792	18.4%	3,463	82.5%	12,689	6,345	1,139	1,519	$260,818	$149,735	$169,126	$444,401	**$1,024,080**
56	18,709	18.4%	3,447	82.5%	12,633	6,316	1,134	1,512	$259,651	$149,075	$168,381	$442,413	**$1,019,520**
57	18,619	18.4%	3,431	82.5%	12,571	6,285	1,129	1,505	$258,386	$148,360	$167,572	$440,257	**$1,014,575**
58	18,522	18.4%	3,413	82.5%	12,504	6,252	1,123	1,497	$257,013	$147,584	$166,696	$437,918	**$1,009,210**
59	18,416	18.4%	3,393	82.5%	12,431	6,216	1,117	1,489	$255,522	$146,740	$165,744	$435,377	**$1,003,383**
60	18,301	43.3%	7,918	89.9%	13,706	11,456	3,185	4,247	$510,264	$418,644	$472,859	$869,425	**$2,271,192**
61	18,176	43.3%	7,864	89.9%	9,367	4,684	3,164	4,218	$273,476	$415,789	$469,634	$465,969	**$1,624,869**
62	18,041	43.3%	7,805	89.9%	9,293	4,647	3,140	4,187	$271,363	$412,691	$466,136	$462,368	**$1,612,558**
63	17,893	43.3%	7,741	89.9%	9,212	4,606	3,114	4,153	$269,059	$409,320	$462,327	$458,442	**$1,599,147**
64	17,733	43.3%	7,672	89.9%	9,124	4,562	3,087	4,115	$266,556	$405,655	$458,188	$454,178	**$1,584,576**
65	17,559	43.3%	7,597	92.7%	9,514	4,757	3,056	4,075	$272,292	$401,675	$453,692	$463,951	**$1,591,610**
66	17,370	43.3%	7,515	92.7%	9,405	4,702	3,023	4,031	$269,240	$397,342	$448,799	$458,751	**$1,574,132**
67	17,164	43.3%	7,426	92.7%	9,286	4,643	2,987	3,983	$265,926	$392,634	$443,481	$453,105	**$1,555,147**
68	16,940	43.3%	7,329	92.7%	9,157	4,579	2,949	3,931	$262,326	$387,519	$437,704	$446,970	**$1,534,520**
69	16,697	43.3%	7,224	92.7%	9,017	4,509	2,906	3,875	$258,413	$381,961	$431,425	$440,303	**$1,512,102**
70	16,434	63.9%	10,505	95.8%	9,380	8,259	4,470	5,960	$443,602	$587,517	$663,601	$755,841	**$2,450,561**
71	16,147	63.9%	10,322	95.8%	5,837	2,918	4,392	5,857	$254,776	$577,278	$652,036	$434,106	**$1,918,196**
72	15,837	63.9%	10,124	95.8%	5,707	2,853	4,308	5,744	$249,572	$566,174	$639,494	$425,239	**$1,880,478**
73	15,500	63.9%	9,909	95.8%	5,567	2,783	4,216	5,622	$243,939	$554,147	$625,910	$415,642	**$1,839,638**
74	15,136	63.9%	9,676	95.8%	5,415	2,707	4,117	5,490	$237,843	$541,126	$611,203	$405,255	**$1,795,427**
75	14,743	63.9%	9,424	93.2%	4,872	2,436	4,010	5,347	$224,647	$527,062	$595,318	$382,769	**$1,729,795**
76	14,318	63.9%	9,153	93.2%	4,706	2,353	3,895	5,193	$217,742	$511,882	$578,172	$371,005	**$1,678,801**
77	13,861	63.9%	8,861	93.2%	4,529	2,265	3,770	5,027	$210,323	$495,544	$559,718	$358,364	**$1,623,948**
78	13,370	63.9%	8,547	93.2%	4,340	2,170	3,637	4,849	$202,365	$477,997	$539,899	$344,804	**$1,565,066**
79	12,844	63.9%	8,211	93.2%	4,137	2,069	3,494	4,659	$193,852	$459,200	$518,667	$330,300	**$1,502,018**
80	12,283	63.9%	7,852	92.9%	3,879	1,940	3,341	4,455	$184,039	$439,129	$495,997	$313,578	**$1,432,743**
81	11,686	63.9%	7,470	92.9%	3,654	1,827	3,179	4,238	$174,446	$417,779	$471,882	$297,234	**$1,361,340**
82	11,053	63.9%	7,066	92.9%	3,416	1,708	3,007	4,009	$164,311	$395,162	$446,337	$279,965	**$1,285,775**
83	10,386	63.9%	6,640	92.9%	3,168	1,584	2,825	3,767	$153,659	$371,324	$419,411	$261,816	**$1,206,210**
84	9,688	63.9%	6,193	92.9%	2,909	1,455	2,635	3,514	$142,536	$346,341	$391,193	$242,863	**$1,122,933**
Total	***1,194,429***	***24.7%***	***295,309***		***663,981***	***343,342***	***113,246***	***150,995***	**$15,912,079**	**$14,883,554**	**$16,811,002**	**$27,112,174**	**$74,718,810**

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.[508]
- Bress and co-authors calculated the cost per serious adverse event (SAE) to be as follows:[509]
  - Hypotension - $7,314 in 2017 USD ($6,304 in 2017 CAD)
  - Syncope - $6,697 in 2017 USD ($5,772 in 2017 CAD)
  - Electrolyte abnormality - $7,142 in 2017 USD ($6,156 in 2017 CAD)
  - Acute kidney injury - $10,041 in 2017 USD ($8,655 in 2017 CAD)

  If one of the above SAE occurs, the probability of that occurrence is 20.4% / 24.8% / 28.4% / 26.4%, respectively.[510] The weighted cost per SAE would therefore be $6,750 in 2017 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.[511] We converted this to $6,281 in 2017 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.[512]
- For modelling purposes, we took the difference for the cost of treating syncope in the Bress study ($5,772) and the Tran study ($4,481), or -$1,291 (-22.4%) and reduced the weighted cost per SAE from the Bress study ($6,750) by this 22.4% ($5,240). 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 $13.3 million in females and males (see Table 25).

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[509] 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.
[510] Ibid.
[511] Richman I, Fairley M, Jorgensen M et al. Cost-effectiveness of intensive blood pressure management. *JAMA Cardiology*. 2016; 8: 872-9.
[512] Tran D, Sheldon R, Kaul P et al. The current and future hospitalization cost burden of syncope in Canada. *Canadian Journal of Cardiology Open*. 2020; 2(4): 222-8.

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	$20,889	$3,551	$24,440	3.7	$19,374	$3,293	$22,668
19	4.0	$20,882	$3,550	$24,432	3.7	$19,365	$3,292	$22,657
20	4.0	$20,876	$3,548	$24,424	3.7	$19,354	$3,290	$22,644
21	4.0	$20,869	$3,547	$24,416	3.7	$19,341	$3,288	$22,628
22	4.0	$20,862	$3,546	$24,408	3.7	$19,326	$3,285	$22,611
23	4.0	$20,855	$3,545	$24,400	3.7	$19,310	$3,282	$22,592
24	4.0	$20,848	$3,544	$24,392	3.7	$19,293	$3,279	$22,573
25	4.0	$20,841	$3,543	$24,384	3.7	$19,277	$3,277	$22,554
26	4.0	$20,835	$3,541	$24,376	3.7	$19,263	$3,274	$22,537
27	4.0	$20,828	$3,540	$24,369	3.7	$19,248	$3,272	$22,520
28	4.0	$20,821	$3,539	$24,360	3.7	$19,234	$3,269	$22,503
29	4.0	$20,814	$3,538	$24,352	3.7	$19,220	$3,267	$22,487
30	4.0	$20,807	$3,537	$24,344	3.7	$19,206	$3,265	$22,470
31	4.0	$20,799	$3,535	$24,334	3.7	$19,191	$3,262	$22,453
32	4.0	$20,790	$3,534	$24,324	3.7	$19,175	$3,259	$22,434
33	4.0	$20,781	$3,532	$24,313	3.7	$19,158	$3,256	$22,415
34	4.0	$20,771	$3,531	$24,301	3.7	$19,141	$3,253	$22,394
35	4.0	$20,760	$3,529	$24,289	3.6	$19,122	$3,250	$22,372
36	4.0	$20,748	$3,527	$24,275	3.6	$19,102	$3,247	$22,349
37	4.0	$20,736	$3,525	$24,260	3.6	$19,082	$3,243	$22,325
38	4.0	$20,722	$3,522	$24,244	3.6	$19,060	$3,240	$22,299
39	4.0	$20,707	$3,520	$24,227	3.6	$19,036	$3,236	$22,272
40	19.6	$102,486	$17,420	$119,907	22.7	$118,936	$20,216	$139,152
41	19.5	$102,401	$17,406	$119,807	22.7	$118,770	$20,188	$138,958
42	19.5	$102,310	$17,390	$119,700	22.6	$118,592	$20,158	$138,749
43	19.5	$102,211	$17,373	$119,584	22.6	$118,402	$20,126	$138,528
44	19.5	$102,105	$17,355	$119,460	22.6	$118,199	$20,091	$138,290
45	19.5	$101,989	$17,336	$119,325	22.5	$117,982	$20,054	$138,036
46	19.4	$101,864	$17,315	$119,179	22.5	$117,747	$20,014	$137,762
47	19.4	$101,729	$17,292	$119,021	22.4	$117,497	$19,972	$137,469
48	19.4	$101,584	$17,267	$118,850	22.4	$117,226	$19,926	$137,152
49	19.4	$101,427	$17,240	$118,667	22.3	$116,936	$19,876	$136,813
50	19.3	$101,256	$17,211	$118,467	22.3	$116,621	$19,823	$136,444
51	19.3	$101,072	$17,180	$118,252	22.2	$116,282	$19,765	$136,048
52	19.3	$100,873	$17,146	$118,019	22.1	$115,915	$19,703	$135,618
53	19.2	$100,657	$17,109	$117,766	22.0	$115,519	$19,636	$135,154
54	19.2	$100,424	$17,070	$117,494	22.0	$115,089	$19,563	$134,652
55	19.1	$100,170	$17,027	$117,197	21.9	$114,623	$19,483	$134,106
56	19.1	$99,894	$16,980	$116,874	21.8	$114,118	$19,397	$133,515
57	19.0	$99,595	$16,929	$116,524	21.7	$113,570	$19,304	$132,875
58	18.9	$99,269	$16,873	$116,143	21.6	$112,976	$19,203	$132,180
59	18.9	$98,913	$16,813	$115,726	21.4	$112,331	$19,094	$131,424
60	60.6	$317,504	$53,968	$371,473	61.2	$320,475	$54,473	$374,948
61	60.3	$316,143	$53,737	$369,880	60.7	$318,289	$54,102	$372,391
62	60.0	$314,658	$53,485	$368,143	60.3	$315,918	$53,699	$369,617
63	59.7	$313,036	$53,209	$366,245	59.8	$313,337	$53,260	$366,597
64	59.4	$311,259	$52,907	$364,166	59.3	$310,532	$52,783	$363,315
65	59.0	$309,315	$52,576	$361,892	58.7	$307,485	$52,265	$359,750
66	58.6	$307,190	$52,215	$359,405	58.0	$304,168	$51,702	$355,870
67	58.2	$304,857	$51,819	$356,676	57.4	$300,564	$51,089	$351,653
68	57.7	$302,303	$51,385	$353,687	56.6	$296,649	$50,423	$347,072
69	57.2	$299,501	$50,908	$350,409	55.8	$292,393	$49,700	$342,094
70	84.4	$442,177	$75,160	$517,337	85.8	$449,748	$76,447	$526,195
71	83.4	$437,147	$74,305	$511,452	84.3	$441,910	$75,115	$517,025
72	82.4	$431,632	$73,368	$505,000	82.7	$433,410	$73,670	$507,079
73	81.2	$425,582	$72,339	$497,921	81.0	$424,203	$72,105	$496,308
74	80.0	$418,947	$71,211	$490,158	79.1	$414,236	$70,411	$484,647
75	78.6	$411,677	$69,976	$481,652	77.0	$403,470	$68,581	$472,050
76	77.0	$403,707	$68,621	$472,327	74.8	$391,849	$66,605	$458,455
77	75.4	$394,981	$67,138	$462,119	72.4	$379,342	$64,479	$443,822
78	73.6	$385,446	$65,517	$450,963	69.8	$365,910	$62,196	$428,107
79	71.6	$375,031	$63,747	$438,778	67.1	$351,520	$59,750	$411,271
80	69.4	$363,681	$61,817	$425,498	64.2	$336,156	$57,139	$393,295
81	67.0	$351,336	$59,719	$411,055	61.0	$319,812	$54,361	$374,173
82	64.5	$337,941	$57,442	$395,383	57.7	$302,500	$51,418	$353,918
83	61.7	$323,460	$54,981	$378,441	54.2	$284,251	$48,316	$332,567
84	58.8	$307,865	$52,330	$360,195	50.6	$265,126	$45,065	$310,192
	2,173	**$11,386,447**	**$1,935,435**	**$13,321,882**	**2,174**	**$11,393,461**	**$1,936,627**	**$13,330,089**

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).[513] We converted this to $11,859 in 2017 CAD.
- Goeree et al estimated the *first year costs* associated with a stroke in Canada by age as follows:[514]
    - <55 years of age - $15,926 in 2004 CAD, converted to $20,170 in 2017 CAD
    - 55-64 - $12,955 ($16,407)
    - 65-74 - $24,593 ($31,147)
    - 75-84 - $28,608 ($36,232)
    - ≥85 - $29,210 ($36,997)
- 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.[515] Based on a mix of 85% ischemic strokes in Canada,[516] the weighted cost would be $8,335. We converted this to $7,562 in 2017 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).[517] We converted this to $8,493 in 2017 CAD.
- Cohen and colleagues estimated the *first year costs* associated with an MI in Ontario to be $20,794 (in 2008 CAD).[518] We converted this to $23,183 in 2017 CAD.
- Cohen and colleagues estimated the *ongoing annual costs* following a myocardial infarct to be $1,325 (in 2008 CAD).[519] We converted this to $1,477 in 2017 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 $99.2 million in females (see Tables 26) and $77.6 million in males (see Table 27).

[513] 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.
[514] Ibid.
[515] 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.
[516] Krueger H, Lindsay P, Cote R et al. Cost avoidance associated with optimal stroke care in Canada. *Stroke*. 2012; 43(8): 2198-206.
[517] Anis A, Sun H, Singh S et al. A cost-utility analysis of losartan versus atenolol in the treatment of hypertension with left ventricular hypertrophy. *Pharmacoeconomics*. 2006; 24: 387-400.
[518] 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.
[519] Ibid.

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	$661		1.9	1.9	$37,799		121	121	$916,883	$955,343
20		0.1	0.1	$661		1.9	1.9	$37,787		119	119	$902,421	$940,869
21		0.1	0.1	$661		1.9	1.9	$37,774		117	117	$887,959	$926,394
22		0.1	0.1	$661		1.9	1.9	$37,762		116	116	$873,507	$911,929
23		0.1	0.1	$661		1.9	1.9	$37,749		114	114	$859,072	$897,482
24		0.1	0.1	$660		1.9	1.9	$37,737		112	112	$846,054	$884,451
25		0.1	0.1	$660		1.9	1.9	$37,725		110	110	$831,637	$870,022
26		0.1	0.1	$660		1.9	1.9	$37,713		108	108	$817,238	$855,611
27		0.1	0.1	$660		1.9	1.9	$37,701		106	106	$802,840	$841,201
28		0.1	0.1	$660		1.9	1.9	$37,688		104	104	$788,443	$826,791
29		0.1	0.1	$659		1.9	1.9	$37,675		103	103	$775,460	$813,795
30		0.1	0.1	$659		1.9	1.9	$37,662		101	101	$761,066	$799,387
31		0.1	0.1	$659		1.9	1.9	$37,648		99	99	$746,660	$784,966
32		0.1	0.1	$659		1.9	1.9	$37,632		97	97	$732,235	$770,525
33		0.1	0.1	$658		1.9	1.9	$37,615		95	95	$717,807	$756,080
34		0.1	0.1	$658		1.9	1.9	$37,597		93	93	$704,773	$743,027
35		0.1	0.1	$658		1.9	1.9	$37,577		91	91	$690,321	$728,556
36		0.1	0.1	$657		1.9	1.9	$37,556		89	89	$675,850	$714,063
37		0.1	0.1	$657		1.9	1.9	$37,533		88	88	$662,775	$700,965
38		0.1	0.1	$656		1.9	1.9	$37,508		86	86	$648,277	$686,441
39		0.1	0.1	$656		1.9	1.9	$37,482		84	84	$633,764	$671,902
40		0.1	0.1	$713		2.0	2.0	$40,749		89	89	$673,726	$715,187
41		0.1	0.1	$712		2.0	2.0	$40,715		87	87	$659,427	$700,854
42		0.1	0.1	$712		2.0	2.0	$40,678		85	85	$643,587	$684,977
43		0.1	0.1	$711		2.0	2.0	$40,639		83	83	$629,253	$670,604
44		0.1	0.1	$710		2.0	2.0	$40,597		81	81	$613,379	$654,686
45		0.3	0.3	$3,960		11.2	11.2	$226,308		442	442	$3,342,932	$3,573,200
46		0.3	0.3	$3,955		11.2	11.2	$226,031		430	430	$3,254,098	$3,484,085
47		0.3	0.3	$3,950		11.2	11.2	$225,731		420	420	$3,173,612	$3,403,293
48		0.3	0.3	$3,944		11.2	11.2	$225,408		408	408	$3,084,560	$3,313,912
49		0.3	0.3	$3,938		11.2	11.2	$225,060		397	397	$3,003,851	$3,232,848
50		0.6	0.6	$6,651		10.9	10.9	$220,056		271	271	$2,050,703	$2,277,410
51		0.6	0.6	$6,638		10.9	10.9	$219,656		264	264	$1,993,143	$2,219,438
52		0.6	0.6	$6,625		10.9	10.9	$219,224		256	256	$1,935,500	$2,161,350
53		0.6	0.6	$6,611		10.8	10.8	$218,755		248	248	$1,871,785	$2,097,150
54		0.6	0.6	$6,596		10.8	10.8	$218,248		240	240	$1,813,966	$2,038,809
55		0.6	0.6	$7,651		10.7	10.7	$175,599		230	230	$1,741,317	$1,924,567
56		0.6	0.6	$7,630		10.7	10.7	$175,115		223	223	$1,683,767	$1,866,513
57		0.6	0.6	$7,607		10.6	10.6	$174,590		215	215	$1,626,117	$1,808,315
58		0.6	0.6	$7,583		10.6	10.6	$174,020		207	207	$1,568,373	$1,749,975
59		0.6	0.6	$7,555		10.6	10.6	$173,396		200	200	$1,510,512	$1,691,464
60	1.3	2.2	3.5	$36,689	14.8	13.6	28.4	$565,861	377	241	618	$2,377,718	$2,980,268
61	1.3	2.1	3.5	$36,531	14.7	13.5	28.3	$563,436	362	231	593	$2,282,906	$2,882,873
62	1.3	2.1	3.4	$36,360	14.7	13.5	28.1	$560,789	347	221	569	$2,187,959	$2,785,109
63	1.3	2.1	3.4	$36,172	14.6	13.4	28.0	$557,898	332	212	544	$2,092,889	$2,686,960
64	1.3	2.1	3.4	$35,967	14.5	13.3	27.8	$554,732	318	202	520	$1,997,698	$2,588,397
65	1.8	3.0	4.8	$50,777	13.7	12.6	26.2	$708,073	149	183	333	$1,607,813	$2,366,663
66	1.8	3.0	4.8	$50,429	13.6	12.5	26.0	$703,207	142	174	316	$1,527,079	$2,280,714
67	1.8	2.9	4.7	$50,046	13.5	12.4	25.8	$697,865	135	166	301	$1,454,007	$2,201,918
68	1.8	2.9	4.7	$49,628	13.4	12.3	25.6	$692,016	128	158	285	$1,380,865	$2,122,509
69	1.8	2.9	4.6	$49,168	13.2	12.2	25.4	$685,600	120	148	269	$1,300,122	$2,034,891
70	2.3	3.8	6.2	$65,445	10.7	9.8	20.4	$551,860	91	112	203	$983,939	$1,601,245
71	2.3	3.8	6.1	$64,701	10.5	9.7	20.2	$545,582	85	106	191	$925,304	$1,535,586
72	2.3	3.7	6.0	$63,885	10.4	9.6	20.0	$538,697	80	99	179	$866,786	$1,469,369
73	2.3	3.7	6.0	$62,990	10.3	9.4	19.7	$531,146	75	93	168	$814,223	$1,408,359
74	2.2	3.6	5.9	$62,008	10.1	9.3	19.4	$522,864	69	86	156	$756,062	$1,340,935
75	2.8	4.7	7.5	$79,424	9.0	8.3	17.3	$508,704	57	73	130	$637,539	$1,225,667
76	2.8	4.6	7.4	$77,891	8.8	8.1	16.9	$498,842	52	67	120	$585,485	$1,162,218
77	2.7	4.5	7.2	$76,212	8.6	7.9	16.6	$488,048	48	62	110	$538,836	$1,103,096
78	2.7	4.4	7.0	$74,377	8.4	7.7	16.2	$476,255	44	57	100	$492,656	$1,043,287
79	2.6	4.2	6.8	$72,370	8.2	7.5	15.7	$463,376	40	51	91	$447,071	$982,817
80	2.5	4.1	6.6	$70,183	8.0	7.3	15.3	$449,344	35	47	82	$406,930	$926,456
81	2.4	4.0	6.4	$67,803	7.7	7.1	14.7	$434,084	31	42	73	$362,874	$864,761
82	2.3	3.8	6.2	$65,220	7.4	6.8	14.2	$417,529	27	38	65	$324,105	$806,854
83	2.2	3.7	5.9	$62,427	7.1	6.5	13.6	$399,635	24	33	57	$286,355	$748,416
84	2.1	3.5	5.6	$59,418	6.7	6.2	12.9	$380,365	21	29	50	$249,837	$689,619
	52	**95**	**147**	**$1,564,416**	**272**	**463**	**736**	**$17,587,301**	**3,188**	**9,961**	**13,150**	**$80,035,708**	**$99,187,425**

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	$1,248		1.2	1.2	$23,487		71	71	$534,503	$559,238
20		0.1	0.1	$1,247		1.2	1.2	$23,473		70	70	$526,270	$550,990
21		0.1	0.1	$1,246		1.2	1.2	$23,457		68	68	$517,115	$541,819
22		0.1	0.1	$1,245		1.2	1.2	$23,439		67	67	$508,799	$533,484
23		0.1	0.1	$1,244		1.2	1.2	$23,419		66	66	$499,593	$524,257
24		0.1	0.1	$1,243		1.2	1.2	$23,399		65	65	$491,274	$515,916
25		0.1	0.1	$1,242		1.2	1.2	$23,380		64	64	$482,106	$506,728
26		0.1	0.1	$1,241		1.2	1.2	$23,362		63	63	$473,853	$498,456
27		0.1	0.1	$1,240		1.2	1.2	$23,345		61	61	$464,750	$489,335
28		0.1	0.1	$1,239		1.2	1.2	$23,328		60	60	$455,660	$480,227
29		0.1	0.1	$1,238		1.2	1.2	$23,311		59	59	$447,462	$472,011
30		0.1	0.1	$1,237		1.2	1.2	$23,293		58	58	$438,393	$462,924
31		0.1	0.1	$1,237		1.2	1.2	$23,275		57	57	$429,325	$453,836
32		0.1	0.1	$1,235		1.2	1.2	$23,256		56	56	$421,124	$445,615
33		0.1	0.1	$1,234		1.2	1.2	$23,236		54	54	$412,049	$436,519
34		0.1	0.1	$1,233		1.2	1.2	$23,214		53	53	$403,838	$428,286
35		0.1	0.1	$1,232		1.1	1.1	$23,192		52	52	$394,752	$419,176
36		0.1	0.1	$1,231		1.1	1.1	$23,168		51	51	$386,528	$410,927
37		0.1	0.1	$1,229		1.1	1.1	$23,143		50	50	$377,430	$401,802
38		0.1	0.1	$1,228		1.1	1.1	$23,116		49	49	$369,194	$393,538
39		0.1	0.1	$1,227		1.1	1.1	$23,088		48	48	$360,085	$384,399
40		0.1	0.1	$1,515		1.4	1.4	$28,525		58	58	$435,265	$465,305
41		0.1	0.1	$1,513		1.4	1.4	$28,485		56	56	$423,978	$453,977
42		0.1	0.1	$1,511		1.4	1.4	$28,443		55	55	$413,745	$443,699
43		0.1	0.1	$1,509		1.4	1.4	$28,397		53	53	$403,503	$433,409
44		0.1	0.1	$1,506		1.4	1.4	$28,348		52	52	$392,181	$422,035
45		0.9	0.9	$10,107		9.4	9.4	$190,238		340	340	$2,567,616	$2,767,960
46		0.9	0.9	$10,086		9.4	9.4	$189,860		330	330	$2,498,455	$2,698,402
47		0.8	0.8	$10,065		9.4	9.4	$189,457		320	320	$2,422,119	$2,621,641
48		0.8	0.8	$10,042		9.4	9.4	$189,020		311	311	$2,352,756	$2,551,818
49		0.8	0.8	$10,017		9.3	9.3	$188,552		302	302	$2,283,308	$2,481,877
50		1.0	1.0	$12,055		9.1	9.1	$184,533		202	202	$1,530,393	$1,726,980
51		1.0	1.0	$12,019		9.1	9.1	$183,997		196	196	$1,481,639	$1,677,655
52		1.0	1.0	$11,982		9.1	9.1	$183,415		189	189	$1,432,796	$1,628,193
53		1.0	1.0	$11,941		9.1	9.1	$182,788		183	183	$1,383,882	$1,578,611
54		1.0	1.0	$11,896		9.0	9.0	$182,109		177	177	$1,334,889	$1,528,894
55		1.1	1.1	$12,589		8.9	8.9	$146,509		169	169	$1,276,882	$1,435,980
56		1.1	1.1	$12,532		8.9	8.9	$145,865		162	162	$1,228,088	$1,386,485
57		1.1	1.1	$12,472		8.8	8.8	$145,164		157	157	$1,183,998	$1,341,634
58		1.0	1.0	$12,407		8.8	8.8	$144,405		150	150	$1,135,058	$1,291,870
59		1.0	1.0	$12,336		8.8	8.8	$143,580		144	144	$1,086,073	$1,241,989
60	1.8	3.0	4.8	$51,144	14.9	13.6	28.5	$568,186	336	212	547	$2,096,659	$2,715,989
61	1.8	3.0	4.8	$50,795	14.7	13.6	28.3	$564,311	320	202	522	$1,998,208	$2,613,314
62	1.8	3.0	4.8	$50,417	14.6	13.5	28.1	$560,107	306	193	499	$1,909,077	$2,519,601
63	1.8	2.9	4.7	$50,005	14.5	13.3	27.9	$555,530	292	184	476	$1,819,840	$2,425,376
64	1.8	2.9	4.7	$49,558	14.4	13.2	27.6	$550,556	278	175	452	$1,730,568	$2,330,681
65	2.7	4.5	7.2	$76,025	12.9	11.9	24.8	$669,388	166	150	316	$1,380,252	$2,125,666
66	2.7	4.4	7.1	$75,206	12.8	11.7	24.5	$662,168	157	142	299	$1,304,929	$2,042,302
67	2.7	4.4	7.0	$74,315	12.6	11.6	24.2	$654,321	148	134	282	$1,229,750	$1,958,386
68	2.6	4.3	6.9	$73,347	12.5	11.5	23.9	$645,797	139	126	264	$1,154,789	$1,873,933
69	2.6	4.2	6.8	$72,295	12.3	11.3	23.6	$636,533	131	118	249	$1,087,391	$1,796,219
70	4.0	6.6	10.6	$111,812	9.9	9.1	19.1	$514,990	95	94	190	$854,994	$1,481,796
71	3.9	6.4	10.4	$109,735	9.8	9.0	18.8	$506,343	89	88	177	$799,222	$1,415,300
72	3.9	6.3	10.2	$107,642	9.6	8.8	18.4	$496,556	83	82	165	$743,158	$1,347,356
73	3.8	6.2	10.0	$105,373	9.4	8.6	18.0	$485,964	76	76	152	$687,556	$1,278,893
74	3.7	6.0	9.7	$102,913	9.2	8.4	17.6	$474,505	70	70	140	$632,532	$1,209,950
75	3.9	6.4	10.3	$109,358	8.5	7.8	16.3	$478,497	57	61	117	$542,560	$1,130,414
76	3.8	6.2	10.0	$106,234	8.2	7.6	15.8	$464,643	52	56	107	$497,290	$1,068,167
77	3.7	6.0	9.7	$102,866	8.0	7.3	15.3	$449,751	47	50	97	$447,967	$1,000,583
78	3.6	5.8	9.4	$99,242	7.7	7.1	14.7	$433,774	42	45	87	$404,455	$937,471
79	3.4	5.6	9.0	$95,354	7.4	6.8	14.2	$416,675	38	41	78	$362,001	$874,030
80	3.3	5.3	8.6	$91,197	7.1	6.5	13.5	$398,432	29	36	65	$312,937	$802,566
81	3.1	5.1	8.2	$86,771	6.7	6.2	12.9	$379,039	26	31	57	$274,088	$739,898
82	2.9	4.8	7.8	$82,078	6.3	5.8	12.2	$358,506	22	27	50	$240,626	$681,210
83	2.8	4.5	7.3	$77,130	6.0	5.5	11.4	$336,870	19	24	43	$208,613	$622,613
84	2.6	4.2	6.8	$71,942	5.6	5.1	10.7	$314,201	16	20	37	$178,260	$564,404
	75	**140**	**214**	**$2,288,853**	**255**	**403**	**658**	**$15,796,714**	**3,032**	**7,284**	**10,316**	**$59,558,452**	**$77,644,019**

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 -$350 (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	$17.69	Table 23
b	Lab test costs (in millions) - Females	$14.87	Table 23
c	Medication costs (in millions) - Females	$14.60	Table 23
d	Patient time costs (in millions) - Females	$30.15	Table 23
e	Physician costs (in millions) - Males	$15.91	Table 24
f	Lab test costs (in millions) - Males	$14.88	Table 24
g	Medication costs (in millions) - Males	$16.81	Table 24
h	Patient time costs (in millions) - Males	$27.11	Table 24
i	**Total Screening Program Costs**	**$152.03**	Sum a...h
	Cost of Harms		
j	Treatment costs for SAE (in millions) - Females	$11.4	Table 25
k	Patient time costs for SAE (in millions) - Females	$1.9	Table 25
l	Treatment costs for SAE (in millions) - Males	$11.4	Table 25
m	Patient time costs for SAE (in millions) - Males	$1.9	Table 25
n	**Total Cost of Harms**	**$26.65**	Sum j...m
	Treatment Costs Avoided with a Screening Program		
o	Cost of treating new AMI and strokes avoided (in millions) - Females	$17.59	Table 26
p	Cost of treating those living with AMI or stroke avoided (in millions) - Females	$80.04	Table 26
q	Cost of treating those who die due to AMI or stroke avoided (in millions) - Females	$1.56	Table 26
r	Cost of treating new AMI and strokes avoided (in millions) - Males	$15.80	Table 26
s	Cost of treating those living with AMI or stroke avoided (in millions) - Males	$59.56	Table 26
t	Cost of treating those who die due to AMI or stroke avoided (in millions) - Males	$2.29	Table 26
p	**Total Treatment Costs Avoided**	**$176.83**	Sum o...t
	CE per QALY Gained		
q	Net cost of screening and treatment (in millions)	$1.85	= i + n - p
r	Total QALYs gained	15,995	Table 20
s	CE ($/QALY gained)	$116	q / r * 1,000,000
t	Net cost of screening and treatment (in millions, 1.5% discount)	-$3.01	Calculated
u	Total QALYs gained, 1.5% Discount	8,605	Calculated
v	**CE ($/QALY gained), 1.5% Discount**	-$350	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 = -$2,136
- 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 = $7,471
- The average disutility of living with a stroke is increased from 0.200 to 0.265. CE = -$317
- The average disutility of living with a stroke is decreased from 0.200 to 0.134. CE = -$391
- The disutility associated with taking preventive medication is increased from 0.0024 to 0.0033. CE = -$353
- The disutility associated with taking preventive medication is reduced from 0.0024 to 0.0. CE = -$341
- Assume that those visits to a physician's office requiring 0.5 of an office visit would instead take a full office visit. CE = $6,413
- Assume that the annual costs associated with care following a stroke are reduced by 25% from $7,562 to $5,672. CE = $2,050
- Assume that the annual costs associated with care following a stroke are increased by 25% from $7,562 to $9,453. CE = -$2,750

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 -$1,690 (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	$17.69	Table 23
b	Lab test costs (in millions) - Females	$14.87	Table 23
c	Medication costs (in millions) - Females	$14.60	Table 23
d	Patient time costs (in millions) - Females	$30.15	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**	**$77.31**	Sum a...h
	Cost of Harms		
j	Treatment costs for SAE (in millions) - Females	$11.4	Table 25
k	Patient time costs for SAE (in millions) - Females	$1.9	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**	**$13.32**	Sum j...m
	Treatment Costs Avoided with a Screening Program		
o	Cost of treating new AMI and strokes avoided (in millions) - Females	$17.59	Table 26
p	Cost of treating those living with AMI or stroke avoided (in millions) - Females	$80.04	Table 26
q	Cost of treating those who die due to AMI or stroke avoided (in millions) - Females	$1.56	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**	**$99.19**	Sum o...t
	CE per QALY Gained		
q	Net cost of screening and treatment (in millions)	-$8.56	= i + n - p
r	Total QALYs gained	8,457	Table 21
s	CE ($/QALY gained)	-$1,012	q / r * 1,000,000
t	Net cost of screening and treatment (in millions, 1.5% discount)	-$7.72	Calculated
u	Total QALYs gained, 1.5% Discount	4,569	Calculated
v	**CE ($/QALY gained), 1.5% Discount**	-$1,690	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 = -$3,351
- 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 = $5,899
- The average disutility of living with a stroke is increased from 0.200 to 0.265. CE = -$1,520
- The average disutility of living with a stroke is decreased from 0.200 to 0.134. CE = -$1,908
- The disutility associated with taking preventive medication is increased from 0.0024 to 0.0033. CE = -$1,707
- The disutility associated with taking preventive medication is reduced from 0.0024 to 0.0. CE = -$1,648
- Assume that those visits to a physician's office requiring 0.5 of an office visit would instead take a full office visit. CE = $5,064
- Assume that the annual costs associated with care following a stroke are reduced by 25% from $7,562 to $5,672. CE = $948
- Assume that the annual costs associated with care following a stroke are increased by 25% from $7,562 to $9,453. CE = -$4,329

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 $1,167 (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	$15.91	Table 24
f	Lab test costs (in millions) - Males	$14.88	Table 24
g	Medication costs (in millions) - Males	$16.81	Table 24
h	Patient time costs (in millions) - Males	$27.11	Table 24
i	**Total Screening Program Costs**	**$74.72**	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	$11.4	Table 25
m	Patient time costs for SAE (in millions) - Males	$1.9	Table 25
n	**Total Cost of Harms**	**$13.33**	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	$15.80	Table 26
s	Cost of treating those living with AMI or stroke avoided (in millions) - Males	$59.56	Table 26
t	Cost of treating those who die due to AMI or stroke avoided (in millions) - Males	$2.29	Table 26
p	**Total Treatment Costs Avoided**	**$77.64**	Sum o...t
	CE per QALY Gained		
q	Net cost of screening and treatment (in millions)	$10.40	= i + n - p
r	Total QALYs gained	7,538	Table 22
s	CE ($/QALY gained)	$1,380	q / r * 1,000,000
t	Net cost of screening and treatment (in millions, 1.5% discount)	$4.71	Calculated
u	Total QALYs gained, 1.5% Discount	4,036	Calculated
v	**CE ($/QALY gained), 1.5% Discount**	$1,167	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 = -$765
- 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 = $9,248
- The average disutility of living with a stroke is increased from 0.200 to 0.265. CE = $1,609
- The average disutility of living with a stroke is decreased from 0.200 to 0.134. CE = $1,288
- The disutility associated with taking preventive medication is increased from 0.0024 to 0.0033. CE = $1,180
- The disutility associated with taking preventive medication is reduced from 0.0024 to 0.0. CE = $1,134
- Assume that those visits to a physician's office requiring 0.5 of an office visit would instead take a full office visit. CE = $7,941
- Assume that the annual costs associated with care following a stroke are reduced by 25% from $7,562 to $5,672. CE = $3,298
- Assume that the annual costs associated with care following a stroke are increased by 25% from $7,562 to $9,453. CE = -$963

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 8,605 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be -$350 per QALY (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	**8,605**	**5,251**	**10,407**
3% Discount Rate	4,655	2,807	5,585
0% Discount Rate	15,995	9,851	19,473
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**-$350**	**-$2,136**	**$7,471**
3% Discount Rate	-$731	-$2,628	$8,273
0% Discount Rate	$116	-$1,629	$7,193
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	**-$5,849**	**-$6,683**	**-$1,541**
3% Discount Rate	-$7,210	-$8,029	-$2,471
0% Discount Rate	-$4,757	-$5,632	-$719

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 4,569 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be -$1,690 per QALY (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	**4,569**	**2,786**	**5,518**
3% Discount Rate	2,488	1,499	2,980
0% Discount Rate	8,457	5,207	10,283
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**-$1,690**	**-$3,351**	**$5,899**
3% Discount Rate	-$2,358	-$4,125	$6,407
0% Discount Rate	-$1,012	-$2,638	$5,834
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	**-$6,163**	**-$7,055**	**-$1,434**
3% Discount Rate	-$7,865	-$8,722	-$2,731
0% Discount Rate	-$4,805	-$5,758	-$327

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 4,036 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $1,167 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	**4,036**	**2,464**	**4,890**
3% Discount Rate	2,167	1,308	2,605
0% Discount Rate	7,538	4,644	9,190
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$1,167**	**-$765**	**$9,248**
3% Discount Rate	$1,136	-$916	$10,412
0% Discount Rate	$1,380	-$501	$8,716
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	**-$5,493**	**-$6,263**	**-$1,662**
3% Discount Rate	-$6,459	-$7,236	-$2,174
0% Discount Rate	-$4,703	-$5,491	-$1,159

Screening for Cardiovascular Disease Risk and Treatment with Statins

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.* [520]

The CTFPHC has not completed a recent update due to the review completed by the Canadian Cardiovascular Society (CCS) in 2016.[521] 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).* [522]

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[520] 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.
[521] Dr. Richard Birtwhistle, Member, Canadian Task Force on Preventive Health Care. Personal communication, January 25, 2017.
[522] 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 2010 to 2012, there are a total of 1,296,348 life years lived and 6,238 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	*Mean Survival Rate*	*Individuals in Birth Cohort*	*Life Years Lived*	*Deaths in Birth Cohort*		*Deaths due to* Cardiovascular Disease		*Deaths due to* Cerebrovascular Disease		Life Expectancy	*Life Years Lost*		
				%	#	%	#	%	#		All Deaths	Cardio	Cerebro
35-39	0.983	39,310											
40-44	0.978	39,105	195,526	0.5%	205	5.9%	12	3.1%	6	41.5	8,499	501	263
45-49	0.970	38,814	194,070	0.8%	291	11.8%	34	3.8%	11	36.8	10,716	1,265	407
50-54	0.960	38,390	191,948	1.1%	424	11.8%	50	3.8%	16	32.2	13,666	1,613	519
55-59	0.944	37,757	188,786	1.7%	632	11.8%	75	3.8%	24	27.7	17,517	2,067	666
60-64	0.920	36,800	183,998	2.6%	958	11.8%	113	3.8%	36	23.4	22,408	2,644	851
65-69	0.883	35,332	176,658	4.2%	1,468	16.7%	245	6.7%	98	19.2	28,186	4,707	1,888
70-74	0.827	33,072	165,362	6.8%	2,259	16.7%	377	6.7%	151	15.3	34,566	5,772	2,316
Total			**1,296,348**		**6,238**	**14.5%**	**907**	**5.5%**	**344**		**135,558**	**18,569**	**6,911**

- Based on BC vital statistics data, 59 of 993 (5.9%) deaths in 25-44 year olds in 2011 were due to cardiovascular disease (ICD-10 codes I00-I51) and 31 of 993 (3.1%) deaths were due to cerebrovascular disease (ICD-10 codes I60-I69). In 45-64 year olds, 601 of 5,076 (11.8%) deaths were due to cardiovascular disease, and 191 of 5,076 (3.8%) deaths were due to cerebrovascular disease. In 65-84 year olds, 2,248 of 13,481 (16.7%) deaths were due to cardiovascular disease while 905 of 13,481 (6.7%) deaths were due to cerebrovascular disease.[523] This data was used to estimate that approximately 907 (14.5%) of the 6,238 deaths in the birth cohort would be due to cardiovascular disease and 344 (5.5%) 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%)[524] (see Table 2 below and Table 3, row *b*).

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[523] British Columbia Vital Statistics Agency. *Selected Vital Statistics and Health Status Indicators: One Hundred and Fortieth Annual Report*. 2011. British Colubmia Ministry of Health. Available at http://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2011/pdf/ann2011.pdf. Accessed January 2017.
[524] 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		Estimated # by CVD Risk Status			Estimated % by CVD Risk Status		
Group	Population	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: [525]
    - 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.[526]
- 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.[527] 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).[528] 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.[529,530]
- 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

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[525] 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.
[526] Ibid.
[527] 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.
[528] 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.
[529] 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.
[530] Thompson P. What to believe and do about statin-associated adverse effects. *Journal of the American Medical Association*. 2016; 316(19): 1969-70.

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."[531]

- 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%[532,533] of patients taking statins would develop muscle problems and that their QoL would be reduced by 53%[534] during the estimated 3 months it would take for the statin withdrawal and rechallenge process[535,536] 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 9,370 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.

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[531] 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.
[532] Parker B, Capizzi J, Grimaldi A et al. The effect of statins on skeletal muscle function. *Circulation*. 2013; 127(1): 96-103.
[533] 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.
[534] 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.
[535] Jacobson T. Toward "pain-free" statin prescribing: clinical algorithm for diagnosis and management of myalgia. *Mayo Clinic Proceedings*. 2008; 83(6): 687-700.
[536] 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	1,296,348	Table 1
b	% of life years at intermediate or high risk	45.2%	Table 2
c	# of life years at intermediate or high risk	586,371	= (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	175,911	= (c * d)
f	Total deaths in birth cohort between the ages of 40-74	6,238	Table 1
g	Cardiovascular deaths in birth cohort between the ages of 40-74	907	Table 1
h	Cerebrovascular deaths in birth cohort between the ages of 40-74	344	Table 1
i	**Life years lost due to total deaths**	**135,558**	Table 1
j	Life years lost per death	21.7	= (i / f)
k	# of nonfatal cardiovascular events per fatal event	5.09	See Ref Doc
l	# of nonfatal cardiovascular events	4,615	= (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)	0.125	See Ref Doc
q	**QALYs lost due to nonfatal cardiovascular events**	**29,120**	= (l * o) + (l * p/12)
r	Ratio of nonfatal cerebrovascular events per fatal event	4.58	See Ref Doc
s	# of nonfatal cerebrovascular events	1,574	= (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	0.264	See Ref Doc
x	**QALYs lost due to nonfatal cerebrovascular events**	**12,525**	= (s * v) + (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	262	= (f * d * y)
aa	**QALYs gained due to a reduction in all cause mortality**	**5,693**	= (z * j)
ab	% reduction in cardiovascular events associated with statin use	36%	√
ac	Cardiovascular events avoided with 30% statin usage	498	= (l * d *ab)
ad	**QALYs gained due to a reduction in nonfatal cardiovascular events associated with statin use**	**3,145**	= (q * d * ab)
ae	% reduction in cerebrovascular events associated with statin use	29%	√
af	Cerebrovascular events avoided with 30% statin usage	137	= (s * d * ae)
ag	**QALYs gained due to a reduction in nonfatal cerebrovascular events associated with statin use**	**1,090**	= (af * t * u)
ah	**Total QALYs gained if 30% of intermediate or high risk individuals were on statins**	**9,928**	= (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**	**-558**	= (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**	**-558**	= (aj + an)
ap	**Potential QALYs gained, Screening & Intervention from 0% to 30%**	**9,370**	= (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 the QoL reduction associated with a stroke is reduced from 0.264 to 0.177 (Table 3, row w): CPB = 9,259.
- Assume that the QoL reduction associated with a stroke is increased from 0.264 to 0.350 (Table 3, row *w*): CPB = 9,480.
- 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 = 5,499.
- 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 = 12,760.
- 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 = 9,928.
- 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 = 9,161.
- Assume that the percent of life years at intermediate risk on statins is reduced from 30% to 25% (Table 3, row *d*): CPB = 7,809.
- Assume that the percent of life years at intermediate risk on statins is increased from 30% to 40% (Table 3, row *d*): CPB = 12,494.
- Assume that statin use is associated with muscle problems in 5% of users (Table 3, row *ak*): CPB = 9,259.

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.[537]
- 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.”[538]

[537] 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.
[538] 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.

- 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 more contemporary and diverse patient population seen in current clinical practice.”[539]
- 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.[540] 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.[541] 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).[542] 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.”[543]
- 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.”[544]
- 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 *p*).[545]
- 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

[539] 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.
[540] 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.
[541] 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.
[542] 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.
[543] Nissen SE. Prevention guidelines: bad process, bad outcome. *Journal of the American Medical Association Internal Medicine*. 2014; 174(12): 1972-3.
[544] 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.
[545] 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.

call to the patient. If the results indicate an intermediate or high risk of CVD, then a 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).[546]
- 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."[547]
- Pandya and colleagues estimated one additional physician visit per year for individuals in a disease-free state taking statins (i.e., for primary prevention).[548]
- 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.[549] 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.[550] The cost of 10mg rosuvastatin, taken by the majority of patients, is $95 plus four dispensing fees of $10 each, for an annual cost of $135 (Table 4, row *w*). The cost of 80mg atorvastatin is $206 plus four dispensing fees of $10 each, for an annual cost of $246. We have used this higher cost in the sensitivity analysis.

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[546] 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.
[547] 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.
[548] 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.
[549] 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.
[550] See BC *Reference Drug Program*. Available online at http://www2.gov.bc.ca/gov/content/health/practitioner-professional-resources/pharmacare/prescribers/reference-drug-program. Accessed March 2017.

Costs Avoided due to the Intervention

- For modelling purposes, we assumed that the acute care costs avoided per death avoided would be $13,929 (Table 4, row *ah*). This is based on the mix of cardiovascular and cerebrovascular deaths in the cohort (73% and 27%, respectively) (see Table 1) and the estimated cost of the acute care phase associated with a fatal myocardial infarction ($15,536) and a fatal stroke ($9,583).
- 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 $3,223 / 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	1,296,348	Table 1
b	% of life years at low risk	54.8%	Table 2
c	# of life years at low risk	709,977	= (a * b)
d	% of life years at intermediate risk	14.4%	Table 2
e	# of life years at intermediate risk	186,329	= (a * d)
f	% of life years at high risk	30.9%	Table 2
g	# of life years at high risk	400,042	= (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	124,449	= (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	$34.85	See Ref Doc
n	Cost of a follow-up phone call	$15.00	See Ref Doc
o	Cost to measure cholesterol	$21.31	√
p	Health care costs of screening - low risk	$4,850,111	= (j * b) * k * (m + n + o)
q	Health care costs of screening - intermediate and high risk	$5,123,096	= ((d + f) * j * l)*(m + (o/2))
r	Patient time required / office visit (hours)	2.0	√
s	Value of patient time (per hour)	$29.69	√
t	Value of patient time and travel for screening	$7,389,806	= (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	175,911	= (e + g) * u
w	Cost of statin therapy / year	$135	√
x	Cost of statin therapy	$23,748,009	= (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	$6,637,129	= (v * y * z * m) + (v * aa * ab)
ad	Value of patient time and travel for intervention	$10,445,606	= (v * y * s * r)
	Estimated costs avoided due to intervention		
ae	# of deaths avoided	262.0	Table 3, row z
af	# of nonfatal cardiovascular events avoided	498.4	Table 3, row ac
ag	# of nonfatal cerebrovascular events avoided	136.9	Table 3, row af
ah	Acute care costs avoided per avoided death	-$13,929	See Ref Doc
ai	First year costs avoided per nonfatal cardiovascular event avoided	-$33,934	See Ref Doc
aj	First year costs avoided per nonfatal cerebrovascular event avoided	-$21,139	See Ref Doc
ak	First-year acute care costs avoided	-$23,455,536	= (ae * ah) + (af * ai) + (ag * aj)
al	Post-first-year annual costs avoided for nonfatal cardiovascular events avoided	-$2,278	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	-$13,736,935	= (af * am * al)
ao	Post-first-year annual costs avoided for nonfatal cerebrovascular events avoided	-$6,246	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	-$7,954,795	= (ag * ap * ao)
ar	Costs avoided due to intervention	-$45,147,265	= ak + an + aq
	CE Calculation		
as	Cost of intervention over lifetime of birth cohort	$58,193,757	= p + q + t + x + ac + ad
at	Costs avoided due to intervention over lifetime of birth cohort	-$45,147,265	= ar
au	QALYs saved	9,370	Table 3, row ap
av	Cost of intervention over lifetime of birth cohort (1.5% discount)	$45,893,093	Calculated
aw	Costs avoided due to intervention over lifetime of birth cohort (1.5% discount)	-$28,135,568	Calculated
ax	QALYs saved (1.5% discount)	5,510	Calculated
ay	**CE ($/QALY saved)**	**$3,223**	= (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 the QoL reduction associated with a stroke is reduced from 0.264 to 0.177 (Table 3, row *w*): CE = $3,261.
- Assume that the QoL reduction associated with a stroke is increased from 0.264 to 0.350 (Table 3, row *w*): CE = $3,186.
- 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 = $7,849.
- 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 = $1,458.
- 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 = $2,996.
- 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 = $3,317.
- Assume that the percent of life years at intermediate risk on statins is reduced from 30% to 25% (Table 3, row *d*): CE = $3,720.
- Assume that the percent of life years at intermediate risk on statins is increased from 30% to 40% (Table 3, row *d*): CE = $2,601.
- Assume that statin use is associated with muscle problems in 5% of users (Table 3, row *ak*): CE = $3,272.
- Assume that the annual frequency of screening is increased from once every five years to once every two years (Table 4, row *i*): CE = $6,950.
- Assume that the cost of statin therapy in increased from $135 per year to $246 per year (Table 4, row *w*): CE = $6,017.
- Assume that the first-year costs avoided following a nonfatal cerebrovascular are decreased from $21,139 to $16,642 (Table 4, row *aj*) and the post-first-year annual costs avoided decreased from $6,246 to $4,930 (Table 4, row *ao*): CE = $3,471.
- Assume that the first-year costs avoided following a nonfatal cerebrovascular are increased from $21,139 to $25,635 (Table 4, row *aj*) and the post-first-year annual costs avoided increased from $6,246 to $7,562 (Table 4, row *ao*): CE = $2,974.

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 5,510 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $3,223 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	5,510	3,204	7,531
3% Discount Rate	3,144	1,800	4,322
0% Discount Rate	***9,370***	5,499	12,760
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	***$3,223***	$1,458	$7,849
3% Discount Rate	$6,222	$3,567	$13,376
0% Discount Rate	$1,392	$169	$4,537
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$1,174	-$409	$3,459
3% Discount Rate	$2,634	$958	$7,109
0% Discount Rate	-$511	-$1,229	$1,293

Screening for Type 2 Diabetes Mellitus

Canadian Task Force on Preventive Health Care (2012)

The CTFPHC suggests a two-phase approach to screening.[551] 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".[552]

United States Preventive Services Task Force Recommendations (2015)

The USPSTF recommends screening for abnormal blood glucose in all adults ages 40 to 70 who are overweight or obese as part of a cardiovascular risk assessment. This recommendation receives a "B" grade from the USPSTF.[553]

Modelling the Clinically Preventable Burden

In this section, we model the CPB associated with the two-phase approach to screening for type 2 diabetes, recommended by the CTFPHC, in a British Columbia birth cohort of 40,000.

In modelling CPB, we made the following assumptions:

- 35% of the population aged 40 or older would have a FINDRISC score of 15-19 (high risk) and 10% would have a score of 20+ (very high risk) (see Table 1 and 2 below).[554]

- Detailed information on the prevalence of diagnosed diabetes in Canada in 2008/09 by age group and sex is provided by the CTFPHC. Overall, rates for Canadian females and males were 6.4% and 7.2%, respectively.[555] Rates of diagnosed diabetes in British Columbia in 2007/08 were 6.0% for females and 6.9% for males.[556] This data was not stratified by age. In estimating the age and sex specific prevalence rates for diagnosed diabetes in BC, we adjusted the Canadian age and sex specific rates downwards by the difference between the Canadian and British Columbian rates (see Figure 1).

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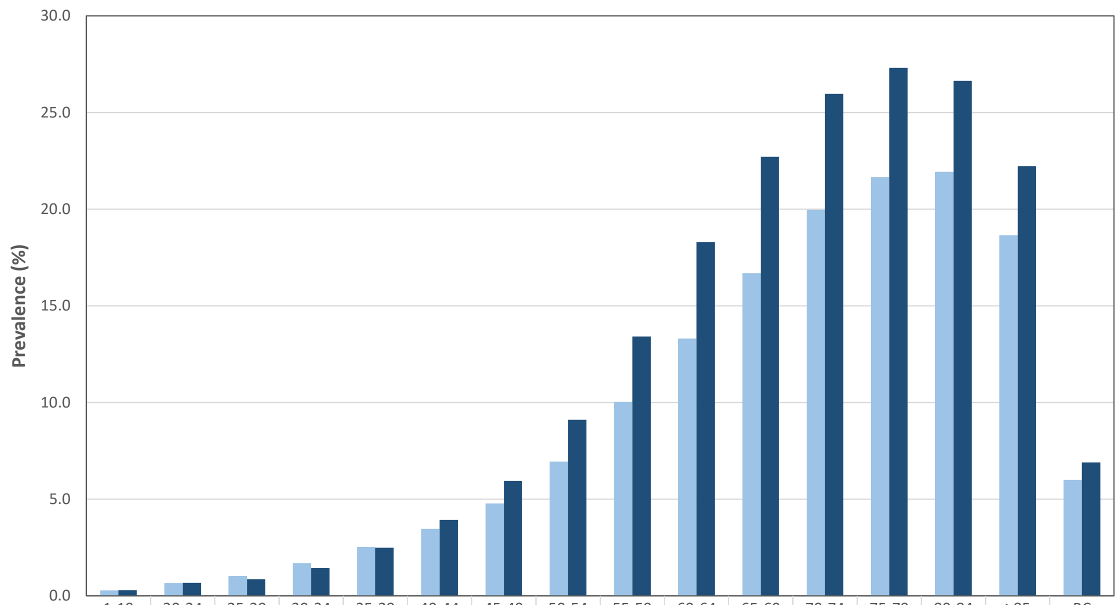
551 Canadian Task Force on Preventive Health Care. Recommendations on screening for type 2 diabetes in adults. *Canadian Medical Association Journal*. 2012; 184(15): 1687-96.
552 Ibid.
553 Siu A. Screening for Abnormal Blood Glucose and Type 2 Diabetes Mellitus: U.S. Preventive Services Task Force Recommendation Statement. *Annals of Internal Medicine.* 2015; 163(11): 861-8.
554 Makrilakis K, Liatis S, Grammatikou S et al. Validation of the Finnish diabetes risk score (FINDRISC) questionnaire for screening for undiagnosed type 2 diabetes, dysglycaemia and the metabolic syndrome in Greece. *Diabetes & Metabolism*. 2011; 37(2): 144-51.
555 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.
556 Provincial Health Services Authority. *Summary Report on Health for British Columbia from Regional, Longitudinal and Gender Perspectives*. 2010. Available at http://www.phsa.ca/population-public-health-site/Documents/BCHealth_Indicators_Report.pdf. Accessed February 2015.

Figure 1: Estimated Prevalence of Diagnosed Diabetes
By Age and Sex, British Columbia, 2008/09



	1-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	≥85	BC
Females	0.3	0.7	1.0	1.7	2.5	3.5	4.8	6.9	10.0	13.3	16.7	20.0	21.7	21.9	18.7	6.0
Males	0.3	0.7	0.9	1.4	2.5	3.9	5.9	9.1	13.4	18.3	22.7	26.0	27.3	26.6	22.2	6.9

Age

- Estimates of the proportion of diabetes cases that are undiagnosed by age group and sex are as follows: [557]

Age Group	Males	Females
40-49	44%	24%
50-59	21%	15%
60-69	17%	16%
70-79	19%	14%
80+	16%	14%

- A total of 798,605 years would be lived by males from age 40 - 89 in a BC birth cohort of 40,000 (see Table 1). The equivalent number for females would be 857,481 (see Table 2). Among males, 279,512 of these years would be spent at high risk for type 2 diabetes, and 79,861 would be spent at very high risk. Among females, 300,118 would be spent at high risk and 85,748 at very high risk.

[557] 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.

Table 1: Prevalence and Increased Risk for Type 2 Diabetes in a *Male* Birth Cohort of 20,000											
Age Group	Mean Survival Rate	Individuals in Birth Cohort	Years of Life in Birth Cohort	Estimated FINDRISC Status		Prevalence of Diabetes				Years of Life with Diabetes	
				High	Very High	Diagnosed %	Diagnosed #	Undiagnosed %	Undiagnosed #	Diagnosed	Undiagnosed
40-44	0.972	19,442	97,211	34,024	9,721	3.9%	764	1.7%	336	3,820	1,681
45-49	0.963	19,263	96,314	33,710	9,631	5.9%	1,145	2.6%	504	5,723	2,518
50-54	0.950	19,003	95,017	33,256	9,502	9.1%	1,730	1.9%	363	8,651	1,817
55-59	0.931	18,619	93,095	32,583	9,310	13.4%	2,498	2.8%	525	12,490	2,623
60-64	0.902	18,041	90,204	31,571	9,020	18.3%	3,302	3.1%	561	16,511	2,807
65-69	0.858	17,164	85,820	30,037	8,582	22.7%	3,898	3.9%	663	19,492	3,314
70-74	0.792	15,837	79,183	27,714	7,918	26.0%	4,113	4.9%	781	20,564	3,907
75-79	0.693	13,861	69,305	24,257	6,931	27.3%	3,786	5.2%	719	18,929	3,596
80-84	0.553	11,053	55,266	19,343	5,527	24.4%	2,697	3.9%	432	13,485	2,158
85-89	0.372	7,438	37,190	13,017	3,719	24.4%	1,815	3.9%	290	9,074	1,452
Total Ages 40 - 89			**798,605**	**279,512**	**79,861**					**128,739**	**25,872**

Table 2: Prevalence and Increased Risk for Type 2 Diabetes in a *Female* Birth Cohort of 20,000											
Age Group	Mean Survival Rate	Individuals in Birth Cohort	Years of Life in Birth Cohort	Estimated FINDRISC Status		Prevalence of Diabetes				Years of Life with Diabetes	
				High	Very High	Diagnosed %	Diagnosed #	Undiagnosed %	Undiagnosed #	Diagnosed	Undiagnosed
40-44	0.984	19,672	98,358	34,425	9,836	3.5%	682	0.8%	164	3,412	819
45-49	0.978	19,560	97,800	34,230	9,780	4.8%	935	1.1%	224	4,676	1,122
50-54	0.970	19,395	96,977	33,942	9,698	6.9%	1,346	1.0%	202	6,728	1,009
55-59	0.957	19,150	95,748	33,512	9,575	10.0%	1,921	1.5%	288	9,605	1,441
60-64	0.939	18,774	93,872	32,855	9,387	13.3%	2,499	2.1%	400	12,497	1,999
65-69	0.909	18,190	90,948	31,832	9,095	16.7%	3,035	2.7%	486	15,177	2,428
70-74	0.863	17,265	86,325	30,214	8,633	20.0%	3,448	2.8%	483	17,238	2,413
75-79	0.790	15,799	78,995	27,648	7,900	21.7%	3,421	3.0%	479	17,107	2,395
80-84	0.676	13,517	67,587	23,655	6,759	20.3%	2,744	2.8%	384	13,720	1,921
85-89	0.509	10,174	50,871	17,805	5,087	20.3%	2,065	2.8%	289	10,327	1,446
Total Ages 40-89			**857,481**	**300,118**	**85,748**					**110,486**	**16,994**

- Screening of the entire target population every 3-5 years starting at age 40 is associated with the following benefits over a 50 year period:[558]
  - ✓ 5.2 (range of 2.7 - 7.5) myocardial infarction events prevented per 1,000 people screened (Table 3, row *d*).
  - ✓ 8.0 (range of 6.2 - 9.5) microvascular events (foot amputations/ulcers, end-stage renal disease or blindness) prevented per 1,000 people screened (Table 3, row *h*).
  - ✓ 3.2 (range of 1.0 - 5.8) premature deaths prevented per 1,000 people screened (Table 3, row *l*).
- We have assumed that each event would be prevented, on average, half way through the 50 year follow-up period.
- A myocardial infarction reduces a person's quality of life by 12.6% for a period of one month or a 0.0105 reduction in QoL (Table 3, row *f*).

[558] Kahn R, Alperin P, Eddy D et al. Age at initiation and frequency of screening to detect type 2 diabetes: a cost-effectiveness analysis. *Lancet*. 2010; 375(9723): 1365-74.

- End-stage renal disease (ESRD) reduces a person's quality of life by 20%, foot amputation by 10.5% and blindness by 16%.[559] For microvascular events prevented, we assumed an overall quality of life reduction of 15.8% based on a 40:33:27 distribution for incidence of ESRD, foot amputation or blindness (Table 3, row *j*).[560]

- 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 type 2 diabetes is 3,494 QALYs (Table 3, row *p*).

Table 3: CPB of Screening for Type 2 Diabetes in a Birth Cohort of 40,000

Row Label	Variable	Base Case	Data Source
a	Individuals in birth cohort at age 40	39,114	Tables 1 and 2
b	Adherence with screening	80%	Ref Doc
c	Individuals screened	31,291	= a * b
	Benefits Associated with Screening		
d	Myocardial infarction events prevented / 1,000 people screened	5.2	√
e	Myocardial infarction events prevented	163	= (c / 1,000) * d
f	Quality of life adjustment per myocardial event	0.0105	Ref Doc
g	QALYs gained	1.7	= e * f
h	Microvascular events prevented / 1,000 people screened	8.0	√
i	Microvascular events prevented	250	= (c / 1,000) * h
j	Quality of life adjustment	15.8%	√
k	QALYs gained	989	= i * 25 * j
l	Premature deaths averted / 1,000 people screened	3.2	√
m	Premature deaths averted	100	= (c / 1,000) * m
n	Life-years gained / death averted	25	√
o	Life-years gained	2,503	= m * n
p	**Potential QALYs gained, Screening increasing from 0% to 80%**	**3,494**	= g + k + o

√ = Estimates from the literature

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

- Assume the number of myocardial infarction events prevented per 1,000 people screened is reduced from 5.2 to 2.7 (Table 3, row *d*), the number of microvascular events prevented per 1,000 people screened is reduced from 8.0 to 6.2 (Table 3, row *h*) and the number of premature deaths prevented per 1,000 people screened is reduced from 3.2 to 1.0 (Table 3, row *l*): CPB = 1,549 QALYs.

- Assume the number of myocardial infarction events prevented per 1,000 people screened is increased from 5.2 to 7.5 (Table 3, row *d*), the number of microvascular events prevented per 1,000 people screened is increased from 8.0 to 9.5 (Table 3, row *h*) and the number of premature deaths prevented per 1,000 people screened is increased from 3.2 to 5.8 (Table 3, row *l*): CPB = 5,714 QALYs.

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[559] Kahn R, Alperin P, Eddy D et al. Age at initiation and frequency of screening to detect type 2 diabetes: a cost-effectiveness analysis. *Lancet*. 2010; 375(9723): 1365-74.
[560] Deshpande AD, Harris-Hayes M and Schootman M. Epidemiology of diabetes and diabetes-related complications. *Physical Therapy*. 2008; 88(11): 1254-64.

Modelling Cost-Effectiveness

In this section, we model the CE associated with the two-phase approach to screening for type 2 diabetes, recommended by the CTFPHC, in a British Columbia birth cohort of 40,000.

In modelling CE, we made the following assumptions:

- Laboratory screening tests - The cost of an A1C test (MSP fee item 91745) in BC is $6.09 (Table 4, row *l*).[561]
- The typical event (i.e., first year) cost for an acute myocardial infarction is $33,934, with annual costs thereafter of $1,193 (see Reference Document).
- The annual costs for blindness are $2,330 (see Reference Document).
- The annual costs for end-stage renal disease are $86,278 (see Reference Document).
- The typical event cost for a lower extremity amputation is $33,642 with annual costs thereafter of $1,396 (see Reference Document).
- We have assumed that each event and the resulting costs would be prevented, on average, half way through the 50 year follow-up period.
- Screening detects diabetes, on average, 5.3 years earlier than no screening.[562]
- Average costs avoided per acute myocardial infarction event would therefore be $6,323 ($1,193 * 5.3) (Table 4, row *t*).
- For microvascular events prevented, we assumed a 40:33:27 distribution for ESRD, foot amputation or blindness.[563] Average costs avoided per microvascular event would therefore be $188,685 (Table 4, 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 CE associated with screening for type 2 diabetes is -$3,121 per QALY (Table 4, row *ee*).

561 BC Ministry of Health. MSP Fee-For-Service Payment Analysis. 2012/2013 - 2016/2017. Available online at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/ffs_complete.pdf. Accessed January 2018.
562 Kahn R, Alperin P, Eddy D et al. Age at initiation and frequency of screening to detect type 2 diabetes: a cost-effectiveness analysis. *Lancet*. 2010; 375(9723): 1365-74.
563 Deshpande AD, Harris-Hayes M and Schootman M. Epidemiology of diabetes and diabetes-related complications. *Physical Therapy*. 2008; 88(11): 1254-64.

Table 4: CE of Screening for Type 2 Diabetes in a Birth Cohort of 40,000			
Row Label	Variable	Base Case	Data Source
a	Individuals in birth cohort at age 40	39,114	Table 3, row a
b	Life years at increased risk for diabetes	1,656,086	Tables 1 and 2
c	Life years at high risk for diabetes	579,630	Tables 1 and 2
d	Life years at very high risk for diabetes	165,609	Tables 1 and 2
	Costs of intervention		
e	Frequency of screening with FINDRISC/CANRISK (every x years)	4	√
f	Total number of screens with FINDRISC/CANRISK (100% adherence)	414,022	= b / e
g	Adherence with screening	80%	Ref Doc
h	Cost of 10-minute office visit	$34.85	Ref Doc
i	Value of patient time and travel for office visit	$59.38	Ref Doc
j	Portion of 10-minute office visit for screen	50%	Ref Doc
k	Cost of screening with FINDRISC/CANRISK	$15,605,298	= (f * g) * (h + i) * j
l	Lab cost of A1C test	$6.09	√
m	Value of patient time and travel for lab test	$29.69	Ref Doc
n	Frequency of lab testing for high risk patients (every x years)	4	√
o	# of lab tests high risk patients	115,926	= (c / n) * g
p	Frequency of lab testing for very high risk patients (every x years)	1	√
q	# of lab tests for very high risk patients	132,487	= d * p * g
r	Cost of lab testing	$20,592,187	= ((o + q) * (l + m))+((o + q) * (h + i) * j)
	Cost avoided		
s	Myocardial infarction events prevented	163	Table 3, row e
t	Cost avoided per event avoided	$6,323	√
u	Total costs avoided	$1,028,837	= s * t
v	Microvascular events prevented	250	Table 3, row i
w	Cost avoided per event avoided	$188,685	√
x	Total costs avoided	$47,233,248	= v * w
	CE calculation		
y	Cost of intervention over lifetime of birth cohort	$36,197,486	= k + r
z	Costs avoided	$48,262,085	= u + x
aa	QALYs saved	3,494	Table 3, row p
bb	Cost of intervention over lifetime of birth cohort (1.5% discount)	$25,566,103	Calculated
cc	Costs avoided (1.5% discount)	$31,908,799	Calculated
dd	QALYs saved (1.5% discount)	2,032	Calculated
ee	**CE ($/QALY saved)**	**-$3,121**	= (bb - cc) / dd

√ = Estimates from the literature

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

- Assume the number of myocardial infarction events prevented per 1,000 people screened is reduced from 5.2 to 2.7 (Table 3, row *d*), the number of microvascular events prevented per 1,000 people screened is reduced from 8.0 to 6.2 (Table 3, row *h*) and the number of premature deaths prevented per 1,000 people screened is reduced from 3.2 to 1.0 (Table 3, row *l*): CE = $1,121
- Assume the number of myocardial infarction events prevented per 1,000 people screened is increased from 5.2 to 7.5 (Table 3, row *d*), the number of microvascular events prevented per 1,000 people screened is increased from 8.0 to 9.5 (Table 3, row *h*) and the number of premature deaths prevented per 1,000 people screened is increased from 3.2 to 5.8 (Table 3, row *l*): CE = -$3,761

- Assume the frequency of screening with FINDRISC is increased from every 4 years to every 3 years (Table 4, row *e*): CE = -$1,313
- Assume the frequency of screening with FINDRISC is decreased from every 4 years to every 5 years (Table 4, row *e*): CE = -$4,206
- Assume that the portion of a 10-minute office visit for the assessment of patient risk is reduced from 50% to 33% (Table 4, row *j*): CE = -$6,348
- Assume that the portion of a 10-minute office visit for the assessment of patient risk is increased from 50% to 67% (Table 4, row *j*): CE = $106

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening for type 2 diabetes is estimated to be 2,032 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to result in cost savings of $3,121 per QALY (see Table 5).

Table 5: Screening for Type 2 Diabetes in a Birth Cohort of 40,000

Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Gap between No Service and 'Best in the World' (80%)			
1.5% Discount Rate	**2,032**	901	3,324
3% Discount Rate	1,162	515	1,901
0% Discount Rate	3,494	1,459	5,714
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**-$3,121**	-$6,348	$1,121
3% Discount Rate	-$1,879	-$5,990	$5,067
0% Discount Rate	-$3,453	-$6,111	-$608
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	-$11,666	-$12,859	-$18,145
3% Discount Rate	-$12,764	-$14,285	-$19,477
0% Discount Rate	-$10,490	-$11,473	-$16,475

Screening for Depression in the General Adult Population

Canadian Task Force on Preventive Health Care (2013)[564]

> *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,[565] 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,[566] we recommend not routinely screening for depression.[567] (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).* [568]

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)* [569]

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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[564] Canadian Task Force on Preventive Health Care. Recommendations on screening for depression in adults. *Canadian Medical Association Journal*. 2013; 185(9): 775-82.

[565] 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.

[566] 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.

[567] 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.

[568] 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.

[569] 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).[570]
- 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).[571]

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.[572] On average, half of individuals experiencing at least one MDE during their lifetime will experience between 5-9 recurrent episodes during their lifetime.[573,574,575] 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

[570] 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.
[571] Patten SB. A major depression prognosis calculator based on episode duration. *Clinical Practice and Epidemiology in Mental Health*. 2006; 2(1): 13-20.
[572] Burcusa SL and Iacono WG. Risk for recurrence in depression. *Clinical Psychology Review*. 2007; 27(8): 959-85.
[573] 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.
[574] 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.
[575] 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	Mean Survival Rate	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
				Males			
18-19	0.993	19,862	58.6	205.2	376.8	39,724	0.95%
20-24	0.991	19,821	146.3	512.0	940.0	99,106	0.95%
25-29	0.987	19,742	145.7	510.0	936.2	98,709	0.95%
30-34	0.983	19,666	145.2	508.0	932.6	98,332	0.95%
35-39	0.979	19,571	144.5	505.6	928.1	97,854	0.95%
40-44	0.972	19,442	143.5	502.3	922.0	97,211	0.95%
45-49	0.963	19,263	142.2	497.6	913.5	96,314	0.95%
50-54	0.950	19,003	140.3	490.9	901.2	95,017	0.95%
55-59	0.931	18,619	137.4	481.0	883.0	93,095	0.95%
60-64	0.902	18,041	133.2	466.1	855.5	90,204	0.95%
65-69	0.858	17,164	126.7	443.4	814.0	85,820	0.95%
70-74	0.792	15,837	116.9	409.1	751.0	79,183	0.95%
75-79	0.693	13,861	102.3	358.1	657.3	69,305	0.95%
80+	0.296	5,918	17.5	61.2	112.3	11,836	0.95%
Total Ages 18+			**1,700**	**5,950**	**10,923**	**1,151,710**	**0.95%**

Table 3: Years of Life Lived with Depression
in a British Columbia Female Birth Cohort of 20,000

Age Group	Mean Survival Rate	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
				Females			
18-19	0.994	19,887	82.5	288.8	530.2	39,775	1.33%
20-24	0.993	19,868	206.1	721.3	1,324.1	99,339	1.33%
25-29	0.992	19,836	205.8	720.2	1,322.0	99,179	1.33%
30-34	0.990	19,799	205.4	718.8	1,319.6	98,997	1.33%
35-39	0.987	19,748	204.8	717.0	1,316.1	98,738	1.33%
40-44	0.984	19,672	204.1	714.2	1,311.1	98,358	1.33%
45-49	0.978	19,560	202.9	710.1	1,303.6	97,800	1.33%
50-54	0.970	19,395	201.2	704.2	1,292.7	96,977	1.33%
55-59	0.957	19,150	198.6	695.2	1,276.3	95,748	1.33%
60-64	0.939	18,774	194.7	681.6	1,251.3	93,872	1.33%
65-69	0.909	18,190	188.7	660.4	1,212.3	90,948	1.33%
70-74	0.863	17,265	179.1	626.8	1,150.7	86,325	1.33%
75-79	0.790	15,799	163.9	573.6	1,053.0	78,995	1.33%
80+	0.384	7,677	95.6	334.5	614.0	46,063	1.33%
Total Ages 18+			**2,533**	**8,867**	**16,277**	**1,221,114**	**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.[576] Individuals living with depression also have higher rates of overall excess mortality with an early meta-analysis suggesting a RR of 1.81

[576] Lépine J-P and Briley M. The increasing burden of depression. *Neuropsychiatric Disease and Treatment*. 2011; 7(Suppl 1): 3-7.

(95% CI of 1.58 to 2.07).[577] 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).[578] Other research has found that the effect of depression on mortality is independent of chronic illnesses such as diabetes[579] and congestive heart failure.[580] 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.[581] 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).[582] 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, 20 deaths and 477 life years lost in the cohort are attributable to depression (see Table 4). In females, 18 deaths and 444 life years lost are attributable to depression (see Table 5).

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	19,862							
20-24	19,821	41	0.95%	0.4	0.6	0.2	58.9	12
25-29	19,742	79	0.95%	0.8	1.1	0.4	56.0	22
30-34	19,666	75	0.95%	0.7	1.1	0.4	51.1	19
35-39	19,571	96	0.95%	0.9	1.4	0.5	46.3	22
40-44	19,442	129	0.95%	1.2	1.9	0.6	41.5	26
45-49	19,263	179	0.95%	1.7	2.6	0.9	36.8	33
50-54	19,003	259	0.95%	2.5	3.7	1.3	32.2	41
55-59	18,619	384	0.95%	3.6	5.5	1.9	27.7	53
60-64	18,041	578	0.95%	5.5	8.3	2.9	23.4	67
65-69	17,164	877	0.95%	8.3	12.6	4.3	19.2	83
70-74	15,837	1,327	0.95%	12.6	19.1	6.5	15.3	100
Total		**4,025**		**38**	**58**	**20**		**477**

[577] Cuijpers P and Smit F. Excess mortality in depression: a meta-analysis of community studies. *Journal of Affective Disorders*. 2002; 72(3): 227-36.
[578] 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.
[579] Lin EH, Heckbert SR, Rutter CM et al. Depression and increased mortality in diabetes: unexpected causes of death. *The Annals of Family Medicine*. 2009; 7(5): 414-21.
[580] Jiang W, Alexander J, Christopher E et al. Relationship of depression to increased risk of mortality and rehospitalization in patients with congestive heart failure. *Archives of Internal Medicine*. 2001; 161(15): 1849-56.
[581] 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.
[582] 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 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	19,887							
20-24	19,868	20	1.33%	0.3	0.4	0.1	62.7	9
25-29	19,836	32	1.33%	0.4	0.6	0.2	57.8	13
30-34	19,799	36	1.33%	0.5	0.7	0.3	52.9	13
35-39	19,748	52	1.33%	0.7	1.0	0.4	48.1	17
40-44	19,672	76	1.33%	1.0	1.5	0.5	43.2	23
45-49	19,560	112	1.33%	1.5	2.3	0.8	38.5	30
50-54	19,395	165	1.33%	2.2	3.3	1.1	33.8	39
55-59	19,150	246	1.33%	3.3	5.0	1.7	29.2	50
60-64	18,774	375	1.33%	5.0	7.6	2.6	24.7	64
65-69	18,190	585	1.33%	7.8	11.8	4.1	20.4	83
70-74	17,265	925	1.33%	12.3	18.7	6.4	16.3	104
Total		**2,622**		**35**	**53**	**18**		**444**

- 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."[583]
- 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 over an extended period of time (3-12 months) rather than relying on a one-time assessment or case-note records.[584]
- 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.[585,586] 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.[587]
- 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.[588] Scores on the HDRS can be interpreted as follows: no

[583] Kessler D, Sharp D and Lewis G. Screening for depression in primary care. *British Journal of General Practice*. 2005; 55(518): 659-60.
[584] Mitchell AJ, Vaze A and Rao S. Clinical diagnosis of depression in primary care: a meta-analysis. *The Lancet*. 2009; 374(9690): 609-19.
[585] 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.
[586] Simon GE and VonKorff M. Recognition, management, and outcomes of depression in primary care. *Archives of Family Medicine*. 1995; 4(2): 99-105.
[587] Coyne JC, Klinkman MS, Gallo SM et al. Short-term outcomes of detected and undetected depressed primary care patients and depressed psychiatric patients. *General Hospital Psychiatry*. 1997; 19(5): 333-43.
[588] Zimmerman M, Posternak MA and Chelminski I. Symptom severity and exclusion from antidepressant efficacy trials. *Journal of Clinical Psychopharmacology*. 2002; 22(6): 610-4.

depression (0-7), mild depression (8-16), moderate depression (17-23) and severe depression (≥24).[589]

- 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.[590,591,592] 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.[593]
- Approximately 60% of patients stay on ADM for at least 3 months and 45% for at least 6 months.[594,595]
- 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[596] and a 70% (OR = 0.30, 95% CI of 0.1 to 1.0) reduced risk after 10 years.[597]
- 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.[598,599] 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.[600,601] 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

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[589] Zimmerman M, Martinez JH, Young D et al. Severity classification on the Hamilton depression rating scale. *Journal of Affective Disorders*. 2013; 150(2): 384-8.
[590] 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.
[591] 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.
[592] 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.
[593] 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.
[594] 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.
[595] 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.
[596] 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.
[597] 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.
[598] Howland RH. Sequenced Treatment Alternatives to Relieve Depression (STAR* D): Part 2: Study Outcomes. *Journal of Psychosocial Nursing & Mental Health Services*. 2008; 46(10): 21.
[599] Sinyor M, Schaffer A and Levitt A. The sequenced treatment alternatives to relieve depression (STAR* D) trial: a review. *Canadian Journal of Psychiatry*. 2010; 55(3): 126-35.
[600] 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.
[601] 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.

depression symptoms."[602] 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.[603] Whiteford and colleagues[604] 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 92 quality-adjusted life years saved (see Table 6, row s). The CPB of 92 represents the gap between existing coverage (no coverage) and the 'best in the world' coverage estimated at 12%.

602 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.
603 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.
604 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	1,151,710	Table 2
b	Life years lived from age 18 to death in a birth cohort of 20,000 females	1,221,114	Table 3
c	Life years lived with depression in a birth cohort of 20,000 males	10,923	Table 2
d	Life years lived with depression in a birth cohort of 20,000 females	16,277	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	477	Table 4
h	Life years lost attributable to depression in a birth cohort of 20,000 females	444	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	1,529	= c * i
k	Life years lived with undiagnosed treatable depression in a birth cohort of 20,000 females	2,279	= d * i
l	Adherence with screening	12%	√
m	Life years lived with undiagnosed treatable depression identified by screening	457	= (j + k) * l
n	Effectiveness of ADM in achieving remission	56%	√
o	Life years lived in remission with treated depression identified by screening	256	= m * n
p	Quality of life reduction	30%	√
q	QALYs gained	77	= o * p
r	Life-years gained / death averted	15	= (g + h) * i * l
s	**Potential QALYs gained, Screening increasing from 0% to 12%**	**92**	= 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 = 90.
- Assume that the RR of excess mortality associated with depression is increased from 1.52 to 1.59 (Table 4 and 5): CPB = 94.
- Assume the proportion of treatable depression that is undiagnosed is increased from 14% to 30% (Table 6, row *i*): CPB = 198.
- Assume the effectiveness of ADM in achieving remission is reduced from 56% to 37% (Table 6, row *l*): CPB = 66.
- Assume the effectiveness of ADM in achieving remission is increased from 56% to 67% (Table 6, row *n*): CPB = 107.
- Assume the QoL adjustment is reduced from 30% to 16% (Table 6, row *p*): CPB = 55.
- Assume the QoL adjustment is increased from 30% to 45% (Table 6, row *p*): CPB = 130.

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.[605] 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.[606] 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.[607] 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.[608] We have not included this potential harm in the modelling.

Based on these additional assumptions, the calculation of CPB is reduced from 92 to -8 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.***

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[605] 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.
[606] 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.
[607] Mitchell AJ, Vaze A and Rao S. Clinical diagnosis of depression in primary care: a meta-analysis. *The Lancet*. 2009; 374(9690): 609-19.
[608] 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	1,151,710	Table 2
b	Life years lived from age 18 to death in a birth cohort of 20,000 females	1,221,114	Table 3
c	Life years lived with depression in a birth cohort of 20,000 males	10,923	Table 2
d	Life years lived with depression in a birth cohort of 20,000 females	16,277	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	477	Table 4
h	Life years lost attributable to depression in a birth cohort of 20,000 females	444	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	1,529	= c * i
k	Life years lived with undiagnosed treatable depression in a birth cohort of 20,000 females	2,279	= d * i
l	Adherence with screening	12%	√
m	Life years lived with undiagnosed treatable depression identified by screening	457	= (j + k) * l
n	Life years treated for depression - false positives	685	= m * 1.5
o	Effectiveness of ADM in achieving remission	56%	√
p	Life years lived in remission with treated depression identified by screening	256	= m * o
q	Quality of life adjustment	30%	√
r	QALYs gained	77	= p * q
s	Life-years gained / death averted	15	= (g + h) * i * l
t	Disutility associated with ADM	-8.8%	√
u	QALYs lost associated with ADM	-101	= (m + n) * t
v	**Potential QALYs gained, Screening increasing from 0% to 12%**	**-8**	= 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 $148,602 (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	1,140,786	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	1,204,837	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)	2,345,623	= (a + b) / c
e	Adherence with screening	12%	Table 6, row l
f	Cost of 10-minute office visit	$34.85	Ref Doc
g	Value of patient time and travel for office visit	$59.38	Ref Doc
h	Portion of 10-minute office visit for screen	50%	Assumed
i	Cost of screening	$13,261,683	= (d * e) * (f + g) * h
j	Life years treated for depression	457	Table 6, row m
k	Annual cost of ADM	$438	Ref Doc
l	Cost of ADM	$200,150	= 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	$258,358	= (m * j) * (f + g)
	CE calculation		
o	Cost of intervention over lifetime of birth cohort	$13,720,192	= (i + l + n)
p	QALYs saved	92	Table 6, row s
q	Cost of intervention over lifetime of birth cohort (1.5% discount)	$8,692,068	Calculated
r	QALYs saved (1.5% discount)	58	Calculated
s	**CE ($/QALY saved)**	**$148,602**	= 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 = $71,996.
- Assume the effectiveness of ADM in achieving remission is reduced from 56% to 37% (Table 6, row *n*): CE = $207,084.
- Assume the effectiveness of ADM in achieving remission is increased from 56% to 67% (Table 6, row *n*): CPB = CE = $127,720.
- Assume the QoL adjustment is reduced from 30% to 16% (Table 6, row *p*): CE = $248,053.
- Assume the QoL adjustment is increased from 30% to 45% (Table 6, row *p*): CE = $105,909.
- Assume that the proportion of an office visit required for screening is reduced from 50% to 33% (Table 8, row *h*): CE = $99,776.
- Assume that the proportion of an office visit required for screening is increased from 50% to 67% (Table 8, row *h*): CE = $197,438.

- Assume that diagnosed depression results in an additional 4 physician visits per year rather than 6 (see Table 8, row *m*): CE = $147,669.
- Assume that diagnosed depression results in an additional 8 physician visits per year rather than 6 (see Table 8, row *m*): CE = $149,535.

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 58 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $148,602 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	**58**	35	125
3% Discount Rate	39	23	84
0% Discount Rate	92	55	198
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$148,602**	$71,996	$207,084
3% Discount Rate	$148,602	$71,996	$207,084
0% Discount Rate	$148,602	$71,996	$207,084
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$56,325	$27,993	$78,492
3% Discount Rate	$56,325	$27,993	$78,492
0% Discount Rate	$56,325	$27,993	$78,492

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**	-29	18
3% Discount Rate	-3	-19	12
0% Discount Rate	-8	-45	29
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate			**$472,872**
3% Discount Rate	Dominated	Dominated	$472,872
0% Discount Rate			$472,872
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate			$179,234
3% Discount Rate	Dominated	Dominated	$179,234
0% Discount Rate			$179,234

Screening for Depression in Pregnant and Postpartum Women

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][609] *we recommend not routinely screening for depression.*[610] *(Weak recommendation; very-low-quality evidence)* [611]

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)* [612]

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 1.42 children over their lifetime (Table 1, row *a*).[613]

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[609] 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.

[610] 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.

[611] Canadian Task Force on Preventive Health Care. Recommendations on screening for depression in adults. *Canadian Medical Association Journal*. 2013; 185(9): 775-82.

[612] 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.

[613] British Columbia Vital Statistics Agency. *Selected Vital Statistics and Health Status Indicators, One Hundred and Fortieth Annual Report 2011*. Available at http://www2.gov.bc.ca/assets/gov/residents/vital-statistics/statistics-reports/annual-reports/2011/pdf/ann2011.pdf. Accessed March 2016.

- 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).[614]
- A 2004 systematic review found prevalence rates of depression of 7.4%, 12.8% and 12.0% during the first, second and third trimesters.[615]
- 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.[616] MDE is a distinct clinical syndrome for which treatment is clearly indicated.[617]
- 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.[618]
- 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:[619]
    - 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*).

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[614] 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.
[615] Bennett HA, Einarson A, Taddio A et al. Prevalence of depression during pregnancy: systematic review. *Obstetrics & Gynecology*. 2004; 103(4): 698-709.
[616] 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.
[617] 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.
[618] 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.
[619] 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*).[620] 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*).[621]
- 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.[622]
- 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.[623,624]
- 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.[625]
- 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*).[626] 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*).[627]
- Pregnancy and postpartum depression are associated with a shorter duration of breastfeeding.[628] 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.[629] 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.[630] For modelling purposes, we assumed a 27% reduction of exclusive

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620 See http://www.statcan.gc.ca/pub/84-537-x/2013005/tbl-eng.htm. Accessed December 2015.

621 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.

622 McLennan JD and Kotelchuck M. Parental prevention practices for young children in the context of maternal depression. *Pediatrics*. 2000; 105(5): 1090-5.

623 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.

624 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.

625 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.

626 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.

627 See http://www.statcan.gc.ca/pub/84-537-x/2013005/tbl-eng.htm. Accessed December 2015.

628 Dias CC and Figueiredo B. Breastfeeding and depression: A systematic review of the literature. *Journal of Affective Disorders*. 2015; 171: 142-54.

629 Henderson JJ, Evans SF, Straton JA et al. Impact of postnatal depression on breastfeeding duration. *Birth*. 2003; 30(3): 175-80.

630 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.[631,632] 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*).[633]
- 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.[634] 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.[635,636]
- 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.[637,638,639]
- 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.[640]
- 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,

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631 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.
632 Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.
633 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.
634 Howard LM, Kirkwood G and Latinovic R. Sudden infant death syndrome and maternal depression. *The Journal of Clinical Psychiatry*. 2007; 68(8): 1279-83.
635 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.
636 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.
637 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.
638 McGowan JE, Alderdice FA, Holmes VA et al. Early childhood development of late-preterm infants: a systematic review. *Pediatrics*. 2011; 127(6): 1111-24.
639 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.
640 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.[641]

- 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."[642]
- 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.[643] 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*).[644]
- The use of second generation antidepressants during pregnancy may be associated with increased risk of some serious side-effects,[645] although the research remains unclear.[646,647]
- 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.[648]
- Other assumptions used in assessing the clinically preventable burden are detailed in the Reference Document.

Based on these assumptions, the CPB is 109 quality-adjusted life years saved (see Table 1, row *ae*). The CPB of 109 represents the gap between no coverage and the 'best in the world' coverage estimated at 40%.

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641 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.
642 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.
643 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.
644 Ibid.
645 Ibid.
646 Molyneaux E, Trevillion K and Howard LM. Antidepressant treatment for postnatal depression. *JAMA*. 2015; 313(19): 1965-6.
647 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.
648 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	1.42	√
b	Proportion of females surviving to age 20 in the cohort	99.39%	√
c	Number of pregnancies in the birth cohort	28,226	= (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	0.85	= 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	55.4	= (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	112	= (r * c) * t
q	Deaths due to unintentional injuries in children age 0-4 attributable to mothers with depression	1.8	= (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	143	= 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	241	= v * c * t * u
x	**Total QALYs lost due to moderate to severe perinatal depression**	**1,189**	= 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 l	366	= (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	117	= aa * ab
ad	% of years lived with moderate to severe perinatal depression reduced by screening	9.2%	= ac / d
ae	**Potential QALYs saved (CPB) - Screening increasing from 0% to 40%**	**109**	= 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 = 202.
- Assume that the disutility associated with moderate to severe depression is reduced from 0.59 to 0.42 (Table 1, row *f*): CPB = 73.
- Assume that the disutility associated with moderate to severe depression is increased from 0.59 to 0.76 (Table 1, row *f*): CPB = 153.
- Assume that the increased risk of unintentional injuries in children (mothers with depression) is reduced from 59% to 24% (Table 1, row *o*): CPB = 94.
- Assume that the increased risk of unintentional injuries in children (mothers with depression) is increased from 59% to 104% (Table 1, row *o*): CPB = 130.
- 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 = 62.
- 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 = 202.
- 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 = 86.
- 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 = 130.

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. [649,650]
- **Cost of office visit** - Screening with the EPDS takes approximately 5 minutes.[651] 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.[652] We assumed a cost of $237.95 for this assessment, based on fee code 00610 – full

[649] British Columbia. *Healthy Start Initiative: Provincial Perinatal, Child and Family Public Health Services.* April 2013
[650] 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.
[651] Ibid.
[652] 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*).[653] 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.[654] The cost of psychiatric treatment in BC is $169.75 per hour[655] for a total cost of $3,225 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.[656] The cost of group therapy in BC with eight clients is $269 per hour.[657] The cost of group therapy would therefore be $1,231 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.[658] The weighted average is $1.15/day or $420/year.
- **Hospitalizations avoided due to unintentional injury** – We assumed that the hospital costs per unintentional injury would be $20,524 (Table 2, row *u*).[659]
- **Costs avoided due to increased duration of breastfeeding -** In a previous analysis of the promotion of breastfeeding, we calculated that exclusive breastfeeding to six months is associated with costs avoided of $2,067 per infant/mother pair (Table 2, row *w*).[660]

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[653] Medical Services Commission. *MSC Payment Schedule*. 2017. Available online at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msc-payment-schedule-july-2017.pdf. Accessed February 2018.

[654] 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.

[655] Medical Services Commission. *MSC Payment Schedule*. 2017. Available online at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msc-payment-schedule-july-2017.pdf. Accessed February 2018.

[656] 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.

[657] Medical Services Commission. *MSC Payment Schedule*. 2017. Available online at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msc-payment-schedule-july-2017.pdf. Accessed February 2018.

[658] 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 December 2015.

[659] 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.

[660] 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.

- 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 $23,042 (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	28,226	= Table 1, row c
c	Total # of screens in birth cohort - 100% adherence	28,226	= a * b
d	Adherence with screening	39%	= Table 1, row z
e	Total # of screens in birth cohort - 40% adherence	11,008	= c * d
f	Cost of 10-minute office visit	$34.85	Ref Doc
g	Value of patient time and travel for office visit	$59.38	Ref Doc
h	Portion of 10-minute office visit for screen	50%	√
i	Cost of screening	$518,652	= 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	688	= b * d * j * k
n	# of false positive screens	113	= b * d * j * l
o	Cost per psychiatric assessment	$237.95	√
p	Cost of psychiatric assessment	$238,068	= (m + n) * o + (m + n) * g
q	Cost of CBT / ADM per individual	$1,231	√
r	Costs of patient time for CBT per individual	$1,217	= 41 * (g / 2)
s	Cost of CBT	$1,683,308	= (q + r) *m
t	Hospitalizations due to unintentional injuries avoided with screening	10.3	= Table 1, row p * Table 1, row ad
u	Cost of hospital treatment	$20,524	√
v	Costs avoided due to unintentional injury hospitalizations avoided	-$211,015	= t * u
w	Costs avoided due to exclusive breastfeeding to six months per mother / infant pair	-$2,067	√
x	Reduced risk of exclusive breastfeeding associated with maternal depression	27%	= Table 1, row u
y	Costs avoided due to longer duration of breastfeeding	-$114,588	= Table 1, row v * Table 1, row c * Table 1, row ad * w * x
z	Net screening and patient costs (undiscounted)	$2,114,425	= i + p + s + v + y
aa	QALYs saved (undiscounted)	109	= Table 1, row ae
ab	Net screening and patient costs (1.5% discount)	$2,131,450	Calculated
ac	QALYs saved (1.5% discount)	93	Calculated
ad	**CE ($/QALY saved)**	**$23,042**	= ab / ac

√ = Estimates from the literature

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 = $28,566.
- Assume that the disutility associated with moderate to severe depression is reduced from 0.59 to 0.42 (Table 1, row *f*): CE = $36,843.

- Assume that the disutility associated with moderate to severe depression is increased from 0.59 to 0.76 (Table 1, row *f*): CE = $15,632.
- Assume that the increased risk of unintentional injuries in children (mothers with depression) is reduced from 59% to 24% (Table 1, row *o*): CE = $27,714.
- Assume that the increased risk of unintentional injuries in children (mothers with depression) is increased from 59% to 104% (Table 1, row *o*): CE = $18,030.
- Assume that the effectiveness of screening in reducing the risk of depression is reduced from 32% to 18% (Table 1, row *ab*): CE = $43,255.
- Assume that the effectiveness of screening in reducing the risk of depression is increased from 32% to 59% (Table 1, row *ab*): CE = $11,149.
- Assume that the portion of a 10-minute office visit required for screening is reduced from 50% to 33% (Table 2, row *h*): CE = $21,163.
- Assume that the portion of a 10-minute office visit required for screening is increased from 50% to 67% (Table 2, row *h*): CE = $24,920.
- Assume that the cost of CBT per individual is increased from $1,231 to $3,225 (Table 2, row *q*): CE = $37,644.
- Assume that 50% of individuals use group CBT and 50% ADM (Table 2, row *q*): CE = $20,072.
- 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 = $29,016.
- 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 = $19,357.

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 93 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $23,042 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	**93**	52	171
3% Discount Rate	79	45	146
0% Discount Rate	109	62	202
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$23,042**	$11,149	$43,255
3% Discount Rate	$26,846	$13,163	$50,109
0% Discount Rate	$19,334	$9,124	$36,688
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$10,140	$4,151	$20,319
3% Discount Rate	$12,002	$5,110	$23,715
0% Discount Rate	$8,258	$3,116	$16,997

Screening for Osteoporosis to Prevent Fractures

United States Preventive Services Task Force Recommendations[661]

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)

In discussing the limitations of their recommendation, the USPSTF states that "…evidence is limited on the direct question of the benefits and harms of screening for elevated osteoporotic fracture risk. The indirect evidence pathway rests on studies evaluating (1) the accuracy of screening approaches in identifying osteoporosis and predicting fractures and (2) the benefits of treatment among those with osteoporosis or at high risk for fractures. Other limitations of the evidence base relate to underlying heterogeneity in baseline risk, prior fractures, prior treatment, and duration of follow-up."[662]

Canadian Task Force on Preventive Health Care Recommendations

The CTFPHC does not have a current published recommendation on screening for osteoporosis.[663]

We will follow the approach of the USPSTF and model the path of indirect evidence.

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with screening for osteoporosis in females ages 65 and older.

In modelling CPB, we made the following assumptions:

- Using longitudinal peak bone mineral data from the Canadian multicentre osteoporosis study (CaMos), Berger et al estimate the prevalence of osteoporosis in Canadian women over 65 years old to be 37.1% (95% CI 33.6% – 42.7%).[664]

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[661] 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.
[662] Viswanathan M, Reddy S, Berkman N et al. Screening to Prevent Osteoporotic Fractures: An Evidence Review for the US Preventive Services Task Force. 2018: Available at https://www.ncbi.nlm.nih.gov/books/NBK532075/. Accessed December 2018.
[663] Canadian Task Force on Preventive Health Care. *Published Guidelines.* 2018. Available at https://canadiantaskforce.ca/guidelines/published-guidelines/ Accessed November 2018.
[664] Berger C, Goltzman D, Langsetmo L et al. Peak bone mass from longitudinal data: implications for the prevalence, pathophysiology, and diagnosis of osteoporosis. *Journal of Bone and Mineral Research*. 2010; 25(9): 1948-57.

- Cheng et al. evaluated Medicare claims in the US and estimated the following prevalence of osteoporosis in women by age:[665] 65 – 69 (29.8%), 70 – 74 (33.7%), and 75 – 79 (41.8%), 80 + (48.3%).
- The prevalence of osteoporosis in BC women by age, based on data from BC's Chronic Disease Registry between 2001 and 2017, is as follows: 65 – 69 (19.2%), 70 – 74 (25.3%), and 75 – 79 (30.7%), 80 + (37.1%). [666]

Table 1: Screening for Osteoporosis in Women Ages 65 and Older
Prevalence of Osteoporosis
In a BC Birth Cohort of 40,000

Age	# in Cohort	Deaths in Cohort	Death Rate / 100,000	Years Lived	Prevalence of Osteoporosis	Years Lived with Osteoporosis
64	18,572					
65	18,456	116	629	18,392	19.2%	3,543
66	18,329	127	692	18,259	19.2%	3,519
67	18,190	139	765	18,113	19.2%	3,492
68	18,037	152	845	17,954	19.2%	3,463
69	17,870	167	936	17,778	19.2%	3,431
70	17,687	183	1,036	17,586	25.3%	4,475
71	17,486	201	1,151	17,375	25.3%	4,424
72	17,265	221	1,278	17,144	25.3%	4,368
73	17,023	242	1,422	16,890	25.3%	4,307
74	16,758	265	1,584	16,612	25.3%	4,240
75	16,467	291	1,766	16,307	30.7%	5,055
76	16,148	319	1,974	15,973	30.7%	4,957
77	15,799	349	2,209	15,608	30.7%	4,850
78	15,418	381	2,474	15,209	30.7%	4,733
79	15,001	417	2,777	14,774	30.7%	4,605
80	14,547	454	3,121	14,300	37.1%	5,397
81	14,053	494	3,514	13,785	37.1%	5,214
82	13,517	536	3,964	13,228	37.1%	5,015
83	12,938	579	4,477	12,626	37.1%	4,800
84	12,314	624	5,066	11,980	37.1%	4,569
85	11,645	669	5,747	11,288	37.1%	4,320
86	10,931	714	6,532	10,553	37.1%	4,055
Total		**7,640**		**341,738**	**28.3%**	**96,834**

- We used the age-specific estimates of prevalence from the BC Chronic Disease Registry applied to our BC cohort of women starting at age 65 and continuing to age 86 (based on the average life expectancy of 22 years for a 65 year old women) and estimated a prevalence in BC of 28.3% (see Table 1), lower than the 37.1% identified by Berger et al.[667]

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[665] Cheng H, Gary L, Curtis J et al. Estimated prevalence and patterns of presumed osteoporosis among older Americans based on Medicare data. *Osteoporosis International*. 2009; 20(9): 1507-15.
[666] Aciemme (Sam) Ospan, Senior Manager, Lifetime Prevention Schedule, Healthy Living and Health Promotion Branch, BC Ministry of Health. September 13, 2019. Personal communication.
[667] Berger C, Goltzman D, Langsetmo L et al. Peak bone mass from longitudinal data: implications for the prevalence, pathophysiology, and diagnosis of osteoporosis. *Journal of Bone and Mineral Research*. 2010; 25(9): 1948-57.

- A 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).[668] The various types of fractures were identified based on International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Canada (ICD-10-CA) codes. We compiled the relevant data for women ages 60-89 and calculated the incidence rate per 100,000 by age group (60-69, 70-79 and 80-89) by fracture type (see Table 2).

Table 2: Screening for Osteoporosis in Women Ages 65 and Older
Incidence of Fractures by Type of Fracture and Age

	Age Group			
	60 - 69	70 - 79	80 - 89	Total
Female Population in 2011	1,760,036	1,085,293	681,159	3,526,488
Number of Fractures in Canada in 2011				
Hip	1,826	4,238	9,612	15,676
Vertebral	904	1,673	2,540	5,117
All Other				
Wrist	7,584	5,131	4,486	17,201
Humerus	1,844	2,015	2,423	6,282
Other	8,867	8,055	11,779	28,701
Multiple	1,271	1,835	2,769	5,875
Subtotal All Other	19,566	17,036	21,457	58,059
Total	**22,296**	**22,947**	**33,609**	**78,852**
Fracture Rate per 100,000 person years				
Hip	104	390	1,411	445
Vertebral	51	154	373	145
All Other				
Wrist	431	473	659	488
Humerus	105	186	356	178
Other	504	742	1,729	814
Multiple	72	169	407	167
Subtotal All Other	1,112	1,570	3,150	1,646
Total	**1,267**	**2,114**	**4,934**	**2,236**

- For modelling purposes, we assumed a hip fracture rate of 104 / 100,000 person years in women ages 65-69, 390 / 100,000 person years in women ages 70-79 and 1,411 / 100,000 person years in women ages 80-86. Furthermore, we assumed a vertebral fracture rate of 51 / 100,000 person years in women ages 65-69, 154 / 100,000 person years in women ages 70-79 and 373 / 100,000 person years in women ages 80-86. Finally, we assumed a non-hip, non-vertebral fracture rate of 1,112 / 100,000 person years in women ages 65-69, 1,570 / 100,000 person years in women ages 70-79 and 3,150 / 100,000 person years in women ages 80-86.

[668] 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.

- Lippuner and colleagues estimated that 71% of hip fractures in 65-74 year olds are attributable to osteoporosis.[669] This increases to 91% in 74-84 year olds. Similarly, approximately 81% of vertebral fractures in 65-84 year olds are attributable to osteoporosis. Finally, non-hip, non-vertebral, non-stress fractures attributable to osteoporosis ranged from 50-78% for ages 65-74 and between 60-91% for ages 75+.
- In their economic modelling, Hopkins et al assumed that 100% of hip and vertebral fractures are attributable to osteoporosis while 81.5% of all other fractures in women are attributable to osteoporosis.[670]

- For modelling purposes, we assumed that 71% of hip fractures in 65-74 year olds are attributable to osteoporosis, increasing to 91% at age 75, that 81% of vertebral fractures are attributable to osteoporosis and 81.5% of all other fractures are attributable to osteoporosis (see Table 3).

- In Table 3, we show that for the 22 years modelled for the cohort beginning at age 65, the total number of osteoporosis-attributable fractures is 7,379. Of these, 1,708 are hip fractures, 507 are vertebral fractures and 5,164 are other fractures.

Table 3: Screening for Osteoporosis in Women Ages 65 and Older
Number of Fractures Attributable to Osteoporosis
In a BC Birth Cohort of 40,000

				Rate per 100,000 Person Years			*Number of Fractures*			*Percent of Fractures Attributable to Osteoporosis*			*Fractures Attributable to Osteoporosis*		
Age	# in Cohort	Deaths in Cohort	Years Lived	Hip Fracture	Vertebral Fracture	All Other Fractures	Hip Fracture	Vertebral Fracture	All Other Fractures	Hip Fracture	Vertebral Fracture	All Other Fractures	Hip Fracture	Vertebral Fracture	All Other Fractures
64	18,572														
65	18,456	116	18,392	104	51	1,112	19	9	204	71.0%	81.0%	81.5%	14	8	167
66	18,329	127	18,259	104	51	1,112	19	9	203	71.0%	81.0%	81.5%	13	8	165
67	18,190	139	18,113	104	51	1,112	19	9	201	71.0%	81.0%	81.5%	13	8	164
68	18,037	152	17,954	104	51	1,112	19	9	200	71.0%	81.0%	81.5%	13	7	163
69	17,870	167	17,778	104	51	1,112	18	9	198	71.0%	81.0%	81.5%	13	7	161
70	17,687	183	17,586	390	154	1,570	69	27	276	71.0%	81.0%	81.5%	49	22	225
71	17,486	201	17,375	390	154	1,570	68	27	273	71.0%	81.0%	81.5%	48	22	222
72	17,265	221	17,144	390	154	1,570	67	26	269	71.0%	81.0%	81.5%	48	21	219
73	17,023	242	16,890	390	154	1,570	66	26	265	71.0%	81.0%	81.5%	47	21	216
74	16,758	265	16,612	390	154	1,570	65	26	261	71.0%	81.0%	81.5%	46	21	213
75	16,467	291	16,307	390	154	1,570	64	25	256	91.0%	81.0%	81.5%	58	20	209
76	16,148	319	15,973	390	154	1,570	62	25	251	91.0%	81.0%	81.5%	57	20	204
77	15,799	349	15,608	390	154	1,570	61	24	245	91.0%	81.0%	81.5%	55	19	200
78	15,418	381	15,209	390	154	1,570	59	23	239	91.0%	81.0%	81.5%	54	19	195
79	15,001	417	14,774	390	154	1,570	58	23	232	91.0%	81.0%	81.5%	52	18	189
80	14,547	454	14,300	1,411	373	3,150	202	53	450	91.0%	81.0%	81.5%	184	43	367
81	14,053	494	13,785	1,411	373	3,150	195	51	434	91.0%	81.0%	81.5%	177	42	354
82	13,517	536	13,228	1,411	373	3,150	187	49	417	91.0%	81.0%	81.5%	170	40	340
83	12,938	579	12,626	1,411	373	3,150	178	47	398	91.0%	81.0%	81.5%	162	38	324
84	12,314	624	11,980	1,411	373	3,150	169	45	377	91.0%	81.0%	81.5%	154	36	308
85	11,645	669	11,288	1,411	373	3,150	159	42	356	91.0%	81.0%	81.5%	145	34	290
86	10,931	714	10,553	1,411	373	3,150	149	39	332	91.0%	81.0%	81.5%	136	32	271
Total		**7,640**	**341,738**	**577**	**183**	**1,854**	**1,971**	**626**	**6,337**				**1,708**	**507**	**5,164**

- 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 women 50 and older with a hip fracture compared to those without.[671] A

[669] Lippuner K, Golder M and Greiner R. Epidemiology and direct medical costs of osteoporotic fractures in men and women in Switzerland. *Osteoporosis International*. 2005; 16(2): S8-S17.
[670] 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.
[671] 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.

hazard ratio of 1.00 suggests that the death rate in the group of interest is the same as that in the general population.

- 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 (1.58 – 2.87) for hip fractures, 1.82 (1.28 – 2.57) for vertebral fractures and 1.38 (1.18 – 1.62) for non-hip, non-vertebral fractures.[672]
- In his commentary on mortality after osteoporotic fractures, Schousboe discusses some of the links between fracture and mortality. He notes that "…after adjustment for comorbidity, and/or functional status, some studies report longer-term excess mortality after hip fracture and others do not."[673]
- We will model the risk of excess mortality for women with a hip fracture using a hazard ratio of 2.87 in the first year after hip fracture (and vary this from 2.52 to 3.27 in our sensitivity analysis). We will model the risk of excess mortality for women with vertebral fractures at 1.82 (varied between 1.28 and 2.57) and for all other fractures (i.e. non-hip, non-vertebral) we use a hazard ratio of 1.38 (varied between 1.18 and 1.62). We conservatively apply the excess mortality only in the year of the incident fracture.
- Based on the number of osteoporotic fractures calculated in Table 3, we calculate the number of deaths and life years lost attributable to osteoporotic fractures (see Table 4).
- In Table 4, we show that 181 excess deaths are attributable to osteoporosis-related fractures, 113 of which are due to hip fractures, 13 to vertebral fractures and 55 to other fractures. Combining the year when the deaths occur with life expectancy at the time of death, we further show that a total of 1,000 life years are lost due to osteoporosis-related fractures. Of these, 571 life years lost are due to hip fractures, 75 are due to vertebral fractures and 354 are due to other fractures.

[672] 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.
[673] Schousboe JT. Mortality After Osteoporotic Fractures: What Proportion Is Caused by Fracture and Is Preventable? *Journal of Bone and Mineral Research*. 2017; 32(9): 1783-8.

Table 4: Screening for Osteoporosis in Women Ages 65 and Older
Number of Deaths Attributable to Osteoporotic Fracture
In a BC Birth Cohort of 40,000

					Fractures Attributable to Osteoporosis			*Hazard Ratio of Excess Death Due to Incident Fracture*			*Excess Deaths Due to Incident Fracture*				*Life Years Lost Due to Osteoporotic Fractures*		
Age	# in Cohort	Deaths in Cohort	Years Lived	Death Rate / 100,000	Hip Fracture	Vertebral Fracture	All Other Fractures	Hip Fracture	Vertebral Fracture	All Other Fractures	Hip Fracture	Vertebral Fracture	All Other Fractures	Life Expectancy	Hip Fracture	Vertebral Fracture	All Other Fractures
64	18,572																
65	18,456	116	18,392	629	14	8	167	2.87	1.82	1.38	0.16	0.04	0.40	22	4	1	9
66	18,329	127	18,259	692	13	8	165	2.87	1.82	1.38	0.17	0.04	0.43	21	4	1	9
67	18,190	139	18,113	765	13	8	164	2.87	1.82	1.38	0.19	0.05	0.48	20	4	1	10
68	18,037	152	17,954	845	13	7	163	2.87	1.82	1.38	0.21	0.05	0.52	19	4	1	10
69	17,870	167	17,778	936	13	7	161	2.87	1.82	1.38	0.23	0.06	0.57	18	4	1	10
70	17,687	183	17,586	1,036	49	22	225	2.87	1.82	1.38	0.94	0.19	0.89	17	16	3	15
71	17,486	201	17,375	1,151	48	22	222	2.87	1.82	1.38	1.04	0.20	0.97	16	17	3	16
72	17,265	221	17,144	1,278	48	21	219	2.87	1.82	1.38	1.14	0.22	1.06	15	17	3	16
73	17,023	242	16,890	1,422	47	21	216	2.87	1.82	1.38	1.24	0.25	1.17	14	17	3	16
74	16,758	265	16,612	1,584	46	21	213	2.87	1.82	1.38	1.36	0.27	1.28	13	18	4	17
75	16,467	291	16,307	1,766	58	20	209	2.87	1.82	1.38	1.91	0.29	1.40	12	23	4	17
76	16,148	319	15,973	1,974	57	20	204	2.87	1.82	1.38	2.10	0.32	1.53	11	23	4	17
77	15,799	349	15,608	2,209	55	19	200	2.87	1.82	1.38	2.29	0.35	1.68	10	23	4	17
78	15,418	381	15,209	2,474	54	19	195	2.87	1.82	1.38	2.50	0.39	1.83	9	23	3	16
79	15,001	417	14,774	2,777	52	18	189	2.87	1.82	1.38	2.73	0.42	1.99	8	22	3	16
80	14,547	454	14,300	3,121	184	43	367	2.87	1.82	1.38	10.72	1.11	4.35	7	75	8	30
81	14,053	494	13,785	3,514	177	42	354	2.87	1.82	1.38	11.63	1.20	4.73	6	70	7	28
82	13,517	536	13,228	3,964	170	40	340	2.87	1.82	1.38	12.59	1.30	5.12	5	63	6	26
83	12,938	579	12,626	4,477	162	38	324	2.87	1.82	1.38	13.57	1.40	5.51	4	54	6	22
84	12,314	624	11,980	5,066	154	36	308	2.87	1.82	1.38	14.57	1.50	5.92	3	44	5	18
85	11,645	669	11,288	5,747	145	34	290	2.87	1.82	1.38	15.58	1.61	6.33	2	31	3	13
86	10,931	714	10,553	6,532	136	32	271	2.87	1.82	1.38	16.55	1.71	6.72	1	17	2	7
Total		**7,640**	**341,738**		**1,708**	**507**	**5,164**				**113**	**13**	**55**		**571**	**75**	**354**

- In Table 5, we subtract the number of deaths from the number of osteoporosis fracture events to determine the number of people still living after osteoporosis-related fractures. This comes to 7,198 people in total, 1,594 of whom have had hip fractures, 494 of whom have had vertebral fractures and 5,110 of whom have had other fractures.

Table 5: Screening for Osteoporosis in Women Ages 65 and Older Number Living with Fracture In a BC Birth Cohort of 40,000									
	Fractures Attributable to Osteoporosis			*Excess Deaths Due to Incident Fracture*			*Number Living with Fractures*		
Age	Hip Fracture	Vertebral Fracture	All Other Fractures	Hip Fracture	Vertebral Fracture	All Other Fractures	Hip Fracture	Vertebral Fracture	All Other Fractures
64									
65	14	8	167	0.2	0.0	0.4	13	8	166
66	13	8	165	0.2	0.0	0.4	13	8	165
67	13	8	164	0.2	0.0	0.5	13	7	164
68	13	7	163	0.2	0.1	0.5	13	7	162
69	13	7	161	0.2	0.1	0.6	13	7	161
70	49	22	225	0.9	0.2	0.9	48	22	224
71	48	22	222	1.0	0.2	1.0	47	21	221
72	48	21	219	1.1	0.2	1.1	46	21	218
73	47	21	216	1.2	0.2	1.2	46	21	215
74	46	21	213	1.4	0.3	1.3	45	20	211
75	58	20	209	1.9	0.3	1.4	56	20	207
76	57	20	204	2.1	0.3	1.5	55	20	203
77	55	19	200	2.3	0.4	1.7	53	19	198
78	54	19	195	2.5	0.4	1.8	52	19	193
79	52	18	189	2.7	0.4	2.0	50	18	187
80	184	43	367	10.7	1.1	4.4	173	42	363
81	177	42	354	11.6	1.2	4.7	165	40	349
82	170	40	340	12.6	1.3	5.1	157	39	334
83	162	38	324	13.6	1.4	5.5	149	37	319
84	154	36	308	14.6	1.5	5.9	139	35	302
85	145	34	290	15.6	1.6	6.3	129	32	283
86	136	32	271	16.6	1.7	6.7	119	30	264
Total	**1,708**	**507**	**5,164**	**113**	**13**	**55**	**1,594**	**494**	**5,110**

- Betram et al use a hip-fracture disability weight of 0.272 based on Global Burden of Disease data to model hip-fracture health burden. The authors state that "29% of hip fracture cases in the elderly do not reach their pre-fracture levels 1 year post-fracture. Those who do recover tend to reach their pre-fracture levels of functioning at around 6 months."[674]
- Vertebral fracture patients are often advised that it will be a full year before they reach their pre-fracture levels of functioning.[675]
- Kanis and colleagues[676] assign different disability weights based on expert opinion derived from a 1998 National Osteoporosis Foundation paper.[677] They suggest a first-year utility loss with vertebral, rib and pelvis fractures of 0.0502, with humerus, clavicle, scapula, sternum and distal forearm fractures of 0.0464 and hip, other femoral fractures and tibia and fibula fractures of 0.4681.[678]

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[674] Bertram M, Norman R, Kemp L et al. Review of the long-term disability associated with hip fractures. *Injury Prevention*. 2011; 17: 365-70.
[675] Dr. Susan Purkiss, MD, FRCPC, Clinical Instructor, General Internal Medicine, Faculty of Medicine, UBC. January 16, 2019. Personal communication.
[676] Kanis J, Oden A, Johnell O et al. The burden of osteoporotic fractures: a method for setting intervention thresholds. *Osteoporosis International.* 2001; 12(5): 417-27.
[677] Eddy D, CC JJ, Cummings S et al. Osteoporosis: review of the evidence for prevention, diagnosis, and treatment and cost-effectiveness analysis. Status report. *Osteoporosis International*. 1998; 8(SUPPL. 4):
[678] Kanis J, Oden A, Johnell O et al. The burden of osteoporotic fractures: a method for setting intervention thresholds. *Osteoporosis International.* 2001; 12(5): 417-27.

- The USPSTF found no harms of screening in terms of anxiety or quality of life.[679]
- We model that 29% of hip fracture patients do not recover their pre-fracture functioning, and have a reduced quality of life for their remaining years of life. We model that the remaining hip fracture patients recover within an average of 6 months. We model vertebral fracture patients recover to pre-fracture levels of functioning in one year and assume that all other fracture types recover in an average of 6 months. We model a 0.27 reduction in QoL following a hip fracture, a 0.050 reduction in QoL for vertebral fractures and a 0.046 QoL reduction for other fractures. Compared to an average quality of life of 0.76 of a 70-79 year old (see Reference Document), this results in a 35.5% (0.27 / 0.76) reduction in QoL due to hip fracture, a 6.6% reduction due to vertebral fracture and a 6.0% reduction due to other fractures.
- We apply our assumptions to the individuals living with fractures and calculate QALYs lost attributable to osteoporotic fractures in Table 6. For example, at age 65, 29% of the 13.4 hip fractures (3.9) will have a lifelong quality decrement. The QALYs lost in this group is the number multiplied by the decrement multiplied by the number of life years remaining, and comes to 30.5 (= 3.9 * 0.355 * 22). The remaining 9.5 hip fractures have the decrement applied for half a year, resulting in 1.7 QALY lost (9.5 * 0.355 * 0.5). The total QALYs lost due to hip fracture is the sum of these two, or 32 QALYs.
- Table 6 shows that the total QALYs lost due to osteoporosis-related fractures is 1,606. Hip fractures account for 1,420 of the QALYs lost, with vertebral fractures and other fractures accounting for 33 and 153 QALYs lost respectively.

[679] Viswanathan M, Reddy S, Berkman N et al. Screening to Prevent Osteoporotic Fractures: An Evidence Review for the US Preventive Services Task Force. 2018: Available at https://www.ncbi.nlm.nih.gov/books/NBK532075/. Accessed December 2018.

Table 6: Screening for Osteoporosis in Women Ages 65 and Older Quality Adjusted Life Years for those Living with Fracture In a BC Birth Cohort of 40,000														
	Number Living with Fractures			*Lifetime Disability in Hip Fracture Cases*		*QoL Decrement*			*Length of Time for QoL Decrement*			*Quality Adjusted Life Years Lost Due to Osteoporotic Fractures*		
Age	Hip Fracture	Vertebral Fracture	All Other Fractures	Percentage	Number	Hip Fracture	Vertebral Fracture	All Other Fractures	Lifetime Hip Cases	Vertebral Fracture Cases	All other cases	Hip Fracture	Vertebral Fracture	All Other Fractures
64														
65	13	8	166	29%	3.9	0.36	0.07	0.06	22	1.0	0.5	32	0.5	5.0
66	13	8	165	29%	3.9	0.36	0.07	0.06	21	1.0	0.5	30	0.5	4.9
67	13	7	164	29%	3.8	0.36	0.07	0.06	20	1.0	0.5	29	0.5	4.9
68	13	7	162	29%	3.8	0.36	0.07	0.06	19	1.0	0.5	27	0.5	4.9
69	13	7	161	29%	3.7	0.36	0.07	0.06	18	1.0	0.5	25	0.5	4.8
70	48	22	224	29%	13.9	0.36	0.07	0.06	17	1.0	0.5	90	1.4	6.7
71	47	21	221	29%	13.7	0.36	0.07	0.06	16	1.0	0.5	84	1.4	6.6
72	46	21	218	29%	13.5	0.36	0.07	0.06	15	1.0	0.5	77	1.4	6.5
73	46	21	215	29%	13.2	0.36	0.07	0.06	14	1.0	0.5	71	1.4	6.4
74	45	20	211	29%	13.0	0.36	0.07	0.06	13	1.0	0.5	65	1.4	6.3
75	56	20	207	29%	16.3	0.36	0.07	0.06	12	1.0	0.5	76	1.3	6.2
76	55	20	203	29%	15.9	0.36	0.07	0.06	11	1.0	0.5	69	1.3	6.1
77	53	19	198	29%	15.4	0.36	0.07	0.06	10	1.0	0.5	61	1.3	5.9
78	52	19	193	29%	14.9	0.36	0.07	0.06	9	1.0	0.5	54	1.2	5.8
79	50	18	187	29%	14.4	0.36	0.07	0.06	8	1.0	0.5	47	1.2	5.6
80	173	42	363	29%	50.1	0.36	0.07	0.06	7	1.0	0.5	146	2.8	10.9
81	165	40	349	29%	48.0	0.36	0.07	0.06	6	1.0	0.5	123	2.7	10.5
82	157	39	334	29%	45.6	0.36	0.07	0.06	5	1.0	0.5	101	2.6	10.0
83	149	37	319	29%	43.1	0.36	0.07	0.06	4	1.0	0.5	80	2.4	9.6
84	139	35	302	29%	40.4	0.36	0.07	0.06	3	1.0	0.5	61	2.3	9.0
85	129	32	283	29%	37.5	0.36	0.07	0.06	2	1.0	0.5	43	2.1	8.5
86	119	30	264	29%	34.5	0.36	0.07	0.06	1	1.0	0.5	27	2.0	7.9
Total	**1,594**	**494**	**5,110**		**462**							**1,420**	**33**	**153**

- The USPSTF found convincing evidence that "…screening can detect osteoporosis and that treatment of women with osteoporosis can provide at least a moderate benefit in preventing fractures."[680]

- We have assumed a potential screening rate of 57.8% (Table 7, row *p*).[681] We assume that all persons with a positive screen for osteoporosis are prescribed medication.

- Fraser and colleagues report on the accuracy of a Canadian modification of the FRAX® fracture prediction screening tool. Combining FRAX® with BMD (bone mineral density) testing resulted in an area under the receiver operator curve of 0.69 (a poor to fair score) for predicting major osteoporotic fractures and 0.80 (a good score) for predicting hip fractures. When just the BMD testing results are used, the equivalent results are 0.66 for major osteoporotic fractures and 0.76 for hip fractures.[682]

- For women over 65, the USPSTF[683] does not explicitly recommend a risk assessment, only DXA screening.[684] We model accordingly.

[680] 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.
[681] 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.
[682] Fraser L-A, Langsetmo L, Berger C et al. Fracture prediction and calibration of a Canadian FRAX® tool: a population-based report from CaMos. *Osteoporosis International*. 2011; 22(3): 829-37.
[683] Viswanathan M, Reddy S, Berkman N et al. Screening to Prevent Osteoporotic Fractures: An Evidence Review for the US Preventive Services Task Force. 2018: Available at https://www.ncbi.nlm.nih.gov/books/NBK532075/. Accessed December 2018.
[684] The USPSTF suggests that a risk assessment, such as FRAX®, is "a reasonable approach" to use on women less than 65 who present with at least one risk factor.

- We model a single screening at age 65 to detect osteoporosis and assume that 76% of hip fractures and 66% of all other fractures could be predicted by screening with DXA alone (Table 7, rows *q* & *r*).

- Bisphosphonates have been shown effective in building back bone mineral density and were the most frequently studied medication referenced by the USPSTF.[685] We therefore model treatment as being carried out with bisphosphonates.

- The review by the USPSTF found that bisphosphonates were found to 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).[686]

- Long-term treatment compliance is critical in achieving a reduced risk of fracture. 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.[687] 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.[688] 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%).

- For the 36.5% of patients in the high compliance group (the 80-100% group) (Table 7, row *s*), we model a 23% reduction in hip fractures, a 26% reduction in vertebral fractures and a 20% reduction in all other fractures (Table 7, rows *t* to *v*).

- Shepstone and colleagues[689] recently published an RCT investigating the potential benefits of a fracture-risk based, community screening program in older women (ages 70-85) in the UK. BMD measurement was only applied to a selected subgroup of these women based on their risk assessment using the Fracture Risk Assessment Tool (FRAX). They found that this screening approach, followed by appropriate osteoporosis medication, did not reduce the overall incidence of osteoporosis-related fractures (hazard ratio [HR] 0.94, 95% CI 0.85 – 1.03), nor the overall incidence of all clinical fractures (0.94, 0.86 – 1.03). It did, however, reduce the incidence of hip fractures (0.72, 0.59 – 0.89). As noted previously, we do not assume any risk stratification in our modelling.

685 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.
686 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.
687 Patrick AR, Brookhart MA, Losina E et al. The complex relation between bisphosphonate adherence and fracture reduction. *The Journal of Clinical Endocrinology & Metabolism*. 2010; 95(7): 3251-9.
688 Patrick AR, Brookhart MA, Losina E et al. The complex relation between bisphosphonate adherence and fracture reduction. *The Journal of Clinical Endocrinology & Metabolism*. 2010; 95(7): 3251-9.
689 Shepstone L, Lenaghan E, Cooper C et al. Screening in the community to reduce fractures in older women (SCOOP): a randomised controlled trial. *The Lancet*. 2018; 391(10122): 741-7.

Based on these assumptions, the CPB associated with screening for osteoporosis in females ages 65 and older is 91 QALYs (see Table 7, row *af*).

Table 7: CPB of Screening for Osteoporosis in Women 65+ In a BC Birth Cohort of 40,000			
Row Label	**Variable**	**Base case**	**Data Source**
a	Expected life-years between age 65 and 86	341,738	Table 1
b	Prevalence of osteoporosis	38.5%	Table 1
c	Years lived with osteoporosis	131,418	= a * b
d	Expected number of hip fractures	1,971	Table 3
e	Expected number of vertebral fractures	626	Table 3
f	Expected number of all other fractures	6,337	Table 3
g	Expected number of hip fractures attributable to osteoporosis	1,708	Table 3
h	Expected number of vertebral fractures attributable to osteoporosis	507	Table 3
i	Expected number of all other fractures attributable to osteoporosis	5,164	Table 3
j	Life years lost due **death from** to osteoporotic hip fractures	571	Table 4
k	Life years lost due to **death from** osteoporotic vertebral fractures	75	Table 4
l	Life years lost due to **death from** all other osteoporotic fractures	354	Table 4
m	QALYs lost due to **living with** osteoporotic hip fractures	1,420	Table 6
n	QALYs lost due to **living with** osteoporotic vertebral fractures	33	Table 6
o	QALYs lost due to **living with** osteoporotic other fractures	153	Table 6
p	Screening Rate	57.8%	√
q	Accuracy of bone density screening to predict hip fractures	76%	√
r	Accuracy of bone density screening to predict non-hip fractures	66%	√
s	Long term compliance rate with medical treatment	36.5%	√
t	Hip fracture reduction rate due to treatment	23.0%	√
u	Vertebral fracture reduction rate due to treatment	26.0%	√
v	Other fracture reduction rate due to treatment	20.0%	√
w	Hip fractures avoided due to treatment	63	= g * p * q * s * t
x	Vertebral fractures avoided due to treatment	18	= h * p * r * s * u
y	Other fractures avoided due to treatment	144	= i * p * r * s * v
z	Life years gained **(deaths avoided)** due to screening, osteoporotic hip fractures	21	= j * p * q * s * t
aa	Life years gained **(deaths avoided)** due to screening, osteoporotic vertebral fractures	2.7	= k * p * r * s * u
ab	Life years gained **(deaths avoided)** due to screening, osteoporotic other fractures	10	= l * p * r * s * v
ac	QALYs gained due to screening in those **living with** osteoporotic hip fractures	52.4	= m * p * q * s * t
ad	QALYs gained due to screening in those **living with** osteoporotic vertebral fractures	1.2	= n * p * r * s * u
ae	QALYs gained due to screening in those **living with** osteoporotic other fractures	4.3	= o * p * r * s * v
af	Total QALYs gained due to screening (going from 0% to 57.8%)	**91**	= z + aa + ab + ac + ad + ae

√ = Estimates from the literature

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

- Assume that the hazard ratio (HR) for death after hip fracture is reduced from 2.87 to 2.52, the HR for death after vertebral fractures is reduced from 1.82 to 1.28 and the HR for death after other fractures is reduced from 1.38 to 1.18 (Table 4): CPB = 88
- Assume that the hazard ratio (HR) for death after hip fracture is increased from 2.87 to 3.27, the HR for death after vertebral fractures is increased from 1.82 to 2.57 and the HR for death after other fractures is increased from 1.38 to 1.62 (Table 4): CPB = 96
- Assume that the hip fracture reduction rate is reduced from 23% to 8% (Table 7, row *t*), the vertebral fracture reduction rate is reduced from 26% to 12% (Table 7, row *u*) and the other fracture reduction rate is reduced from 20% to 9% (Table 7, row *v*): CPB = 34

- Assume that the hip fracture reduction rate is increased from 23% to 36% (Table 7, row *t*), the vertebral fracture reduction rate is increased from 26% to 38% (Table 7, row *u*) and the other fracture reduction rate is increased from 20% to 29% (Table 7, row *v*): CPB = 141

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with screening for osteoporosis in women ages 65 and older.

In modelling CE, we made the following assumptions:

- We model that 57.8%[690] of 65 year old women are referred to and receive a bone density (DXA) scan (Table 8, row *b*). This rate takes into account both physician adherence (willingness to make the referral) and patient adherence (willingness to get the scan done).
- The cost of each 10 minute primary care provider office visit is $34.85 (Reference Document) (Table 8, row *d)*
- The value of patient time for each visit to a primary care office and for bone density scanning is $59.38 (Reference Document) (Table 8, row *e*).
- The proportion of each office visit attributable to screening is 50% (Reference Document) (Table 8, row *f*).
- We model that all those who receive a DXA scan have also visited their primary care provider to receive the referral for the scan. During this appointment, a risk assessment (e.g. FRAX®) could be conducted within the portion of the office visit attributable to screening. The FRAX® tool adapted for the Canadian population can be found online at no cost.[691]
- According to the BC Medical Services Plan Fee-For-Service Payment Analysis for 2012/13 – 2016/17, a single area bone density scan (fee item 8688) averages $66.94 per scan. Adding a second area (fee item 8689) costs an additional $45.88 per scan. A second area scan occurred at a rate of approximately 95.2% of single area scans.[692]
- We assume that bone scans to determine bone mineral density are conducted by means of DXA and model the cost of the average bone scan as $66.94 + (0.952 * 45.88) = $110.62 (Table 8, row *h*).
- In the study by Patrick et al[693] of 19,987 individuals initiating treatment with bisphosphonates, they found that 31.8% had a cumulative proportion of days covered (i.e. the proportion of days taking medication) between 0 – 19%, 11.3% had a proportion of days covered (PDC) between 20 – 39%, 8.8% had a PDC between 40 – 59%, 11.5% had a PDC between 60 – 79% and 36.5% had a PDC between 80 -100%.

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690 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.
691 University of Sheffield. *FRAX® Fracture Risk Assessment Tool*. 2018. Available at https://www.sheffield.ac.uk/FRAX/tool.aspx?country=19. Accessed January 2019.
692 B.C. Ministry of Health, Health Sector Information, Analysis & Reporting Division. *MSP Fee-For-Service Payment Analysis 2012/2013 - 2016/2017*. 2017. Available at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/ffs_complete.pdf. Accessed November 2018.
693 Patrick AR, Brookhart MA, 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 8, rows *l* to *p*). Their study assessed medication compliance rates over a 300 day period.

- For modelling purposes, we assume that each PDC group has a compliance rate at the midpoint of their range. Groups with a PDC of between 0 - 79% stop taking medication after 300 days. For the high compliance group, we assume that the medication is taken for 5 years in the base model (Table 8, row *y*). In the sensitivity analysis, we model 5 years of taking medication, followed by a 5 year medication 'holiday' followed by a further 5 years of taking medication.

- Alendronate is the most commonly prescribed bisphosphonate in BC and is typically prescribed to be taken orally once per week at a dose of 70mg.[694]

- We model weekly treatment with 70mg alendronate. The cost per 70mg pill ranges from $2.17 - $13.88 in BC.[695] Only two records for BC, however, showed a price above $3.21. We assume pricing above $3.21 per 70mg are outliers and model using the mid-point of the $2.17 - $3.21 range for the pills, or $2.69. The dispensing fee ranges from $4.49 - $13.99, with only a single dispensing fee below $9.95. We assume a dispensing fee at the midpoint of $9.95 - $13.99 (or $11.97) and assume a 3-month dose is dispensed each time.

- We model the annual cost of treatment as $187.76 (($2.69 * 52) + (4 * $11.97)). Translating this into a daily cost results in $0.51 / day ($187.76 / 365). Using the low and high numbers of the ranges above (excluding outliers), we use a range of between $0.42 and $0.62 / day in the sensitivity analysis (Table 8, row *v*).

- A December 20, 2018 publication by Reid and colleagues assessed the efficacy of 4 infusions of 5mg zoledronate (or zoledronic acid) at 18-month intervals vs. placebo in older women (mean age of 71) with osteopenia.[696] They noted a 37% (HR of 0.63, 94% CI 0.50 – 0.79) reduction in fragility fractures in women receiving zoledronate. The efficacy of such a reduction in medication dose and frequency is encouraging for the potential compliance with and cost of treatment.

- In comparing less-frequent zoledronic acid infusions with more frequent bisphosphonate treatment regimes, Lozano and Sanchez-Fidalgo report that "patients appear to have (a) preference for less frequent dosing. Switching from oral to intravenous therapy…may allow obtaining better outcomes in adherence to osteoporosis treatment."[697]

- Potential changes in adherence and the costs associated with zoledronic acid infusions are two important variables that should be considered in future updates of this model, should the results observed by Reid and colleagues[698] be confirmed for patients with osteoporosis.

- We model one additional visit to a primary care provider for monitoring medication for those with low compliance (PDC of 0 – 79%) (Table 8, row ab) and one **annual**

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[694] Dr. Susan Purkiss, MD, FRCPC, Clinical Instructor, General Internal Medicine, Faculty of Medicine, UBC. January 16, 2019. Personal communication.

[695] Pacific Blue Cross. *Pharmacy Compass*. 2018. Available online at https://www.pac.bluecross.ca/pharmacycompass. Accessed January 2019.

[696] Reid IR, Horne AM, Mihov B et al. Fracture prevention with zoledronate in older women with osteopenia. *New England Journal of Medicine*. 2018; 379(25): 2407-16.

[697] Lozano MJF and Sánchez-Fidalgo S. Adherence and preference of intravenous zoledronic acid for osteoporosis versus other bisphosphonates. *European Journal of Hospital Pharmacy.* 2019; 26(1): 4-9.

[698] Reid IR, Horne AM, Mihov B et al. Fracture prevention with zoledronate in older women with osteopenia. *New England Journal of Medicine*. 2018; 379(25): 2407-16.

visit to a primary care provider for monitoring medication for those with high compliance (PDC of 80 – 100%) (Table 8, row *i*).

- A recent Canadian study by Hopkins et al. estimated the annual direct medical costs of a hip fracture to be $61,540, the cost of a vertebral fracture to be $25,965 and the cost of "other" fractures to be $13,579 (all in 2014 CAD).[699] Costs included acute care, rehabilitation care, long term care, home care, outpatient physician services and mobility devices.
- We adjusted the costs calculated by Hopkins et al. to 2017 CAD and use $62,152 for the total cost per hip fracture (Table 8, row *ai*), $26,223 (Table 8, row *aj*) per vertebral fracture and $13,714 for all other fractures (Table 8, row *ak*).

Based on these assumptions, the CE associated with screening for osteoporosis in women ages 65 and older is cost saving (-$29,412/QALY) (see Table 8, row *ar*).

[699] 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.

Table 8: Cost Effectiveness of Osteoporosis Screening in Women 65+ In a BC Birth Cohort of 40,000			
Row Label	Variable	Base case	Data Source
a	Population in cohort, age 65	18,456	BC Life Table
b	Proportion screened for osteoporosis	0.578	Table 7, row p
c	Number in cohort receiving bone density screen (DXA)	10,667	= a * b
d	Cost of 10 minute office visit	$34.85	Ref Doc
e	Value of patient time and travel for office visit	$59.38	Ref Doc
f	Portion of 10-minute visit for screening	50%	Ref Doc
g	Cost of initial screening visit	**$502,592**	= c * f * (d + e)
h	Bone density screening cost, per screen	$110.62	√
i	Cost of bone density screening	**$1,813,447**	c * (e + h)
j	Number of osteoporotic patients at age 65	3,543	Table 1
k	Number of osteoporotic patients identified via screening	2,048	= j * b
l	Percent of patients with proportion of days covered (PDC) 0 -19%	31.8%	√
m	Percent of patients with PDC of 20 - 39%	11.3%	√
n	Percent of patients with PDC of 40 - 59%	8.8%	√
o	Percent of patients with PDC of 60 - 79%	11.5%	√
p	Percent of patients with PDC of 80 - 100%	36.5%	Table 7, row s
q	Average days taking medication - PDC 0 -19% group	30	= 300 * 0.10
r	Average days taking medication - PDC 20 - 39% group	90	= 300 * 0.30
s	Average days taking medication - PDC 40 - 59% group	150	= 300 * 0.50
t	Average days taking medication - PDC 60 - 79% group	210	= 300 * 0.70
u	Total days taking medication - PDC 0 - 79% group	116,866	= (k * l * q) + (k * m * r) + (k * n * s) + (k * o * t)
v	Daily cost of medication	$0.51	√
w	Total cost of medication - PDC 0-79%	**$60,117**	= u * v
x	Average days taking medication - PDC 80-100% group	329	= 365 * 0.90
y	Years of treatment - PDC 80-100% group	5	√
z	Total days taking medication - PDC 80-100% group	1,227,879	= k * p * x * y
aa	Total cost of medication - PDC 80-100% group	**$631,634**	= z * v
ab	Annual office visits required to monitor medication	1	Assumption
ac	Cost of annual visits to monitor medication - PDC 0 - 79% group	**$61,276**	= (1 - p) * k * ab * (d + e) * f
ad	Cost of annual visits to monitor medication - PDC 80 - 100% group	**$176,108**	= p * k * y * ab * (d + e) * f
ae	Total cost of screening and treatment	**$3,245,174**	= g + i + w + aa + ac + ad
	Potential Costs Avoided		
af	Total hip fractures avoided	63	Table 7, row w
ag	Total vertebral fractures avoided	18	Table 7, row x
ah	Other fractures avoided	144	Table 7, row y
ai	Average cost per hip fracture in the year following the fracture	$62,152	√
aj	Average cost per vertebral fracture in the year following the fracture	$26,223	√
ak	Average cost per other fracture in the year following the fracture	$13,714	√
al	Total costs avoided	**$6,367,537**	= (af * ai) + (ag * aj) + (ah * ak)
am	**Net cost of intervention**	**-$3,122,363**	= ae - al
an	QALYs gained	91	Table 7, row af
ao	Cost effectiveness (CE) of intervention, $/QALY	-$34,145	= am / an
ap	Net Cost of Intervention (1.5% Discount)	-$2,248,682	Calculated
aq	Net QALYs Gained (1.5% Discount)	76	Calculated
ar	Cost Effectiveness (CE) of Intervention, $/QALY (1.5% Discount)	-$29,412	= ap / aq

√ = Estimates from the literature

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

- Assume that the hazard ratio (HR) for death after hip fracture is reduced from 2.87 to 2.52, the HR for death after vertebral fractures is reduced from 1.82 to 1.28 and the HR for death after other fractures is reduced from 1.38 to 1.18 (Table 4):
  CE = - $30,527

- Assume that the hazard ratio (HR) for death after hip fracture is increased from 2.87 to 3.27, the HR for death after vertebral fractures is increased from 1.82 to 2.57 and the HR for death after other fractures is increased from 1.38 to 1.62 (Table 4): CE = - $28,234
- Assume that the hip fracture reduction rate is reduced from 23% to 8% (Table 7, row *t*), the vertebral fracture reduction rate is reduced from 26% to 12% (Table 7, row *u*) and the other fracture reduction rate is reduced from 20% to 9% (Table 7, row *v*): CE = $38,997
- Assume that the hip fracture reduction rate is increased from 23% to 36% (Table 7, row *t*), the vertebral fracture reduction rate is increased from 26% to 38% (Table 7, row *u*) and the other fracture reduction rate is increased from 20% to 29% (Table 7, row *v*): CE = - $43,257
- Assume that the cost of treatment is increased from $0.51 / day to $0.61 / day (Table 8, row *v*): CE = - $27,765
- Assume that the cost of treatment is reduced from $0.51 / day to $0.42 / day (Table 8, row *v*): CE = - $31,060
- Assume that treatment pattern for the PDC 80 – 100% group changes from five years of treatment to five years of treatment followed by five years untreated followed by another five years of treatment, for a total treatment time of 10 years (Table 8, row *y*): CE = - $20,574

A number of others have calculated the cost-effectiveness of screening and treatment options for osteoporosis in women ages 65 and older.[700,701,702,703] In a Canadian cost-effectiveness analysis published in 2006, Goeree and colleagues estimated a CE of $32,571 / QALY for etidronate when compared with no intervention.[704] The CE / QALY was $38,623 for alendronate and $114,070 for raloxifine. Their study made a number of different key assumptions than we have. First, they assumed that 100% of patients with osteoporosis would adhere to medication regimens for a five year period. Based on a large real-world adherence study published in 2010,[705] we assume that just 36.5% of patients with osteoporosis would adhere to a medication regimens for a five year period. In addition, their estimated annual cost of drugs was between $546 and $969 compared to our base case scenario of $188. Applying an annual drug cost of $546 to our model results in a cost / QALY of -$12,608. An annual drug cost of $969 would increase the cost / QALY to $7,234.

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[700] Mobley LR, Hoerger TJ, Wittenborn JS et al. Cost-effectiveness of osteoporosis screening and treatment with hormone replacement therapy, raloxifene, or alendronate. *Medical Decision Making*. 2006; 26(2): 194-206.
[701] Hiligsmann M, Gathon HJ, Bruyère O et al. Cost–effectiveness of osteoporosis screening followed by treatment: the impact of medication adherence. *Value in Health*. 2010; 13(4): 394-401.
[702] Nayak S, Roberts MS and Greenspan SL. Cost-effectiveness of different screening strategies for osteoporosis in postmenopausal women. *Annals of Internal Medicine.* 2011; 155(11): 751-61.
[703] Nayak S, Roberts MS and Greenspan SL. Impact of generic alendronate cost on the cost-effectiveness of osteoporosis screening and treatment. *PloS one*. 2012; 7(3): e32879.
[704] Goeree R, Blackhouse G and Adachi J. Cost-effectiveness of alternative treatments for women with osteoporosis in Canada. *Current Medical Research and Opinion.* 2006; 22(7): 1425-36.
[705] Patrick AR, Brookhart MA, Losina E et al. The complex relation between bisphosphonate adherence and fracture reduction. *The Journal of Clinical Endocrinology & Metabolism*. 2010; 95(7): 3251-9.

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 76 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to result in cost savings of $29,412 per QALY (see Table 9).

Table 9: Osteoporosis Screening in Women 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	**76**	28	118
3% Discount Rate	65	24	100
0% Discount Rate	91	34	141
CE ($/QALY) ***including*** patient time costs			
1.5% Discount Rate	**-$29,412**	-$43,257	$38,997
3% Discount Rate	-$24,048	-$40,489	$57,000
0% Discount Rate	-$34,145	-$45,672	$22,976
CE ($/QALY) ***excluding*** patient time costs			
1.5% Discount Rate	-$43,755	-$52,552	$81
3% Discount Rate	-$40,996	-$51,474	$11,028
0% Discount Rate	-$46,171	-$53,466	-$9,663

Screening for Abdominal Aortic Aneurysms

United States Preventive Services Task Force Recommendations[706]

> *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[707]

> *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."[708]

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.[709]

The USPSTF considers an "ever-smoker" someone who has smoked at least 100 cigarettes in their lifetime.[710]

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%.[711] We use 85.8% as the best in the world screening rate for AAA.

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[706] LeFevre ML. Screening for abdominal aortic aneurysm: US Preventive Services Task Force recommendation statement. *Annals of Internal Medicine.* 2014; 161(4): 281-90.
[707] 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.
[708] 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.
[709] Sakalihasan N, Limet R and Defawe OD. Abdominal aortic aneurysm. *The Lancet*. 2005; 365(9470): 1577-89.
[710] LeFevre ML. Screening for abdominal aortic aneurysm: US Preventive Services Task Force recommendation statement. *Annals of Internal Medicine.* 2014; 161(4): 281-90.
[711] 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.[712]

- 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"[713] and referenced a study by Svensjö et al. citing an AAA prevalence rate of 1.7% in Sweden.[714]

- In the UK, the AAA prevalence rate in 65-year old men has decreased from 5.0% in 1991 to 1.3% in 2015.[715] In Denmark, the prevalence rate in 65-year old men was 2.6% during 2008-2011.[716]

- 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".[717] 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.[718]

- 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.[719] 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.[720]

- 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-

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712 LeFevre ML. Screening for abdominal aortic aneurysm: US Preventive Services Task Force recommendation statement. *Annals of Internal Medicine.* 2014; 161(4): 281-90.

713 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.

714 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.

715 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.

716 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.

717 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.

718 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.

719 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.

720 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."[721]

- 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".[722]
- 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.[723] 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%.[724]
- 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.[725]
- 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.[726]

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[721] 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.
[722] 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.
[723] 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.
[724] 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.
[725] 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.
[726] 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.[727]

- 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.[728] 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.[729]

- 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 from 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.

[727] 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.
[728] 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.
[729] 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,[730] 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 1.90% of the total 7,872 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.[731,732] These 149 deaths would result in the loss of 1,068 (259 + 464 + 346) 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[733], 2014[734] and 2015[735] 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 1.90%. 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.[736] 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. We include the 0.74% in our sensitivity analysis.

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[730] 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.

[731] 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.

[732] 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.

[733] 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.

[734] 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.

[735] 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.

[736] 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	17,559	47.0%	6.1	0.5	40.1%	12.9	0.9	12.9%	29.8	0.7	1.6	20	10.1	18.1	13.5
66	17,370	47.0%	6.1	0.5	40.1%	12.9	0.9	12.9%	29.8	0.7	1.6	19	9.5	17.0	12.7
67	17,164	47.0%	6.1	0.5	40.1%	12.9	0.9	12.9%	29.8	0.7	1.5	18	8.9	15.9	11.9
68	16,940	47.0%	6.1	0.5	40.1%	12.9	0.9	12.9%	29.8	0.7	1.5	17	8.3	14.8	11.1
69	16,697	47.0%	6.1	0.5	40.1%	12.9	0.9	12.9%	29.8	0.6	1.5	16	7.7	13.8	10.3
70	16,434	47.0%	6.1	0.5	40.1%	12.9	0.8	12.9%	29.8	0.6	1.5	15	7.1	12.7	9.5
71	16,147	47.0%	6.1	0.5	40.1%	12.9	0.8	12.9%	29.8	0.6	1.5	14	6.5	11.7	8.7
72	15,837	47.0%	6.1	0.5	40.1%	12.9	0.8	12.9%	29.8	0.6	1.4	13	5.9	10.6	7.9
73	15,500	47.0%	6.1	0.4	40.1%	12.9	0.8	12.9%	29.8	0.6	1.4	12	5.4	9.6	7.2
74	15,136	47.0%	6.1	0.4	40.1%	12.9	0.8	12.9%	29.8	0.6	1.4	11	4.8	8.6	6.4
75	14,743	47.0%	53.9	3.7	40.1%	113.1	6.7	12.9%	262.3	5.0	11.7	10	37.3	66.9	49.9
76	14,318	47.0%	53.9	3.6	40.1%	113.1	6.5	12.9%	262.3	4.8	11.3	9	32.6	58.4	43.6
77	13,861	47.0%	53.9	3.5	40.1%	113.1	6.3	12.9%	262.3	4.7	11.0	8	28.1	50.3	37.5
78	13,370	47.0%	53.9	3.4	40.1%	113.1	6.1	12.9%	262.3	4.5	10.6	7	23.7	42.4	31.7
79	12,844	47.0%	53.9	3.3	40.1%	113.1	5.8	12.9%	262.3	4.3	10.2	6	19.5	35.0	26.1
80	12,283	47.0%	53.9	3.1	40.1%	113.1	5.6	12.9%	262.3	4.2	9.7	5	15.5	27.9	20.8
81	11,686	47.0%	53.9	3.0	40.1%	113.1	5.3	12.9%	262.3	4.0	9.3	4	11.8	21.2	15.8
82	11,053	47.0%	53.9	2.8	40.1%	113.1	5.0	12.9%	262.3	3.7	8.8	3	8.4	15.0	11.2
83	10,386	47.0%	53.9	2.6	40.1%	113.1	4.7	12.9%	262.3	3.5	8.2	2	5.3	9.4	7.0
84	9,688	47.0%	53.9	2.5	40.1%	113.1	4.4	12.9%	262.3	3.3	7.7	1	2.5	4.4	3.3
Total			**26.6**	**36**		**55.9**	**65**		**129.7**	**48**	**113**		**259**	**464**	**346**

- 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.[737] 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)

[737] 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: [738]
    - 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.[739,740,741,742,743]

- 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.[744]
- 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.[745]
- 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%).[746]

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[738] 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.
[739] 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.
[740] 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.
[741] 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.
[742] Wanhainen A, Hultgren R, Linné A et al. Outcome of the Swedish nationwide abdominal aortic aneurysm screening program. *Circulation*. 2016; 134(16): 1141-8.
[743] 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.
[744] 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.
[745] 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.
[746] 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%. [747,748]

- 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.[749] One study was conducted in the UK (UKSAT)[750] and the other in the US (ADAM).[751]

- 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. [752] 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.[753]

- 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).[754]

- 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.[755]

- 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.[756,757] Neither study explicitly states the mean age of patients receiving surgery, but

[747] 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.
[748] Wanhainen A, Hultgren R, Linné A et al. Outcome of the Swedish nationwide abdominal aortic aneurysm screening program. *Circulation*. 2016; 134(16): 1141-8.
[749] 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.
[750] 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.
[751] 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.
[752] 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.
[753] 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.
[754] 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.
[755] 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.
[756] 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.
[757] 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.[758] report on screening of 65 year-old men and Wanhainen et al.[759] 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.[760]

- In a report using Ontario data de Mestral and colleagues report a 90-day mortality rate following endovascular repair of 1.6%.[761]
- Reporting on outcomes of open repair of AAA in Ontario, Dubois and colleagues report a 30-day mortality for open repair of 3%.[762]
- 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.[763]
- 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 340 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. [764] 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, [765] the ratio of elective to emergency surgeries was 4.13, indicating that while

[758] 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.
[759] Wanhainen A, Hultgren R, Linné A et al. Outcome of the Swedish nationwide abdominal aortic aneurysm screening program. *Circulation*. 2016; 134(16): 1141-8.
[760] 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.
[761] 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.
[762] 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.
[763] 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.
[764] Aciemme (Sam) Ospan, Senior Manager, Lifetime Prevention Schedule, Healthy Living and Health Promotion Branch, BC Ministry of Health. June 3, 2019. Personal communication.
[765] 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%[766]) are screened.

Row Label	Variable	Base Case	Data Source
Table 5: CPB of Abdominal Aortic Aneurysm Screening in Ever-Smoking Men 65+ In a BC Birth Cohort of 40,000			
	Deaths and Life-Years Lost due to AAA in an Unscreened Cohort		
a	Number of 65-year old men in cohort	17,559	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	289,017	Table 3
j	Life years, ever-smokers for cohort from 65 - 84	153,179	= i * (c + d)
k	Number with AAA in cohort at age 65, *never-smokers*	100	=a * b * f
l	Number with AAA in cohort at age 65, *former smokers*	179	=a * c * g
m	Number with AAA in cohort at age 65, *current smokers*	134	=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	36.2%	= 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**	**259**	Table 3
t	Life years lost over cohort lifetime, **former smokers**	**464**	Table 3
u	Life years lost over cohort lifetime, **current smokers**	**346**	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	63	= (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**	**1.2**	= 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	63	= (ac / 100,000) * j
ae	Death rate, emergency surgery	41%	√
af	Number of deaths associated with **emergency surgeries**	**25.8**	= ad * ae
ag	Number of deaths **prior to arriving at hospital for surgery**	**86.2**	= (q + r) - ab - af

[766] 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)	9,306	= a * (c + d)
ai	Screening Rate	85.8%	√
aj	Total Number screened	7,985	= 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	135	= ((am / 100,000) * j)
ao	Number of elective surgeries in cohort, due to screening alone	63	= 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	33	= (au / 100,000) * j
ax	Death rate, emergency surgery	41%	√
ay	Number of deaths associated with **emergency surgeries**	**13.4**	= 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**	**49.7**	= 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	-12.4	= 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**	**-47.6**	= 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	810	Table 3
bk	QALYs saved by screening	340	= 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 = 97
- 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 = 494
- 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 = 449
- Assume vital statistics death rate of 0.74% in population 65 and older due to abdominal aortic aneurysm, rather than the 1.90% calculated in the model: CPB = 133

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*).[767]
- The cost of each 10 minute primary care provider office visit is $34.85 (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 $59.38 (Reference Document) (Table 6, row *h*).
- The proportion of each office visit attributable to recommending screening is 50% (Reference Document) (Table 8, row *i*).
- The average service fee cost of an abdominal B-scan (ultrasound – fee item 8648) in BC between 2012 and 2016 was $106.81 (Table 6, row *k*).[768]
- Visser reported elective endovascular surgery costs at €20,767 (2003) or $38,084 (2017 CAD), with those costs rising to €23,588 (2003) or $43,257 (2017 CAD) if one-year follow-up costs were included.[769]
- Matsumura and colleagues reported elective endovascular surgery costs between $34,800 – 38,900 USD (2008) or $33,750 – 37,726 (2017 CAD), depending on which device was used in the surgery.[770]
- 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-

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[768] B.C. Ministry of Health, Health Sector Information, Analysis & Reporting Division. *MSP Fee-For-Service Payment Analysis 2012/2013 - 2016/2017*. 2017. Available at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/ffs_complete.pdf. Accessed November 2018.
[769] 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.
[770] 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.[771] Converted to 2017 CAD the amounts are $40,778 and $49,544 respectively.

- For elective endovascular surgery, Burgers and colleagues reported surgery costs of €14,690 (2013) or $22,534 (2017 CAD).[772]

- Elective endovascular surgery costs, adjusted to 2017 CAD, range between $22,534 (Burgers et al.) and $49,544 (Svensjö et al.). We model elective endovascular AAA-repair surgery costs at $36,039 (the mid-point of this) and vary this to $22,534 and $49,544 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.[773,774,775]

- 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”.[776]

- 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.”[777] 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.”[778] Cost-effectiveness studies with a follow-up period of less than 4 years, on the other hand, find EVAR to be cost-effective

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[771] 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.
[772] 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.
[773] 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.
[774] Deery SE and Schermerhorn ML. Open versus endovascular abdominal aortic aneurysm repair in Medicare beneficiaries. *Surgery*. 2017; 162(4): 721-31.
[775] 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.
[776] 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.
[777] 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.
[778] 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.[779]

- 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 $65,047 (2017 CAD), with those costs rising to €36,448 (2003) or $66,840 (2017 CAD) if one-year follow-up costs were included.[780]
- Matsumura and colleagues reported elective open surgery costs between $38,900 – 45,100 USD (2008) or $37,726 – 43,739 (2017 CAD), depending on which device was used in the surgery.[781]
- 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.[782] Converted to 2017 CAD the amounts are $50,112 and $59,295 respectively.
- For elective open surgery, Burgers and colleagues reported surgery costs of €16,399 (2013) or $25,156 (2017 CAD).[783]
- In papers not reporting on the specific type of elective surgery, the elective surgery costs ranged from $14,075 - $44,388 (2017 CAD).[784,785,786,787,788,789,790,791]

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779 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.

780 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.

781 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.

782 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.

783 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.

784 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.

785 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.

786 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.

787 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.

788 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.

789 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.

790 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.

791 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 2017 CAD, range between $25,156 (Burgers et al.) and $66,840 (Visser et al.). We model elective open AAA-repair surgery costs at $45,998 (open surgery mid-point) and vary this to $25,156 and $66,840 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 $27,500 (2017 CAD).[792]

- In a Swedish cost analysis, Wanhainen and colleagues used €32,183 (2003) for emergency AAA-repair with rupture or $50,301 (2017 CAD).[793]

- 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 2017 CAD, this comes to $66,582.[794]

- 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 $43,494 (2017 CAD).[795]

- Lindholt and colleagues reported an emergency AAA-repair surgery cost of €35,928 (2007) in Denmark or $63,497 (2017 CAD).[796]

- 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 $29,935 (2017 CAD).[797]

- Giardina and colleagues report an emergency AAA-repair cost of €15,602 (2009) in Italy, or $27,123 (2017 CAD).[798]

- Emergency AAA-repair surgery costs, adjusted to 2017 CAD, range between $27,123 (Giardina et al.) and $66,582 (Silverstein et al.). We model the cost of emergency surgery as $46,853 (mid-point of emergency surgery range) and vary this from $27,123 to $66,582 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.[799] We model accordingly (Table 6, rows *aq* & *ar*)

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792 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.

793 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.

794 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.

795 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.

796 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.

797 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.

798 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.

799 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.[800,801]
- The Canadian Society for Vascular Surgery suggests that elective open AAA-repair surgery will require 5 – 7 days in hospital.[802]
- 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.[803]
- 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.[804] The CSVS reports a full recovery time between 2 – 4 weeks.[805]
- 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.[806] The CSVS reports a full recovery time between 1 – 3 months.[807]
- 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 $530 for non-MSP beneficiaries.[808] 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 $11,995 / QALY (see Table 6, row *bg*).

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800 Canadian Society for Vascular Surgery. *Abdominal Aortic Aneurysm.* 2018. Available at https://canadianvascular.ca/Abdominal-Aortic-Aneurysms. Accessed February 2019.
801 HealthLinkBC. *Endovascular Repair for Abdominal Aortic Aneurysm.* 2018. Available at https://www.healthlinkbc.ca/health-topics/abn3549#abn3550. Accessed February 2019.
802 Canadian Society for Vascular Surgery. *Abdominal Aortic Aneurysm.* 2018. Available at https://canadianvascular.ca/Abdominal-Aortic-Aneurysms. Accessed February 2019.
803 Aciemme (Sam) Ospan, Senior Manager, Lifetime Prevention Schedule, Healthy Living and Health Promotion Branch, BC Ministry of Health. June 3, 2019. Personal communication.
804 HealthLinkBC. *Endovascular Repair for Abdominal Aortic Aneurysm.* 2018. Available at https://www.healthlinkbc.ca/health-topics/abn3549#abn3550. Accessed February 2019.
805 Canadian Society for Vascular Surgery. *Abdominal Aortic Aneurysm.* 2018. Available at https://canadianvascular.ca/Abdominal-Aortic-Aneurysms. Accessed February 2019.
806 HealthLinkBC. *Open Repair Surgery for Abdominal Aortic Aneurysm.* 2018. Available at https://www.healthlinkbc.ca/health-topics/abn3540. Accessed February 2019
807 Canadian Society for Vascular Surgery. *Abdominal Aortic Aneurysm.* 2018. Available at https://canadianvascular.ca/Abdominal-Aortic-Aneurysms. Accessed February 2019.
808 BC Emergency Health Services. *Fees*. 2019. Available at http://www.bcehs.ca/about/billing/fees. Accessed March 2019.

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	17,559	BC Life Table
b	Proportion who are former smokers	40.1%	√
c	Proportion who are current smokers	12.9%	√
d	Number targeted for screening	9,306	= a * (d + e)
e	Screening Rate	85.8%	√
f	Total Number screened	7,985	= f * g
g	Cost of 10 minute office visit	$34.85	Ref Doc
h	Value of patient time and travel for office visit	$59.38	Ref Doc
i	Portion of 10-minute office visit for screening	50%	Ref Doc
j	Cost of initial primary care visit for cohort	$376,207	= f * (g + h) * i
k	Cost of ultrasonic screening session	$107	√
l	Cost of ultrasonic screening for cohort	$1,327,006	= f * (h + k)
m	Number of elective surgeries in ever-smokers, unscreened	63	Table 5, row w
n	Number of elective surgeries in ever-smokers, screened	135	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	63	= ((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	$36,039	√
t	Cost per elective surgery, open AAA repair	$45,998	√
u	Cost of additional elective surgery due to screening	$2,533,146	= 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	$223	Ref Doc
aa	Patient time cost for additional elective AAA surgeries	$377,903.66	= p * ((q * (v + x)) + (r * (w + y)) * z
ab	Number of elective surgeries, endoscopic	37	= p * q
ac	Cost of CT Scan	$223.50	√
ad	Cost of office visit, 100% for AAA follow-up	$94	= 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	$114,973	= ab * ac * ae * af
ah	Cost of follow-up office visits	$48,474	= ab * ad * ae * af
ai	Lifetime failure rates of EVAR	10%	√
aj	Cost to correct EVAR failure with open surgery	$169,017	= ab * ai * t
ak	Total cost due to additional elective AAA surgery in cohort	$3,243,513	= u + aa + ag + ah + aj
al	Number of emergency surgeries in ever-smokers, unscreened	63.0	Table 5, row ad
am	Number of emergency surgeries in ever-smokers, screened	32.8	Table 5, row aw
an	Reduction in emergency surgeries in screened population	30.2	= al - am
ao	Cost of emergency surgery, AAA rupture repair	$46,853	√
ap	Cost reduction due to avoided surgery	$1,416,717	= 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	$103,195	an * at * z
av	Total cost reduction due to avoided surgeries	$1,519,913	= 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	83	Table 5, row aw + Table 5, row bb
ay	Number of avoided emergency transports due to screening	67	= aw - ax
az	Average cost of emergency transport	$530	√
ba	Avoided emergency transportation cost	$35,361	= ay * az
bb	Net cost of intervention	$3,391,452	= j + l + ak - av - ba
bc	QALYs saved	340	Table 5, row bk
bd	Cost effectiveness (CE) of intervention, $/QALY	$9,973	= bb / bc
be	Net Cost of Intervention (1.5% Discount)	$3,512,843	Calculated
bf	Net QALYs Gained (1.5% Discount)	293	Calculated
bg	Cost Effectiveness (CE) of Intervention, $/QALY (1.5% Discount)	$11,995	= be / bf

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 = $38,251
- 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 = $9,328
- Assume the rate of opportunistically detected AAA in the population increases from 13% to 25% (Table 5, row *ak*): CE = $10,512
- Assume the rate of opportunistically detected AAA in the population decreases from 13% to 7% (Table 5, row *ak*): CE = $12,736
- Assume the cost of elective endovascular surgery increases from $36,039 to $49,544 (Table 6, row *s*), the cost of elective open endovascular surgery increases from $45,998 to $66,840 (Table 6, row *t*), and the cost of emergency AAA-repair surgery increases from $46,853 to $66,582 (Table 6, row *af*): CE = $13,955
- Assume the cost of elective endovascular surgery decreases from $36,039 to $22,534 (Table 6, row *s*), the cost of elective open endovascular surgery decreases from $45,998 to $25,156 (Table 6, row *t*), and the cost of emergency AAA-repair surgery decreases from $46,853 to $27,123 (Table 6, row *af*): CE = $10,034
- 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 = $12,239
- 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 = $11,778
- Assume vital statistics death rate of 0.74% in population 65 and older due to abdominal aortic aneurysm, rather than the 1.90% calculated in the model: CE = $21,015
- 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 = $17,293

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 293 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $11,995 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	**293**	84	425
3% Discount Rate	254	73	369
0% Discount Rate	340	97	494
CE ($/QALY) ***including*** patient time costs			
1.5% Discount Rate	**$11,995**	$9,328	$38,251
3% Discount Rate	$14,175	$11,053	$44,859
0% Discount Rate	$9,973	$7,725	$32,136
CE ($/QALY) ***excluding*** patient time costs			
1.5% Discount Rate	$8,516	$6,750	$26,836
3% Discount Rate	$10,162	$8,079	$31,705
0% Discount Rate	$6,984	$5,511	$22,315

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 386 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $17,293 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	**386**	110	561
3% Discount Rate	335	96	487
0% Discount Rate	449	128	652
CE ($/QALY) ***including*** patient time costs			
1.5% Discount Rate	**$17,293**	$13,475	$54,894
3% Discount Rate	$20,409	$15,941	$64,341
0% Discount Rate	$14,403	$11,184	$46,152
CE ($/QALY) ***excluding*** patient time costs			
1.5% Discount Rate	$12,319	$9,788	$38,573
3% Discount Rate	$14,672	$11,689	$45,534
0% Discount Rate	$10,130	$8,018	$32,111

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)*[809]

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.[810]

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).[811]

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[809] Moyer VA. Screening for HIV: U.S. Preventive Services Task Force Recommendation Statement. *Annals of Internal Medicine*. 2013; 159(1): 51-60.
[810] 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.
[811] 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*).[812]
- 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*).[813]
- The average age at which undiagnosed HIV is detected is 40 (Table 2, row *bb*).[814]
- The gain in quality of life associated with early detection and treatment of an HIV infection is 0.11 (Table 2, row *ee*).[815]
- 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).[816] 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

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812 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.
813 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.
814 Ibid.
815 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.
816 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).[817,818] 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.[819] 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*).[820]
- 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.

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817 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.
818 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.
819 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.
820 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.[821] Long and colleagues estimated the high-risk population to be 2.85% of the total population ages 15-65 in the US[822] and 1.62% in the UK.[823] 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*).[824]
- **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) (Table 3, rows *m* & *n*).[825]
- **Cost of a counselling session -** We estimated the average cost of a counselling session associated with a true / false positive result to be $84.45, 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*).[826]

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[821] 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.

[822] 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.

[823] 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.

[824] Dr. Mel Krajden, Associate Medical Director, BCCDC Public Health Microbiology and Reference Laboratory, BC Centre for Disease Control. Personal communication, March, 2014.

[825] Ibid.

[826] Medical Services Commission. *Payment Schedule: Section 7 General Practice*. 2017. Available online at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msc-payment-schedule-july-2017.pdf. Accesed February 2018.

- **Average annual cost of antiretrovirals for HIV** – Calculated based on an estimated average cost per day of treatment in Canada of $26.00[827] (Table 3, row *s*). Costs in BC may be as high as $47.00 per day.[828] 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).[829] We modelled avoided cost using the annual direct medical costs associated with symptomatic HIV, updated to 2017 CAD of $2,843 (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 $16,434 (see Table 3, row *gg*).

[827] 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 January 2014.
[828] 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.
[829] 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	45,583	Calculated
f	Lifetime screens in low risk populations	170,778	Calculated
g	Total screens	216,361	=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	$34.85	Ref Doc
k	Value of patient time and travel for office visit	$59.38	Ref Doc
l	Proportion of office visit required	0.50	Assumed
m	Cost per screen	$7	√
n	Cost per true/false positive screen	$400	√
o	Cost per counselling session	$84.45	√
p	Cost of screening	$5,303,081	=(g*j*l)+(g*m)+(h+i)*n
q	Cost of counselling	$3,900	=(h+i)*o
r	Patient time costs	$6,423,750	= g*k*l
	Costs of antiretrovirals		
s	Cost per day of treatment	$26	√
t	Cost of antiretrovirals	$9,640,931	=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	-$11,894,198	= -u * Table 2, row cc*365*s
w	Annual direct medical costs (excluding medications) associated with symptomatic HIV	$2,843	√
x	Direct medical costs avoided	-$3,563,246	= -u * Table 2, row cc*w
	CE calculation		
y	Cost of screening and counseling (undiscounted)	$11,730,731	= p+q+r
z	Cost of antiretrovirals (undiscounted)	$9,640,931	= t
aa	Costs avoided (undiscounted)	-$15,457,444	= v+x
bb	QALYs saved (undiscounted)	360	Table 2, row qq
cc	Cost of screening and counseling (1.5% discount rate)	$8,603,838	Calculated
dd	Cost of antiretrovirals (1.5% discount rate)	$7,071,086	Calculated
ee	Costs avoided (1.5% discount rate)	-$11,337,175	Calculated
ff	QALYs saved (1.5% discount rate)	264	Calculated
gg	**CE ($/QALY saved)**	**$16,434**	=(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 = $24,483.
- Assume the prevalence of individuals living with HIV infections in BC is increased from 12,100 to 14,500 (Table 2, row *a*): CE = $11,049.

- 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 = -$12,463.
- 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 = $80,739.
- Assume screening once every 10 years rather than once every 5 years in the low-risk population (Table 3, row *d*): CE = $3,521.
- Assume screening once per lifetime rather than once every 5 years in the low-risk population (Table 3, row *d*): CE = -$6,669.
- Assume the cost of screening is reduced from $7 and $400 to $5 and $300 (Table 3, rows *m* & *n*): CE = $15,218.
- Assume the cost of screening is increased from $7 and $400 to $9 and $500 (Table 3, rows *m* & *n*): CE = $17,649.
- Assume the proportion of an office visit required is reduced from 0.50 to 0.33 (Table 3, row *l*): CE = $6,803.
- Assume the proportion of an office visit required is increased from 0.50 to 0.67 (Table 3, row *l*): CE = $26,084.
- Assume the average annual cost of antiretrovirals for HIV is increased from $26 to $47 per day (Table 3, row *s*): CE = $11,377.

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 $16,434 per QALY (see Table 4).

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	**$16,434**	-$12,463	$80,739
3% Discount Rate	$16,434	-$12,463	$80,739
0% Discount Rate	$16,434	-$12,463	$80,739
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	-$1,416	-$24,516	$49,990
3% Discount Rate	-$1,416	-$24,516	$49,990
0% Discount Rate	-$1,416	-$24,516	$49,990

Chlamydia / Gonorrhea

There is a strong overlap in the at-risk populations for chlamydia and gonorrhea with both STIs often seen in the same individual. Indeed, the USPSTF recommends "chlamydia and gonorrhea screening for all sexually active women younger than 25 years (including adolescents), even if they are not engaging in high-risk sexual behaviours."[830] They further note that younger women tend to be at higher risk as they tend to have more new sex partners, their immune system tends to be relatively immature and the presence of "columnar epithelium on the adolescent exocervix." [831]

Following are the specific recommendations from the USPSTF and the CTFPHC with respect to screening for chlamydia and gonorrhea.

USPSTF Recommendations (2014)

> *The USPSTF recommends screening for chlamydia in sexually active females aged 24 years or younger and in older women who are at increased risk for infection. (B recommendation)*
>
> *The USPSTF recommends screening for gonorrhea in sexually active females aged 24 years or younger and in older women who are at increased risk for infection. (B recommendation)*[832]

CTFPHC Recommendations (1994)

The CTFPHC recommendations have not been updated since 1994.

> *Although there is sufficient evidence linking chlamydial infections to many complications, there is currently insufficient evidence in males and non-pregnant females to show that screening is effective in preventing these complications. Thus routine screening is not recommended in the general population (D Recommendation).* [833]
>
> *The low prevalence rate of infection with N. gonorrheae would make mass screening of the general population an inefficient intervention (D Recommendation). However, screening should be performed in certain populations: 1) individuals under 30 years, particularly adolescents, with at least 2 sexual partners in the previous year; 2) prostitutes; 3) sexual contacts of individuals known to have a sexually transmitted disease; and 4) age ≤16 years at first intercourse (A Recommendation).* [834]

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with screening females less than 30 years of age at increased risk for infection with chlamydia and gonorrhea.

The USPSTF recommends that screening be performed in all sexually active females younger than 25. The CTFPHC also recommends screening in individuals under 30 years with at least

[830] Meyers D, Wolff T, Gregory K et al. USPSTF recommendations for STI screening. *American Family Physician*. 2008; 77(6): 819-24.
[831] Ibid.
[832] LeFevre ML. Screening for chlamydia and gonorrhea: US Preventive Services Task Force recommendation statement. *Annals of Internal Medicine*. 2014; 161(12): 902-10.
[833] Canadian Task Force on Preventive Health Care. *Canadian Guide to Clinical Preventive Health Care: Chapter 60: Screening for Chlamydial Infection*. 1994. Available at http://canadiantaskforce.ca/wp-content/uploads/2013/03/Chapter60_chlamydia94.pdf?0136ff. Accessed November 2013.
[834] Beagan BL and Wang EEL. *Canadian Guide to Clinical Preventive Health Care: Chapter 59: Prevention of Gonorrhea*. 1994. Available at http://canadiantaskforce.ca/wp-content/uploads/2013/03/Chapter59_gonorrhea94.pdf?0136ff. Accessed November 2013.

2 sexual partners in the previous year. This means that approximately 189,099 females would be eligible for screening in BC in 2017 (see Table 1).

Table 1: Relevant Female Population for Chlamydia/Gonorrhea Screening in B.C.

Age	% Sexual Intercourse*	% Multiple Partners in Past Year**	2017 B.C. Female Population	Eligible for Screening
12-14	8.2%		68,283	5,599
15-17	17.5%		79,417	13,898
18-19	58.5%		52,944	30,966
20-24	82.3%		158,416	130,381
25-29	85.2%	6.0%	161,437	8,254
		Total	520,497	**189,099**

* Age 12-14 - Statistics Canada. *Table 1: Number and Percentage of 15- to 24-year-olds who had First Sexual Intercourse before Age 17, by Sex, Household Population, Canada, 2003 and 2009/2010.* 2013. Available at http://www.statcan.gc.ca/pub/82-003-x/2012001/article/11632/tbl/tbl1-eng.htm. Accessed January 2014.

* Age 15-29 "This analysis is based on the Statistics Canada's **Canadian Community Health Survey 1.1 Public Use Microdata File** and the **Canadian Community Health Survey 2010 Public Use Microdata File**. All computations, use and interpretation of these data are entirely that of **H. Krueger & Associates Inc.**"

** Centre for Infectious Disease Prevention and Control. *Sexual Risk Behaviours of Canadians - HIV/AIDS Epi Updates.* 1999. Available at http://www.phac-aspc.gc.ca/publicat/epiu-aepi/hiv-vih/epi0599/sexbe-eng.php. Accessed January 2014.

In estimating CPB, we used the results based on a state transition simulation model developed by Hu and colleagues.[835] They found the most cost-effective approach to screening included annual screening in at-risk women ages 15 to 29 years of age followed by semi-annual screening for those with a history of infection. Our analysis is based on the assumption that this screening approach would be followed. Unless otherwise noted, the following assumptions are based on their analysis.

- In the absence of screening, the lifetime risk of chronic pelvic pain, infertility and ectopic pregnancy is 3.44%, 3.88% and 1.74%, respectively (Table 2, rows *d*, *e* & *f*).
- With the screening protocol noted above, the lifetime risk of chronic pelvic pain, infertility and ectopic pregnancy is reduced by 41% (Table 2, row *g)*.
- The quality of life impact estimates for chronic pelvic pain, infertility and ectopic pregnancy can have a significant impact on model results.[836]
- Hu and colleagues suggest that chronic pelvic pain is associated with a 0.40 reduction in quality of life for a period of 5 years.[837] The GBD study, however, found that

[835] Hu D, Hook EW and Goldie SJ. 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.
[836] Jackson L, Auguste P, Low N et al. Valuing the health states associated with Chlamydia trachomatis infections and their sequelae: A systematic review of economic evaluations and primary studies. *Value in Health*. 2014; 17: 116-30.
[837] Hu D, Hook EW and Goldie SJ. 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.

moderate pelvic pain is associated a disability weight of 0.114 (95% CI of 0.078 to 0.159).[838] 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%) (Table 2, row *n)*.

- Hu and colleagues suggest that infertility is associated with a 0.18 reduction in quality of life up until age 50.[839] 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).[840] 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 assumed the average infection would occur at age 21[841] with 29 potential years of infertility (Table 2, rows *o)*.
- Hu and colleagues suggest that ectopic pregnancy is associated with a 0.42 reduction in quality of life for a period of 4 weeks.[842] The GBD study, however, found that an ectopic pregnancy is associated a disability weight of 0.114 (95% CI of 0.078 to 0.159).[843] 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%) (Table 2, rows *p)*.
- 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 *t*) is 143 QALYs. This represents the potential CPB moving from no screening to approximately 55% screening uptake.

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838 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.
839 Hu D, Hook EW and Goldie SJ. 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.
840 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.
841 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.
842 Hu D, Hook EW and Goldie SJ. 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.
843 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.

Table 2: CPB of Screening to Detect and Treat Chlamydia/Gonorrhea in a Birth Cohort of 40,000 (B.C.)			
Row Label	**Variable**	**Base Case**	**Data Source**
a	At-risk population in B.C. birth cohort of 40,000	20,000	√
b	Potential adherence with screening	55%	Ref Doc
c	At-risk population screened	11,000	= a*b
d	Lifetime risk of chronic pelvic pain (CPP) without screening	3.44%	√
e	Lifetime risk of infertility without screening	3.88%	√
f	Lifetime risk of ectopic pregnancy (EP) without screening	1.74%	√
g	Effectiveness of screening in reducing CPP, infertility and EP	41%	√
h	Lifetime risk of chronic pelvic pain with screening	2.03%	= (1-g)*d
i	Lifetime risk of infertility with screening	2.29%	= (1-g)*e
j	Lifetime risk of ectopic pregnancy with screening	1.03%	= (1-g)*f
k	Cases of chronic pelvic pain avoided with screening	155	=(c*d)-(c*h)
l	Cases of infertility avoided with screening	175	=(c*e)-(c*i)
m	Cases of ectopic pregnancy avoided with screening	79	=(c*f)-(c*j)
n	QALYs parameters - chronic pelvic pain (5 years)	0.125	√
o	QALYs parameters - infertility (to age 50)	0.009	√
p	QALYs parameters - ectopic pregnancy (4 weeks)	0.125	√
q	QALYs gained with screening - chronic pelvic pain	97	=k*n*5
r	QALYs gained with screening - infertility	46	=l*o*29
s	QALYs gained with screening - ectopic pregnancy	0.8	=m*p*0.077
t	Total QALYs gained, 55% adherence with screening	143	=q+r+s

√ = Estimates from the literature

As noted by Hu and colleagues, the effectiveness and cost-effectiveness associated with their modelling is highly sensitive to a number of key assumptions.[844] Furthermore, there is 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 suggests that the rate might be much lower, resulting in a change in the lower end of the range from 10% to just 0.43%.[845,846] Others indicate that we simply do not know very much about the natural progression from infection with either chlamydia or gonorrhea to PID.[847]

There is also significant debate about whether screening is associated with any significant reduction in PID and its sequelae. In a seminal article published in the *New England Journal of Medicine* in 1996, Scholes et al. present 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).[848] Subsequent research, however, has not been able to replicate these results. The Prevention of Pelvic Infection (POPI) trial in the UK, also

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[844] Hu D, Hook III EW and Goldie SJ. The impact of natural history parameters on the cost-effectiveness of Chlamydia trachomatis screening strategies. *Sexually Transmitted Diseases*. 2006; 33(7): 428-36.
[845] van Valkengoed IG, Morré SA, van den Brule AJ 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.
[846] Hu D, Hook III EW and Goldie SJ. The impact of natural history parameters on the cost-effectiveness of Chlamydia trachomatis screening strategies. *Sexually Transmitted Diseases*. 2006; 33(7): 428-36.
[847] Herzog SA, Heijne JC, Althaus CL 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.
[848] Scholes D, Stergachis A, Heidrich FE et al. Prevention of pelvic inflammatory disease by screening for cervical chlamydial infection. *New England Journal of Medicine*. 1996; 334(21): 1362-6.

a randomized controlled trail, found a non-significant reduction in PID associated with screening (relative risk of 0.65; 95% CI of 0.34 to 1.22).[849]

Assumptions about the proportion of women with an infection that progresses to PID and the effectiveness of screening (and early treatment) in reducing the proportion of women with an infection who progress to PID are critical to any analysis about the effectiveness and cost-effectiveness of screening. In fact, Low notes that "under realistic assumptions, introducing a chlamydia screening programme is likely to be an expensive intervention".[850] She further notes that many chlamydia screening programs have been uncritically accepted as being effective.

With these caveats in mind, we modified the following major assumptions and recalculated the CPB as follows:

- Assume the potential adherence rate with screening is reduced from 55% to 45% (Table 2, row *b)*: CPB = 117.
- Assume the potential adherence rate with screening is increased from 55% to 65% (Table 2, row *b)*: CPB = 169.
- Assume the effectiveness of screening in reducing chronic pelvic pain, infertility and ectopic pregnancies is reduced from 41% to 10% (Table 2, rows *g)*: CPB = 35.
- Assume that the QoL reduction associated with chronic pelvic pain is reduced from 12.5% to 8.5% (Table 2 – row *n*), the QoL reduction associated with infertility is reduced from 0.9% to 0.3% (Table 2 – row *o*) and the QoL reduction associated with ectopic pregnancy is reduced from 12.5% to 8.5% (Table 2 – row *p*): CPB = 84.
- Assume that the QoL reduction associated with chronic pelvic pain is increased from 12.5% to 17.4% (Table 2 – row *n*), the QoL reduction associated with infertility is increased from 0.9% to 1.7% (Table 2 – row *o*) and the QoL reduction associated with ectopic pregnancy is increased from 12.5% to 17.4% (Table 2 – row *p*): CPB = 222.

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with screening females less than 30 years of age at increased risk for infection with chlamydia and gonorrhea.

In modelling CE, we made the following assumptions:

- **Proportion of at-risk population with infection** – We assumed that 5.68% of the at-risk population would test positive for either chlamydia or gonorrhea (Table 3, row *f*).[851] This assumption was varied between 2% and 33% in the sensitivity analysis.[852]

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[849] 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.
[850] Low N. Screening programmes for chlamydial infection: when will we ever learn? *British Medical Journal*. 2007; 334(7596): 725-8.
[851] 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.
[852] Hu D, Hook III EW and Goldie SJ. The impact of natural history parameters on the cost-effectiveness of Chlamydia trachomatis screening strategies. *Sexually Transmitted Diseases*. 2006; 33(7): 428-36.

- **Screening protocol** – We assumed that screening included annual screening in at-risk women ages 15 to 29 years of age followed by semi-annual screening for those with a history of infection (Table 3, rows *g*, *h* and *i*).[853]
- **Costs of screening tests** – Hu et al. estimated the cost of a urine nucleic acid amplification test to be $13 (2000 USD)[854] or $15.28 in 2017 CAD. Robinson et al. estimated the costs to be £7.35 (in 2005)[855] or $16.17 in 2017 CAD. We used an estimate of $15.73 (the midpoint between the two estimates) per screening test in the model (Table 3, row *m*).
- **Average cost of antibiotic treatment –** The recommended drug regimen for chlamydia is doxycycline 100 mg PO bid for 7 days (estimated cost of $22.18 including dispensing fee[856]) or azithromycin 1g PO in a single dose (estimated cost of $18.10 including dispensing fee[857]) while the recommended drug regimen for gonorrhea is cefixime 800mg PO in a single dose (estimated cost of $19.04 including dispensing fee[858]) or ceftriaxone 250mg in a single dose plus azithromycin 1 g PO in a single dose.[859] We used an average cost of $19.77 (Table 3, row *p*) with a range from $18.10 to $22.18.
- 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 $57,174 (see Table 3, row *v*).

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853 Hu D, Hook EW and Goldie SJ. 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.
854 Ibid.
855 Robinson S, Roberts T, Barton P et al. Healthcare and patient costs of a proactive chlamydia screening programme: the Chlamydia Screening Studies project. *Sexually Transmitted Infections*. 2007; 83(4): 276-81.
856 Pacific Blue Cross. *Pharmacy Compass*. 2018. Available at http://pharmacycompass.ca/BestPrice. Accessed February 2018.
857 Ibid.
858 Ibid.
859 BC Centre for Disease Control. *British Columbia Treatment Guidelines: Sexually Transmitted Infections in Adolescents and Adults*. 2014. Available at http://www.bccdc.ca/resource-gallery/Documents/Communicable-Disease-Manual/Chapter%205%20-%20STI/CPS_BC_STI_Treatment_Guidelines_20112014.pdf. Accessed February 2018.

Table 3: CE of Screening to Detect and Treat Chlamydia/Gonorrhea in a Birth Cohort of 40,000 (B.C.)			
Label	**Variable**	**Base Case**	**Data Source**
a	At-risk population screened	11,000	Table 2, row c
b	# of annual screens between age 15 and 24	10	√
c	Total # of screens, 15 - 24	110,000	=a*b
d	% Population at-risk between 25-29	6%	√
e	Total # of screens, 25 - 29	3,300	=d*a*5
f	% with chlamydia/gonorrhea infection	5.68%	√
g	Total screens - positive	6,435	= (c+e)*d
h	Total screens - negative	106,865	= c+e-g
i	Additional follow-up screens in positive women	6,435	= g
	Costs of screening		
j	Cost of 10-minute office visit	$34.85	Ref Doc
k	Cost of patient time and travel for office visit	$59.38	Ref Doc
l	Portion of office visit needed	50%	Ref Doc
m	Cost per screening test	$15.73	√
n	Costs of screening	$7,524,774	= (g+h+i)*(((j+k)*l)*m)
o	**Costs of antibiotics**		
p	Cost per treatment	$19.77	√
q	Cost of antibiotics	$127,218	= g*p
	CE calculation		
r	Costs (undiscounted)	$7,651,992	= n+q
s	QALYs saved (undiscounted)	143	Table 2, row t
t	Costs (1.5% discount rate)	$6,813,920	Calculated
u	QALYs saved (1.5% discount rate)	119	Calculated
v	**CE ($/QALY saved)**	**$57,174**	= t/u

√ = Estimates from the literature

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

- Assume the effectiveness of screening in reducing chronic pelvic pain, infertility and ectopic pregnancies is reduced from 41% to 10% (Table 2, row *b)*: CE = $234,414.
- Assume that the QoL reduction associated with chronic pelvic pain is reduced from 12.5% to 8.5% (Table 2 – row *n*), the QoL reduction associated with infertility is reduced from 0.9% to 0.3% (Table 2 – row *o*) and the QoL reduction associated with ectopic pregnancy is reduced from 12.5% to 8.5% (Table 2, row *p*): CE = $96,519.
- Assume that the QoL reduction associated with chronic pelvic pain is increased from 12.5% to 17.4% (Table 2 – row *n*), the QoL reduction associated with infertility is increased from 0.9% to 1.7% (Table 2 – row *o*) and the QoL reduction associated with ectopic pregnancy is increased from 12.5% to 17.4% (Table 2, row *p*): CE = $37,189.
- Assume that the proportion of the at-risk population who would test positive for either chlamydia or gonorrhea is reduced from 5.68% to 2.0% (Table 3, row *f*): CE = $54,601.
- Assume that the proportion of the at-risk population who would test positive for either chlamydia or gonorrhea is increased from 5.68% to 33.0% (Table 3, row *f*): CE = $76,281.
- Assume the portion of an office visit required is decreased from 50 to 33% (Table 3, row *l*): CE = $42,843.

- Assume the portion of an office visit required is increased from 50% to 67% (Table 3, row *l*): CE = $71,506.
- Assume the cost for antibiotic treatment is decreased from $19.77 to $18.10 (Table 3, row *p*): CE = $57,094.
- Assume the cost for antibiotic treatment is increased from $19.77 to $22.18 (Table 3, row *p*): CE = $57,290.

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening females less than 30 years of age at increased risk for infection with chlamydia and gonorrhea is estimated to be 119 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $57,174 per QALY (see Table 4).

Table 4: Screening to Diagnose and Treat Chlamydia/Gonorrhea Infections in a Birth Cohort of 40,000
Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
1.5% Discount Rate	**119**	29	183
3% Discount Rate	100	24	153
0% Discount Rate	143	35	222
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$57,174**	$37,189	$234,414
3% Discount Rate	$60,733	$39,750	$249,007
0% Discount Rate	$53,410	$34,494	$218,983
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$30,612	$19,912	$125,511
3% Discount Rate	$32,518	$21,283	$133,324
0% Discount Rate	$28,597	$18,469	$117,248

Hepatitis C Virus

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)*[860]

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.)*[861]

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[860] 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.
[861] 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.*[862]

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.[863]
- 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[864], which could be split into sub-types, but as genome sequencing

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[862] Canadian Task Force on Preventive Health Care. Recommendations on hepatitis C screening for adults. *Canadian Medical Association Journal*. 2017; 189(16): E594-E604.
[863] 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):
[864] 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.[865]

- HCV genotypes are important because different genotypes respond differently to some medication used to treat and cure HCV.[866] 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."[867]
- 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.[868,869]
- HCV Genotype 1 is the most common genotype in North America.[870] Genotypes 1, 2 and 3 are the most common in BC.[871]
- 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.[872]
- 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.[873]
- Approximately 25% of persons infected with HCV spontaneously clear the infection (i.e. without medication).[874,875,876] In these individuals, the hepatitis C virus stops replicating and they are considered cured.

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[865] 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.
[866] Treatment Action Group. *HCV Genotypes.*2016. Available at http://www.treatmentactiongroup.org/sites/default/files/Genotypes.pdf. Accessed October 2019.
[867] 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.
[868] Treatment Action Group. *HCV Genotypes.*2016. Available at http://www.treatmentactiongroup.org/sites/default/files/Genotypes.pdf. Accessed October 2019.
[869] 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.
[870] Hajarizadeh B, Grebely J and Dore GJ. Epidemiology and natural history of HCV infection. *Nature Reviews Gastroenterology & Hepatology.* 2013; 10(9): 553.
[871] 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.
[872] Hajarizadeh B, Grebely J and Dore GJ. Epidemiology and natural history of HCV infection. *Nature Reviews Gastroenterology & Hepatology.* 2013; 10(9): 553.
[873] 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.
[874] 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.
[875] Hajarizadeh B, Grebely J and Dore GJ. Epidemiology and natural history of HCV infection. *Nature Reviews Gastroenterology & Hepatology.* 2013; 10(9): 553.
[876] 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.[877] Removal of the virus and an absence of HCV RNA after 12 weeks indicates having achieved a sustained virologic response (SVR), or a cure.[878]
- 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[879] 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.[880]
- Fibrosis generally progresses slowly and is classified in stages. One commonly used classification system is the METAVIR system (see Table 1).[881,882]

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.*

877 Treatment Action Group. *HCV Genotypes.*2016. Available at http://www.treatmentactiongroup.org/sites/default/files/Genotypes.pdf. Accessed October 2019.
878 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.
879 Scar tissue
880 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.
881 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.
882 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.[883]
- There is not any conclusive evidence linking genotype and the rate of fibrosis progression.[884]
- 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.[885] 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.[886] 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%**

[883] 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.
[884] Hajarizadeh B, Grebely J and Dore GJ. Epidemiology and natural history of HCV infection. *Nature Reviews Gastroenterology & Hepatology*. 2013; 10(9): 553.
[885] 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.
[886] 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**.[887,888] 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%.[889,890,891] 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).[892,893,894,895] 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.[896]

- We model the annual probability of a **liver transplant** following decompensated cirrhosis or liver cancer is 3.2%.[897,898]

- 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.[899]

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[887] 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.
[888] Westbrook RH and Dusheiko G. Natural history of hepatitis C. *Journal of Hepatology.* 2014; 61(1): S58-S68.
[889] 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.
[890] Westbrook RH and Dusheiko G. Natural history of hepatitis C. *Journal of Hepatology.* 2014; 61(1): S58-S68.
[891] 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.
[892] 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.
[893] Hajarizadeh B, Grebely J and Dore GJ. Epidemiology and natural history of HCV infection. *Nature Reviews Gastroenterology & Hepatology.* 2013; 10(9): 553.
[894] Westbrook RH and Dusheiko G. Natural history of hepatitis C. *Journal of Hepatology.* 2014; 61(1): S58-S68.
[895] 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.
[896] 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.
[897] 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.
[898] 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.
[899] 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.

- 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.[900]

- We model annual probability of death after **liver transplant** after Myers et al.[901] 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%.[902]

- 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%.[903]

- 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.[904]

- 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[905] and an estimated 6,482 are undiagnosed.[906] 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*).

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[900] 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.
[901] 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.
[902] 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.
[903] 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.
[904] 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.
[905] 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.
[906] Dr. Mel Krajden. Medical Head, Hepatitis, BC Centre for Disease Control. Personal Communication. November 2019.

- 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 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.[907] 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

[907] 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.[908]

- 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.[909] 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.[910] 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.

[908] 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.
[909] 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.
[910] 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%.[911,912,913,914]
- As noted above, the effectiveness of DAA treatment in BC in the 1945-64 birth cohort appears to be 90.6% (see Table 6).[915]
- 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.[916] 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.[917] Overall, Epclusa achieved SVR rates of 95 – 99% in clinical trials.[918,919]
- In clinical trials of **Zepatie**r, overall SVR rates of 95% were reported for treatment-naïve participants with HCV genotypes 1, 4 and 6.[920]
- 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%.[921,922]

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[911] 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.
[912] 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.
[913] 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.
[914] 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.
[915] 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.
[916] Tijana Fazlagic. A/Executive Director, Pharmacare Benefits, Pharmaceutical Therapies & Pharmacare Division, BC Ministry of Health. Personal Communication. October 30, 2019.
[917] 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.
[918] 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.
[919] 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.
[920] 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.
[921] 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.
[922] 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).*[923]

- 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

[923] 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[924] and utilized in Canadian modelling studies.[925,926,927] Impairment in QoL following a liver transplant are from Ratcliffe and colleagues[928] as calculated by Williams et al.[929]
- 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*)

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[924] 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.
[925] 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.
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[929] 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.[930] 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.[931,932] 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.

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[930] 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.
[931] 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.
[932] 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.[933]
- 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.[934]
- We estimated the cost of a hepatitis C antibody EIA test to be $24.28 (Table 12, row *n*).[935] 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.[936] Total lab costs associated with a positive screening test of $469.24 (Tale 12, row *o*) 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.
- **Epclusa** is made by Gilead Sciences and contains the following medicines: sofosbuvir – 400 mg and velpatasvir – 100 mg. The wholesale price of Epclusa in

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[933] 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.
[934] 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.
[935] 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.
[936] Ibid.

Canada is reported as $60,000 per treatment (1 pill per day x 12 weeks).[937] Using the Pacific Blue Cross Pharmacy Compass[938] 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.[939]
- **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.[940] The Government of BC lists three treatment lengths with Maviret; 8, 12 and 16 weeks.[941] 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[942] 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."[943]
- Available evidence suggests that Australia, Italy, Spain and Portugal have all negotiated DAA course prices of between $10,000 and $16,000.[944] DAA prices in the UK have also recently been "slashed"[945] leading Williams et al to use a cost of approximately $17,000 in their recent UK-based cost-effectiveness modelling.[946]
- 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

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937 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.
938 Pacific Blue Cross. *Pharmacy Compass.* 2019. Available at https://www.pac.bluecross.ca/pharmacycompass. Accessed November 2019.
939 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.
940 ClaimSecure. *MAVIRET^{TM} - 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.
941 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.
942 Pacific Blue Cross. *Pharmacy Compass.* 2019. Available at https://www.pac.bluecross.ca/pharmacycompass. Accessed November 2019.
943 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.
944 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.
945 Hurley R. Slashed cost of hepatitis C drugs spurs drive to eliminate the disease. BMJ. 2018; 361: k1679.
946 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:

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*).[947] 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,[948] $9.90[949] and $31.52,[950] respectively, for a total cost of $52.38[951] (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 $400. 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.[952] 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.[953]

- The incremental annual health care cost associated with compensated cirrhosis (stage f4) is $843. These costs are also based on El Saadany et al.'s research and include inpatient care, outpatient visits, diagnostic procedures, surgical procedures, and medication.[954,955]

- The incremental annual health care cost associated with decompensated cirrhosis is $15,284. These costs are also based on El Saadany et al.'s research and include

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[947] 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.
[948] Fee item 90205 – hematology profile
[949] Fee item 92325 - thyroid stimulating hormone (TSH) – any method
[950] 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).
[951] BC Ministry of Health. Schedule of Fees for the Laboratory Services Outpatient. January 1, 2019. Available on-line at https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/laboratory-services/laboratory_services_schedule_of_fees.pdf. Accessed November 2019.
[952] 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.
[953] 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.
[954] 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.
[955] 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.

inpatient care, outpatient visits, diagnostic procedures, surgical procedures, and medication.[956]

- 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).[957] We converted this to $30,922 in 2017 CDN.
- 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).[958] We converted this to $36,708 in 2017 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 $6,287 in 2017 CAD.[959] 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 $162,901. Annual costs following the first year post-transplant average $9,654.[960]
- 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.[961] 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 $3,170 (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.

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956 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.
957 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.
958 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.
959 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.
960 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.
961 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	$34.85	Ref Doc
n	Portion of office visit needed	50%	Ref Doc
o	Cost of office visits	$721,838	(e * l * m * n) + (g * l)
p	Lab costs initial screening test	$24.28	√
q	Lab costs per positive screening tests (including 2nd confirmatory test at 6 months)	$469.24	√
r	Costs of lab tests	$570,565	(e * p) + (g * q)
s	Cost of patient time and travel for office visit and per lab test	$59.38	Ref Doc
t	Patient time costs - screening	$2,450,812	(e * l * n * s) + (e * s) + (g * s)
u	Total costs of screening	$3,743,215	= 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)	$77,840	= k * (x * (m + y))
aa	Patient time (office & lab visits)	$105,976	= k * (x * 2) * s
ab	Total cost of treatment - first round	$1,522,343	
	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)	$2,335	= (ae * ag) * (m + y)
ai	Patient time (office & lab visits)	$3,179	= (ae * ag) * 2 * s
aj	Total cost of treatment - second round	$65,748	= af + ah + ai
ak	Total cost of screening and treatment	$5,331,307	= u + ab + aj
	Costs Avoided		
al	Costs avoided, living with HCV stages f0 - f3	$399,667	Calculated
am	Costs avoided, living with cirrhosis	$572,608	Calculated
an	Costs avoided, living with decompensated cirrhosis	$1,707,820	Calculated
ao	Costs avoided, living with HCC	$373,370	Calculated
ap	Costs avoided, dying of HCC	$629,710	Calculated
aq	Costs avoided, living with liver transplant	$970,603	Calculated
ar	Total cost avoided (undiscounted)	$4,653,779	= al + am + an + ao + ap + aq + ar
	CE calculation		
as	Net Costs (undiscounted)	$677,528	= ak - ar
at	QALYs saved (undiscounted)	555	Table 11, row aj
au	Costs (1.5% discount rate)	$1,479,696	Calculated
av	QALYs saved (1.5% discount rate)	467	Calculated
aw	**CE ($/QALY saved)**	**$3,170**	= 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 = $3,263
- 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 = $2,905
- 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 = $3,170 (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 = $3,170 (no change)
- Assume that the uptake of treatment is **reduced** from 87.5% to 80.0% (Table 11, row n). CE = $3,922
- Assume that the uptake of treatment is **increase**d from 87.5% to 95.0% (Table 11, row n). CE = $2,537
- 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 = $2,812
- 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 = $3,696

- Assume the proportion of an office visit required is **reduced** from 50% to 33% (Table 12, row n). CE = $1,759
- Assume the proportion of an office visit required is **increased** from 50% to 67% (Table 12, row n). CE = $4,582
- Assume the costs of DAA per treatment are **reduced** from $13,500 to $10,000 (Table 12, row v). CE = $2,393
- Assume the costs of DAA per treatment are **increased** from $13,500 to $17,000 (Table 12, row v). CE = $3,947
- Assume the annual treatment costs per disease state are **reduced** by 25%. CE = $5,233
- Assume the annual treatment costs per disease state are **increased** by 25%. CE = $1,107
- Assume the rate of sustained virologic response (SVR) **increases** from 97% to 99% (Table 11, row *p*). CE = $3,067
- Assume the rate of sustained virologic response (SVR) **decreases** from 97% to 95% (Table 11, row *p*). CE = $3,283

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 $3,170 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	**$3,170**	$1,107	$5,233
3% Discount Rate	$5,330	$3,300	$7,359
0% Discount Rate	$1,222	-$876	$3,320
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	-$2,314	-$251	-$4,378
3% Discount Rate	-$1,128	$902	-$3,157
0% Discount Rate	-$3,395	-$1,297	-$5,493

Our calculated cost per QALY of $3,170 (ranging from $1,107 to $5,233) is substantially lower than the Canadian estimate modelled by Wong et al in 2015 ranging from $34,359 to $44,034.[962] 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 $3,170 to $12,283.

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 $3,170 to $11,422.

If these last two variables were modified simultaneously in our base case, then our cost per QALY would increase from $3,170 to $20,635.

[962] 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.[963] 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.[964] Researchers are encouraged to pay closer attention to these issues in designing and writing up their behavioural intervention research.

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[963] 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.

[964] 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.

Prevention of Sexually Transmitted Diseases

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.*[965]

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.*[966]

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[965] 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.

[966] 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.

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.

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.[967] 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.[968] The age and sex specific incidence rates per 100,000 for chlamydia, gonorrhea and syphilis infections are taken from the BCCDC Annual Report 2015.[969] The incidence of human papillomavirus (HPV) infection in females is taken from an Ontario study.[970] We have assumed that the age specific incidence rate for males is the same as for females.[971] 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.[972] 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

[967] 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.
[968] 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.
[969] 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.
[970] 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.
[971] 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.
[972] 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.

- 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).

Table 2: Estimated Number of Sexually Transmitted Infections in a *Male* Birth Cohort of 20,000

Age Group	Mean Survival Rate	Individuals in Birth Cohort	Years of Life in Birth Cohort	Chlamydia	HIV	Gonorrhea	Hepatitis B - Acute	Syphilis	HPV	HSV-2
15-19	0.994	19,875	99,374	320	1	63	0	6	24,844	63
20-24	0.991	19,813	99,065	952	11	217	0	34	8,718	94
25-29	0.987	19,734	98,672	883	22	277	0	63	8,190	99
30-34	0.983	19,658	98,289	388	14	198	0	59	12,778	110
35-39	0.978	19,560	97,798	386	13	197	0	59	12,714	110
40-44	0.971	19,427	97,134	100	13	67	0	47	7,382	72
45-49	0.962	19,241	96,203	99	12	66	0	47	7,311	72
50-54	0.949	18,971	94,855	98	12	65	0	46	7,209	71
55-59	0.929	18,570	92,852	96	12	64	0	45	7,057	69
Total Ages 15 - 59			**874,242**	**3,323**	**111**	**1,215**	**2**	**408**	**96,202**	**760**

Table 3: Estimated Number of Sexually Transmitted Infections in a *Female* Birth Cohort of 20,000

Age Group	Mean Survival Rate	Individuals in Birth Cohort	Years of Life in Birth Cohort	Chlamydia	HIV	Gonorrhea	Hepatitis B - Acute	Syphilis	HPV	HSV-2
15-19	0.995	19,897	99,484	1,425	2	120	0	1	24,871	139
20-24	0.993	19,865	99,323	1,979	1	193	0	4	8,740	208
25-29	0.992	19,833	99,163	1,102	1	161	0	3	8,231	221
30-34	0.990	19,795	98,975	423	4	76	0	2	12,867	245
35-39	0.987	19,741	98,706	422	4	75	0	2	12,832	245
40-44	0.983	19,662	98,311	85	2	17	0	1	7,472	162
45-49	0.977	19,546	97,730	84	2	16	0	1	7,427	161
50-54	0.969	19,375	96,873	83	2	16	0	1	7,362	160
55-59	0.956	19,118	95,591	82	2	16	0	1	7,265	158
Total Ages 15 - 59			**884,156**	**5,685**	**21**	**691**	**1**	**17**	**97,067**	**1,699**

- 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*).[973]
- 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

[973] 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.

y, *aa*, *dd* & *ee*).[974] These appendixes include an estimated rate for all sequelae 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).[975] 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).[976] 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[977] with 44 years of life remaining at a 17% reduced quality of life (Table 4, row *z*).[978] 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*).[979]
- 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 3,285 QALYs (Table 4, row *ff*).

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974 Institute of Medicine. *Vaccines for the 21st Century: A Tool for Decision Making.* Washington, DC: National Academy Press; 2000.

975 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.

976 Ibid.

977 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.

978 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.

979 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	1,745	Tables 2 and 3
b	Estimated number of STIs in birth cohort as adults - Chlamydia	7,263	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	128	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	1,722	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	418	Tables 2 and 3
k	Estimated number of STIs in birth cohort as adolescents - HPV	49,715	Tables 2 and 3
l	Estimated number of STIs in birth cohort as adults - HPV	143,554	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	2,257	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	946	= ((a * o) + (b * p)) * q
s	Estimated # of HIV infections avoided	12	= ((c * o) + (d * p)) * q
t	Estimated # of gonorrhea infections avoided	183	= ((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	38	= ((i * o) + (j * p)) * q
w	Estimated # of HPV infections avoided	21,428	= ((k * o) + (l * p)) * q
x	Estimated # of HSV-2 infections avoided	233	= ((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%**	**3,285**	= 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 = 1,706 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 = 4,498 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.[980] 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 $53.42 per hour ($100,000 per year) would lead the session.[981] 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 $487 (Table 7, row *n*). We have

[980] 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.
[981] *Nurse Practitioner (NP) Salary*. Available online at https://www.payscale.com/research/CA/Job=Nurse_Practitioner_(NP)/Salary. Accessed February 2018.

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*).[982] These costs, provided in 2010 US dollars, were adjusted to 2017 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

		2010 US$			2016 Can$			2017 Can$						
STI	**Sex**	Est	Range		Est	Range		Est	Range		% M/F	Est	Range	
Chlamydia														
	Male	$30	$15	$45	$40	$20	$59	$29	$14	$43	37%	$229	$114	$343
	Female	$364	$182	$546	$481	$241	$722	$346	$173	$519	63%			
Gonorrhea														
	Male	$79	$40	$119	$104	$53	$157	$75	$38	$113	64%	$169	$85	$254
	Female	$354	$177	$531	$468	$234	$702	$337	$168	$505	36%			
HBV		$2,667	$2,172	$2,924	$3,525	$2,871	$3,865	$2,536	$2,065	$2,780				
HIV		$304,500	$229,300	$379,700	$402,494	$303,093	$501,895	$289,543	$218,037	$361,049				
HPV														
	Male	$45	$23	$78	$59	$30	$103	$43	$22	$74	50%	$112	$57	$194
	Female	$191	$96	$329	$252	$127	$435	$182	$91	$313	50%			
HSV-2														
	Male	$761	$381	$1,142	$1,006	$504	$1,510	$724	$362	$1,086	31%	$632	$316	$948
	Female	$621	$311	$932	$821	$411	$1,232	$590	$296	$886	69%			
Syphilis		$709	$355	$1,064	$937	$469	$1,406	$674	$338	$1,012				

- 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 $10,267 per QALY (Table 7, row *kk*).

[982] 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	1,758,398	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	439,600	= a / c
e	Cost of 10-minute office visit	$34.85	Ref Doc
f	Value of patient time and travel for office visit	$59.38	Ref Doc
g	Portion of 10-minute office visit for screen	50%	Ref Doc
h	Cost of screening	$20,711,730	= d * (e + f) * g
i	Screen positive for sexual activity	356,076	= d * b
j	Adherence with behavioural counselling	29%	Table 4, row q
k	Attendance at a behavioural counselling intervention	103,262	= i * j
l	Individuals per behavioural counselling intervention	5	Assumed
m	Total number of behavioural counselling interventions	20,652	= k / m
n	Cost per behavioural counselling intervention	$487	√
o	Value of patient time and travel for behavioural counselling intervention	$89.07	√
p	Cost of behavioural counselling interventions	$19,255,251	= (m * n) + (k * o)
	Cost avoided		
q	Estimated # of chlamydia infections avoided	946	Table 4, row r
r	Estimated # of HIV infections avoided	12	Table 4, row s
s	Estimated # of gonorrhea infections avoided	183	Table 4, row t
t	Estimated # of Hep B-Acute infections avoided	0.2	Table 4, row u
u	Estimated # of syphilis infections avoided	38	Table 4, row v
v	Estimated # of HPV infections avoided	21,428	Table 4, row w
w	Estimated # of HSV-2 infections avoided	233	Table 4, row x
x	Cost of chlamydia infection avoided	$229	√
y	Cost of HIV infection avoided	$289,543	√
z	Cost of gonorrhea infection avoided	$169	√
aa	Cost of Hep B-Acute infection avoided	$2,536	√
bb	Cost of syphilis infection avoided	$674	√
cc	Cost of HPV infection avoided	$112	√
dd	Cost of HSV-2 infection avoided	$632	√
	CE calculation		
ee	Cost of intervention over lifetime of birth cohort	$39,966,981	= h + p
ff	Costs avoided	$6,239,820	= q * x + r * y + s * z + t * aa + u * bb + v * cc + w * dd
gg	QALYs saved	3,285	Table 4, row ff
hh	Cost of intervention over lifetime of birth cohort (1.5% discount)	$29,128,113	Calculated
ii	Costs avoided (1.5% discount)	$4,547,608	Calculated
jj	QALYs saved (1.5% discount)	2,394	Calculated
kk	**CE ($/QALY saved)**	**$10,267**	= (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 = $21,687/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 = $6,921/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 = $7,833/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 = $14,322/QALY.
- Assume the average number of individuals attending each behavioural counselling intervention is increased from 5 to 10 (Table 7, rows *l*): CE = $8,736/QALY.
- Assume the average number of individuals attending each behavioural counselling intervention is reduced from 5 to 1 (Table 7, rows *l*): CE = $22,513/QALY.
- Assume the average direct cost per HIV infection is reduced from $289,543 to $218,037 (Table 7, rows *y*): CE = $10,524/QALY.
- Assume the average direct cost per HIV infection is increased from $289,543 to $361,049 (Table 7, rows *y*): CE = $10,010/QALY.
- Assume the average direct cost per HPV infection is reduced from $112 to $57 (Table 7, rows *cc*): CE = $10,625/QALY.
- Assume the average direct cost per HPV infection is increased from $112 to $194 (Table 7, rows *cc*): CE = $9,732/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 2,394 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $10,267 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	**2,394**	1,243	3,278
3% Discount Rate	1,790	929	2,451
0% Discount Rate	3,285	1,706	4,498
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$10,267**	$6,921	$22,513
3% Discount Rate	$10,267	$6,921	$22,513
0% Discount Rate	$10,267	$6,921	$22,513
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$3,494	$1,974	$15,740
3% Discount Rate	$3,494	$1,974	$15,740
0% Discount Rate	$3,494	$1,974	$15,740

Smoking Cessation Advice and Help to Quit

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)*[983]

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.*[984]

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

[983] 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.

[984] 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.[985] 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 8.0% (200,747 of 2,524,990 life years), moderate smoking is 3.9% (98,886 of 2,524,990 life years) and heavy smoking is 2.4% (59,461 of 2,524,990 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**	*Mean Survival Rate*	*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	0.994	39,744	10.3%	0.4%	0.4%	4,092	143	143	4,378	79,488	8,183	286	287
20-24	0.992	39,682	20.5%	1.9%	0.4%	8,131	767	176	9,074	198,408	40,654	3,835	879
25-29	0.989	39,570	14.9%	5.2%	2.3%	5,905	2,074	907	8,885	197,850	29,523	10,368	4,533
30-34	0.986	39,458	16.6%	5.2%	1.3%	6,552	2,048	518	9,118	197,290	32,759	10,242	2,589
35-39	0.983	39,310	8.9%	6.7%	1.2%	3,513	2,645	489	6,647	196,550	17,566	13,224	2,444
40-44	0.978	39,105	6.8%	5.0%	3.5%	2,672	1,939	1,385	5,996	195,526	13,360	9,693	6,927
45-49	0.970	38,814	4.4%	2.9%	3.2%	1,726	1,119	1,247	4,092	194,070	8,632	5,593	6,235
50-54	0.960	38,390	7.6%	4.1%	4.6%	2,918	1,560	1,766	6,244	191,948	14,590	7,799	8,832
55-59	0.944	37,757	3.9%	7.9%	4.3%	1,468	2,987	1,635	6,089	188,786	7,341	14,933	8,173
60-64	0.920	36,800	3.9%	4.7%	3.5%	1,427	1,746	1,289	4,462	183,998	7,137	8,728	6,446
65-69	0.883	35,332	4.7%	3.5%	3.0%	1,654	1,235	1,061	3,950	176,658	8,269	6,176	5,304
70-74	0.827	33,072	3.7%	3.6%	2.1%	1,208	1,207	701	3,116	165,362	6,038	6,033	3,507
75-79	0.741	29,628	2.9%	0.9%	1.4%	857	253	423	1,532	148,142	4,283	1,264	2,115
80-84	0.614	24,551	1.4%	0.4%	0.7%	355	105	175	635	122,756	1,775	524	876
85-89	0.441	17,632	0.7%	0.2%	0.4%	127	38	63	228	88,158	637	188	315
Total			**8.0%**	**3.9%**	**2.4%**					**2,524,990**	**200,747**	**98,886**	**59,461**

- A significant proportion of smokers quit on their own.[986] 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.[987] 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.

Based on these assumptions, the CPB associated with behavioural counselling and interventions for the prevention of tobacco use is 5,944 QALYs (Table 2, row *ac*). The CPB of 5,944 represents the gap between no coverage and the 'best in the world' coverage estimated at 51%.

[985] 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.
[986] 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.
[987] 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.

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	2,524,990	Table 1
b	% of life years at light smoking (<10 cigarettes / day)	8.0%	Table 1
c	# of life years at light smoking	200,747	= (a * b)
d	% of life years at moderate smoking (10-19 cigarettes / day)	3.9%	Table 1
e	# of life years at moderate smoking	98,886	= (a * d)
f	% of life years at heavy smoking (≥20 cigarettes / day)	2.4%	Table 1
g	# of life years at heavy smoking	59,461	= (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	20,478	= (c * h)
j	% of life years lost due to moderate smoking	18.4%	Ref Doc
k	# of life years lost due to moderate smoking	18,188	= (e * j)
l	% of life years lost due to heavy smoking	28.0%	Ref Doc
m	# of life years lost due to heavy smoking	16,634	= (g * l)
n	Life years lost due to smoking	**55,300**	= 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	6,590	= (c - i) * o
q	% of QoL lost due to moderate smoking	3.9%	Ref Doc
r	# of QALYs lost due to moderate smoking	3,140	= (e - k) * q
s	% of QoL lost due to heavy smoking	7.3%	Ref Doc
t	# of QALYs lost due to heavy smoking	3,131	= (g - m) * s
u	QALYs lost due to smoking	**12,862**	= p + r + t
v	**Total QALYs lost due to smoking**	**68,162**	= 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	7,430	= v * w
z	QALYs gained with intervention with 100% adherence	19,085	= v * x
aa	Net QALYs gained with 100% adherence	11,656	= z - y
ab	Estimated adherence with screening and intervention	51%	Ref Doc
ac	**Potential QALYs gained, Screening & Intervention from 0% to 51%**	**5,944**	= 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 = 5,499 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 = 6,408 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 = 4,206 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 = 7,891 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.[988] 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 57% of all smokers would use either varenicline or buproprion and 43% of all smokers would use either the nicotine patch or nicotine gum. 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 $257.87 (in 2011 CAD) or $272.41 (in 2017 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 $785 per light smoker, $1,386 per moderate smoker and $2,050 per heavy smoker (see Reference Document). These costs avoided, however, are not fully realized until 20 years following smoking cessation.[989,990] 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,[991] 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.
- Discount rate of 1.5%, varied from 0% to 3% in the sensitivity analysis.

Based on these assumptions, the CE associated with behavioural counselling and interventions for the prevention of tobacco use is -$3,440 / QALY (Table 3, row *y*).

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988 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.

989 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.

990 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.

991 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.

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	2,524,990	Table 1
b	# of life years lived as smokers between the ages of 18-89 in birth cohort	359,095	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	359,095	= b
d	Proportion of office visit required	50%	See Ref Doc
e	Cost of 10-minute office visit	$34.85	See Ref Doc
f	Patient time costs / office visit	$59.38	See Ref Doc
g	Estimated cost of screening	$16,918,757	= (e + f) * d * c
	Estimated cost of intervention		
h	Average # of smokers in birth cohort ages 20-29	8,979	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	$272.41	√
l	Estimated cost of intervention	$2,542,040	= (h * i * j) * (e + f) + (h * i * k)
m	Average # of smokers in birth cohort ages 30-39	7,882	Table 1
n	Estimated cost of intervention	$2,231,511	= (m * i * j) * (e + f) + (m * i * k)
o	Average # of smokers in birth cohort ages 40-49	5,044	Table 1
p	Estimated cost of intervention	$1,427,929	= (o * i * j) * (e + f) + (o * i * k)
q	**Total cost of interventions**	**$6,201,480**	= l + n + p
r	**Estimated costs avoided due to intervention**	**$49,085,691**	Calculated
	CE Calculation		
s	Cost of intervention over lifetime of birth cohort	$23,120,237	= g + q
t	Costs avoided due to intervention over lifetime of birth cohort	$49,085,691	= r
u	QALYs saved	5,944	Table 2, row ac
v	Cost of intervention over lifetime of birth cohort (1.5% discount)	$16,638,976	Calculated
w	Costs avoided due to intervention over lifetime of birth cohort (1.5% discount)	$27,946,815	Calculated
x	QALYs saved (1.5% discount)	3,287	Calculated
y	**CE ($/QALY saved)**	**-$3,440**	= (v - w) / x

√ = 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 = -$3,719.
- 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 = -$3,191.
- Assume that the quit rate with intervention (2-3 sessions + medication) is reduced from 28.0% to 23.0% (Table 2, row *x*): CE = -$1,348
- Assume that the quit rate with intervention (2-3 sessions + medication) is increase from 28.0% to 33.6% (Table 2, row *x*): CE = -$4,689.
- Assume the proportion of an office visit required for screening is reduced from 50% to 33% (Table 3, row *d*): CE = -$4,675.
- Assume the proportion of an office visit required for screening is increased from 50% to 67% (Table 3, row *d*): CE = -$2,205.

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 3,287 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to result in cost savings of $3,440 per QALY (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	**3,287**	2,326	4,364
3% Discount Rate	1,833	1,297	2,433
0% Discount Rate	5,944	4,206	7,891
Gap between BC Current (19%) and 'Best in the World' (51%)			
1.5% Discount Rate	1,225	867	1,626
3% Discount Rate	683	483	906
0% Discount Rate	2,214	1,567	2,940
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**-$3,440**	-$4,689	-$1,348
3% Discount Rate	-$2,094	-$3,751	$681
0% Discount Rate	-$4,368	-$5,328	-$2,761
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	-$6,210	-$6,775	-$5,263
3% Discount Rate	-$5,769	-$6,519	-$4,513
0% Discount Rate	-$6,496	-$6,931	-$5,769

Screening and Behavioural Counseling Interventions to Reduce Unhealthy Alcohol Use

United States Preventive Services Task Force Recommendations (2018)[992]

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) [993]

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.[994]
- 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).[995]
- 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.[996]
- In Oregon, 4.6% of individuals are screened in primary care for unhealthy alcohol use[997] but 41% of Medicaid enrollees in the state with an alcohol use disorder receive

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[992] 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.
[993] 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.
[994] 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.
[995] 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.
[996] 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.
[997] 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.

treatment,[998] 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).[999]
- 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.[1000]
- 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%).[1001]
- 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.[1002] 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.[1003]

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[998] 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.

[999] 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.

[1000] 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.

[1001] 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).

[1002] 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.

[1003] 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[1004] and 97% (Table 14, row *ba*) for pregnant women based on the results from Norwegian midwives.[1005] 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[1006] – 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 2,426,833 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, 1,237,859 are in females (Table 14, row *a*) and 1,188,974 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	19,871	**39,765**	39,775	39,723	**79,498**
20-24	19,881	19,850	**39,731**	99,323	99,062	**198,385**
25-29	19,848	19,772	**39,620**	99,162	98,673	**197,835**
30-34	19,815	19,698	**39,513**	98,972	98,285	**197,257**
35-39	19,771	19,612	**39,383**	98,701	97,791	**196,492**
40-44	19,706	19,499	**39,204**	98,303	97,123	**195,427**
45-49	19,610	19,342	**38,952**	97,719	96,187	**193,906**
50-54	19,469	19,119	**38,588**	96,856	94,829	**191,685**
55-59	19,260	18,792	**38,052**	95,564	92,812	**188,376**
60-64	18,944	18,301	**37,245**	93,587	89,774	**183,360**
65-69	18,456	17,559	**36,015**	90,497	85,168	**175,665**
70-74	17,687	16,434	**34,120**	85,608	78,208	**163,816**
75-79	16,467	14,743	**31,209**	77,872	67,907	**145,779**
80-84	14,547	12,283	**26,830**	65,919	53,435	**119,354**
Total				**1,237,859**	**1,188,974**	**2,426,833**

[1004] 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.
[1005] Wangberg SC. Norwegian midwives' use of screening for and brief interventions on alcohol use in pregnancy. *Sexual & Reproductive Healthcare*. 2015; 6(3): 186-90.
[1006] 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.[1007]
- The categorization of alcohol exposure commonly used in Canadian research[1008,1009] 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.[1010] Alcohol consumption rates are adjusted for underreporting.[1011,1012,1013] 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 (635,884 of 2,426,833) are lived with unhealthy alcohol use. The proportion is lower for females (21.5% or 266,098 of 1,237,859) than for males (31.1% or 369,785 of 1,188,974) (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.

1007 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.
1008 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.
1009 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.
1010 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.
1011 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.
1012 Kerr WC and Stockwell T. Understanding standard drinks and drinking guidelines. *Drug and Alcohol Review*. 2012; 31(2): 200-5.
1013 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* Low	Low-Binge	Hazardous	Harmful	Total	*% of BC **Male** Pop by Alcohol Use Status* 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**		12,120	2,782	2,896	**17,797**
20-24		25,957	5,044	3,760	**34,761**		30,225	6,937	7,221	**44,383**
25-29		25,915	5,035	3,754	**34,705**		30,107	6,910	7,193	**44,209**
30-34		12,832	4,697	2,937	**20,466**		21,054	8,045	7,744	**36,842**
35-39		12,797	4,684	2,929	**20,410**		20,948	8,005	7,705	**36,657**
40-44		12,746	4,665	2,917	**20,328**		20,805	7,950	7,652	**36,407**
45-49		11,340	5,815	2,229	**19,385**		15,920	6,415	5,853	**28,188**
50-54		11,241	5,764	2,209	**19,214**		15,695	6,325	5,770	**27,790**
55-59		11,091	5,687	2,180	**18,958**		15,361	6,190	5,648	**27,199**
60-64		3,724	6,883	1,859	**12,466**		9,426	6,637	4,954	**21,017**
65-69		3,601	6,656	1,798	**12,055**		8,943	6,297	4,699	**19,939**
70-74		1,973	9,347	1,855	**13,175**		3,492	4,490	3,035	**11,018**
75-79		1,795	8,502	1,688	**11,985**		3,032	3,899	2,635	**9,566**
80-84		1,447	11,287	1,539	**14,272**		538	5,166	3,067	**8,771**
Total		**146,853**	**86,086**	**33,160**	**266,098**		**207,667**	**86,048**	**76,071**	**369,785**
			% 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.[1014] 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.

[1014] 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.

- 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.[1015]
- 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 (551,699 of 2,426,833) are lived with unhealthy alcohol use. The proportion is lower for females (18.1% or 224,624 of 1,237,859) than for males (27.5% or 327,076 of 1,188,974) (see Table 2). ***Note that these proportions are not adjusted for underreporting of alcohol consumption.***

[1015] 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

	*% of BC **Female** Pop by Alcohol Use Status*					*% of BC **Male** Pop by Alcohol Use Status*				
Age Group	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**		7,438	-	1,366	**8,805**
20-24		22,337	-	5,019	**27,356**		25,439	-	6,462	**31,901**
25-29		29,056	-	7,221	**36,277**		34,169	-	9,367	**43,536**
30-34		15,588	-	7,793	**23,381**		37,137	25	8,210	**45,373**
35-39		15,382	74	6,311	**21,767**		21,652	-	10,515	**32,167**
40-44		11,342	108	3,996	**15,446**		16,987	162	8,575	**25,724**
45-49		12,750	371	4,129	**17,251**		18,158	873	7,563	**26,593**
50-54		15,673	1,434	3,354	**20,461**		15,517	1,474	6,727	**23,719**
55-59		10,055	739	3,387	**14,180**		16,580	1,481	9,143	**27,204**
60-64		10,726	2,054	3,060	**15,841**		14,185	832	5,459	**20,476**
65-69		4,615	4,141	2,128	**10,884**		8,295	1,319	6,312	**15,925**
70-74		2,133	2,846	2,537	**7,516**		7,484	3,006	3,428	**13,917**
75-79		1,242	2,965	1,337	**5,544**		4,058	1,705	2,611	**8,374**
80-84		170	1,007	114	**1,291**		1,873	1,208	279	**3,361**
Total		**156,883**	**15,740**	**52,001**	**224,624**		**228,973**	**12,086**	**86,016**	**327,076**
			% 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.[1016]
- Based on ***2007/8*** CCHS *self-reported data*, an estimated 7.2% of pregnant women in B.C. reported consuming alcohol while pregnant.[1017] 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.[1018]
- 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%).[1019]
- 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,[1020] particularly those who consume a higher volume of drinks.[1021] 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.[1022,1023]
- This underestimate of self-reported alcohol consumption in pregnant women is supported by the research of Ethan and colleagues.[1024] 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

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1016 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.
1017 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.
1018 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.
1019 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.
1020 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.
1021 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.
1022 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
1023 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.
1024 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.[1025] 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.[1026]
- 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."[1027]
- 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.[1028]
- 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).[1029]
- An estimated one of every 13 pregnant women who consumed alcohol during pregnancy delivered a child with FASD.[1030]

[1025] 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.
[1026] 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.
[1027] Popova S, Lange S, Shield K et al. Comorbidity of fetal alcohol spectrum disorder: A systematic review and meta-analysis. *The Lancet*. 2016.
[1028] Popova S, Lange S, Shield K et al. Comorbidity of fetal alcohol spectrum disorder: A systematic review and meta-analysis. *The Lancet*. 2016.
[1029] 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.
[1030] 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).[1031]
- An estimated one out of every 67 women who consume alcohol during pregnancy will deliver a child with FAS.[1032]
- 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.[1033]
- 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.[1034]
- 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 27,066 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%[1035] 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 490 of the 27,066 (1.81%) births would have FASD.
- Globally, the prevalence of FASD in children and youth is estimated at 0.77%[1036] while the prevalence of FAS is estimated at 0.146%,[1037] 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 490 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*).

1031 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.
1032 Ibid.
1033 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.
1034 Popova S, Lange S, Poznyak V et al. Population-based prevalence of fetal alcohol spectrum disorder in Canada. *BMC Public Health*. 2019.
1035 Ibid.
1036 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.
1037 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	
18-19	39,775	6.85	272	4.9	8.0	0.9	1.5
20-24	99,323	29.74	2,954	53.5	86.6	10.1	16.4
25-29	99,162	71.64	7,104	128.6	208.1	24.4	39.5
30-34	98,972	99.53	9,850	178.3	288.6	33.8	54.7
35-39	98,701	57.06	5,632	101.9	165.0	19.3	31.3
40-44	98,303	11.98	1,177	21.3	34.5	4.0	6.5
45-49	97,719	0.79	77	1.4	2.3	0.3	0.4
Total	**631,955**		**27,066**	**490**	**793**	**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.[1038]
- 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.[1039]
- 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.[1040]

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 10,328 life years lost (2,990 in females [Table 14, row *o*] and 7,338 in males [Table 14, row *p*]) due to unhealthy alcohol use (see Table 7).

[1038] 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.
[1039] 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.
[1040] 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	6.4	3.0%	66.6	12.8	9.2	5.9%	62.7	34.0
19	6.6	3.0%	65.7	13.0	11.6	5.9%	61.7	42.2
20	6.6	5.0%	64.7	21.4	13.8	12.0%	60.8	100.7
21	6.6	5.0%	63.7	21.0	15.6	12.0%	59.8	111.9
22	6.6	5.0%	62.7	20.7	16.6	12.0%	58.9	117.3
23	6.4	5.0%	61.7	19.7	16.8	12.0%	57.9	116.7
24	6.4	5.0%	60.8	19.5	16.2	12.0%	57.0	110.8
25	6.4	4.6%	59.8	17.6	15.2	11.0%	56.0	93.6
26	6.4	4.6%	58.8	17.3	14.8	11.0%	55.1	89.7
27	6.6	4.6%	57.8	17.5	14.4	11.0%	54.1	85.7
28	6.8	4.6%	56.8	17.8	14.4	11.0%	53.1	84.1
29	7.2	4.6%	55.9	18.5	14.8	11.0%	52.2	85.0
30	7.6	4.4%	54.9	18.4	15.4	9.8%	51.2	77.3
31	8.2	4.4%	53.9	19.4	16.2	9.8%	50.2	79.7
32	8.8	4.4%	52.9	20.5	17.0	9.8%	49.3	82.1
33	9.6	4.4%	51.9	21.9	18.0	9.8%	48.3	85.2
34	10.4	4.4%	51.0	23.3	19.0	9.8%	47.4	88.3
35	11.2	4.3%	50.0	24.1	20.2	8.8%	46.4	82.5
36	12.0	4.3%	49.0	25.3	21.4	8.8%	45.5	85.7
37	13.0	4.3%	48.1	26.9	22.6	8.8%	44.5	88.5
38	14.0	4.3%	47.1	28.4	24.0	8.8%	43.6	92.1
39	15.0	4.3%	46.1	29.7	25.6	8.8%	42.6	96.0
40	16.4	4.6%	45.1	34.0	27.2	8.5%	41.7	96.4
41	17.6	4.6%	44.2	35.8	29.2	8.5%	40.7	101.0
42	19.0	4.6%	43.2	37.8	31.2	8.5%	39.8	105.5
43	20.6	4.6%	42.3	40.1	33.2	8.5%	38.9	109.8
44	22.2	4.6%	41.3	42.2	35.6	8.5%	37.9	114.7
45	24.0	4.8%	40.4	46.5	38.2	8.1%	37.0	114.5
46	26.0	4.8%	39.4	49.2	41.2	8.1%	36.1	120.5
47	28.0	4.8%	38.5	51.7	44.2	8.1%	35.1	125.7
48	30.2	4.8%	37.5	54.4	47.8	8.1%	34.2	132.4
49	32.8	4.8%	36.6	57.6	51.4	8.1%	33.3	138.6
50	35.4	4.7%	35.6	59.2	55.6	7.6%	32.4	136.9
51	38.2	4.7%	34.7	62.3	60.2	7.6%	31.5	144.1
52	41.4	4.7%	33.8	65.8	65.0	7.6%	30.6	151.2
53	45.0	4.7%	32.8	69.4	70.4	7.6%	29.7	158.9
54	48.8	4.7%	31.9	73.2	76.4	7.6%	28.8	167.2
55	53.0	4.1%	31.0	67.4	82.8	6.4%	27.9	147.8
56	57.6	4.1%	30.1	71.1	89.8	6.4%	27.0	155.2
57	62.6	4.1%	29.2	74.9	97.4	6.4%	26.2	163.3
58	68.2	4.1%	28.3	79.1	105.8	6.4%	25.3	171.3
59	74.4	4.1%	27.4	83.6	114.8	6.4%	24.4	179.3
60	81.2	3.1%	26.5	66.7	124.8	4.9%	23.6	144.3
61	88.6	3.1%	25.6	70.3	135.6	4.9%	22.7	150.8
62	96.8	3.1%	24.7	74.1	147.4	4.9%	21.9	158.2
63	106.0	3.1%	23.8	78.2	160.2	4.9%	21.1	165.6
64	116.0	3.1%	22.9	82.3	174.2	4.9%	20.3	173.3
65	127.0	2.3%	22.1	64.6	189.2	3.6%	19.5	132.8
66	139.0	2.3%	21.2	67.8	205.8	3.6%	18.7	138.5
67	152.4	2.3%	20.4	71.5	223.6	3.6%	17.9	144.1
68	167.2	2.3%	19.6	75.4	243.0	3.6%	17.1	149.6
69	183.4	2.3%	18.7	78.9	263.8	3.6%	16.4	155.7
70	201.0	1.5%	17.9	54.0	286.4	2.4%	15.6	107.2
71	220.6	1.5%	17.1	56.6	310.6	2.4%	14.9	111.1
72	242.0	1.5%	16.3	59.2	336.4	2.4%	14.2	114.6
73	265.4	1.5%	15.6	62.1	364.2	2.4%	13.5	118.0
74	291.0	1.5%	14.8	64.6	393.4	2.4%	12.8	120.9
75	318.8	0.9%	14.1	38.2	424.4	1.4%	12.1	71.9
76	349.0	0.9%	13.3	39.5	457.0	1.4%	11.5	73.6
77	381.6	0.9%	12.6	40.9	490.8	1.4%	10.8	74.2
78	416.6	0.9%	11.9	42.1	525.8	1.4%	10.2	75.1
79	454.0	0.9%	11.2	43.2	561.4	1.4%	9.6	75.5
80	493.8	0.6%	10.6	29.3	597.2	0.8%	9.0	45.1
81	535.6	0.6%	9.9	29.7	632.6	0.8%	8.4	44.6
82	579.2	0.6%	9.3	30.2	666.8	0.8%	7.9	44.2
83	624.0	0.6%	8.7	30.4	698.8	0.8%	7.4	43.4
84	669.2	0.6%	8.1	30.4	727.6	0.8%	6.9	42.2
Total				***2,990***				***7,338***

- 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%).[1041]
- 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.[1042]
- 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.[1043,1044,1045,1046,1047,1048,1049]
- 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 490 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 11,425 life years would be lost, 4,477 in children born with FAS (Table 14, row *ak*) and 6,948 in all other children born with FASD (see Table 8 and Table 14, row *al*).

[1041] Thanh NX and Jonsson E. Life expectancy of people with fetal alcohol syndrome. *Journal of Population Therapeutics and Clinical Pharmacology*. 2016; 23(1):

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[1043] 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.

[1044] 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.

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[1048] 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.

[1049] 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	19,884	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	19,865	29.74	591	10.7	2.0	151.7	97.7
23	19,858	29.74	591	10.7	2.0	151.6	97.7
24	19,852	29.74	590	10.7	2.0	151.6	97.7
25	19,845	71.64	1,422	25.7	4.9	364.9	235.2
26	19,839	71.64	1,421	25.7	4.9	364.8	235.1
27	19,833	71.64	1,421	25.7	4.9	364.7	235.0
28	19,826	71.64	1,420	25.7	4.9	364.6	234.9
29	19,819	71.64	1,420	25.7	4.9	364.4	234.9
30	19,812	99.53	1,972	35.7	6.8	506.1	326.2
31	19,804	99.53	1,971	35.7	6.8	505.9	326.0
32	19,795	99.53	1,970	35.7	6.8	505.7	325.9
33	19,786	99.53	1,969	35.6	6.8	505.5	325.7
34	19,776	99.53	1,968	35.6	6.8	505.2	325.6
35	19,765	57.06	1,128	20.4	3.9	289.5	186.6
36	19,754	57.06	1,127	20.4	3.9	289.3	186.5
37	19,741	57.06	1,126	20.4	3.9	289.1	186.3
38	19,728	57.06	1,126	20.4	3.9	288.9	186.2
39	19,713	57.06	1,125	20.4	3.9	288.7	186.1
40	19,697	11.98	236	4.3	0.8	60.6	39.0
41	19,680	11.98	236	4.3	0.8	60.5	39.0
42	19,662	11.98	235	4.3	0.8	60.4	39.0
43	19,642	11.98	235	4.3	0.8	60.4	38.9
44	19,621	11.98	235	4.3	0.8	60.3	38.9
45	19,598	0.79	15	0.3	0.1	4.0	2.5
46	19,573	0.79	15	0.3	0.1	4.0	2.5
47	19,546	0.79	15	0.3	0.1	3.9	2.5
48	19,517	0.79	15	0.3	0.1	3.9	2.5
49	19,485	0.79	15	0.3	0.1	3.9	2.5
Total			**27,066**	**490**	**93**	**6,948**	**4,477**

Estimating the Quality of Life Reduction - General

- 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,[1050] alcohol abuse[1051] and alcohol dependence[1052] 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.[1053]

- 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%.[1054]

- The GBD study found that a very mild alcohol use disorder[1055] is associated with a *disutility* of 0.123 (95% CI of 0.082 to 0.177), a mild alcohol use disorder[1056] is associated with a *disutility* of 0.235 (95% CI of 0.160 to 0.327), a moderate alcohol use disorder[1057] is associated with a disutility of 0.373 (95% CI of 0.248 to 0.508) and a severe alcohol use disorder[1058] is associated with a disutility of 0.570 (95% CI of 0.396 to 0.732).[1059]

- 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

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[1050] **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."

[1051] **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."

[1052] **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."

[1053] 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.

[1054] 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.

[1055] **Very mild alcohol use disorder** – "Drinks alcohol daily and has difficulty controlling the urge to drink. When sober, the person functions normally."

[1056] **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."

[1057] **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."

[1058] **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."

[1059] 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.

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).[1060,1061]

- 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.[1062]
- 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 107,624 QALYs lost, with 43,553 QALYs lost in females (Table 14, row *w*) and 64,071 QALYs lost in males (Table 14, row *aa*).

[1060] 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.
[1061] 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.
[1062] 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	639	181	229	1,049	19,867	6,062	1,391	1,448	746	249	440	1,435
19	19,884	5,197	1,010	753	639	181	229	1,049	19,856	6,058	1,390	1,447	745	249	440	1,434
20	19,878	5,195	1,009	753	639	181	229	1,048	19,844	6,055	1,390	1,447	745	249	440	1,433
21	19,871	5,193	1,009	752	639	181	229	1,048	19,829	6,050	1,389	1,445	744	249	439	1,432
22	19,865	5,191	1,009	752	639	181	229	1,048	19,813	6,045	1,387	1,444	744	248	439	1,431
23	19,858	5,190	1,008	752	638	181	229	1,047	19,796	6,040	1,386	1,443	743	248	439	1,430
24	19,852	5,188	1,008	752	638	180	228	1,047	19,780	6,035	1,385	1,442	742	248	438	1,429
25	19,845	5,186	1,008	751	638	180	228	1,047	19,764	6,030	1,384	1,441	742	248	438	1,427
26	19,839	5,185	1,007	751	638	180	228	1,046	19,749	6,026	1,383	1,440	741	248	438	1,426
27	19,833	5,183	1,007	751	638	180	228	1,046	19,734	6,021	1,382	1,439	741	247	437	1,425
28	19,826	5,181	1,007	751	637	180	228	1,046	19,720	6,017	1,381	1,438	740	247	437	1,424
29	19,819	5,180	1,006	750	637	180	228	1,045	19,705	6,012	1,380	1,436	740	247	437	1,423
30	19,812	2,569	940	588	316	168	179	663	19,690	4,218	1,612	1,551	519	289	472	1,279
31	19,804	2,568	940	588	316	168	179	663	19,675	4,215	1,611	1,550	518	288	471	1,278
32	19,795	2,566	939	587	316	168	179	662	19,658	4,211	1,609	1,549	518	288	471	1,277
33	19,786	2,565	939	587	316	168	178	662	19,640	4,207	1,608	1,547	517	288	470	1,276
34	19,776	2,564	939	587	315	168	178	662	19,622	4,203	1,606	1,546	517	288	470	1,274
35	19,765	2,563	938	587	315	168	178	661	19,602	4,199	1,605	1,544	516	287	469	1,273
36	19,754	2,561	937	586	315	168	178	661	19,582	4,195	1,603	1,543	516	287	469	1,272
37	19,741	2,560	937	586	315	168	178	661	19,560	4,190	1,601	1,541	515	287	468	1,270
38	19,728	2,558	936	585	315	168	178	660	19,536	4,185	1,599	1,539	515	286	468	1,269
39	19,713	2,556	936	585	314	167	178	660	19,511	4,180	1,597	1,537	514	286	467	1,267
40	19,697	2,554	935	585	314	167	178	659	19,485	4,174	1,595	1,535	513	286	467	1,266
41	19,680	2,552	934	584	314	167	178	659	19,457	4,168	1,593	1,533	513	285	466	1,264
42	19,662	2,549	933	583	314	167	177	658	19,427	4,161	1,590	1,531	512	285	465	1,262
43	19,642	2,547	932	583	313	167	177	657	19,395	4,155	1,588	1,528	511	284	465	1,260
44	19,621	2,544	931	582	313	167	177	657	19,360	4,147	1,585	1,525	510	284	464	1,257
45	19,598	2,274	1,166	447	280	209	136	624	19,323	3,198	1,289	1,176	393	231	357	982
46	19,573	2,272	1,165	446	279	208	136	624	19,283	3,192	1,286	1,173	393	230	357	979
47	19,546	2,268	1,163	446	279	208	136	623	19,241	3,185	1,283	1,171	392	230	356	977
48	19,517	2,265	1,161	445	279	208	135	622	19,195	3,177	1,280	1,168	391	229	355	975
49	19,485	2,261	1,160	444	278	208	135	621	19,145	3,169	1,277	1,165	390	229	354	972
50	19,451	2,257	1,158	444	278	207	135	620	19,091	3,160	1,273	1,162	389	228	353	970
51	19,414	2,253	1,155	443	277	207	135	619	19,034	3,150	1,269	1,158	387	227	352	967
52	19,375	2,249	1,153	442	277	206	134	617	18,971	3,140	1,265	1,154	386	226	351	964
53	19,331	2,243	1,150	441	276	206	134	616	18,903	3,129	1,261	1,150	385	226	350	960
54	19,285	2,238	1,148	440	275	205	134	614	18,830	3,117	1,256	1,146	383	225	348	956
55	19,234	2,232	1,145	439	275	205	133	613	18,750	3,103	1,251	1,141	382	224	347	952
56	19,178	2,226	1,141	437	274	204	133	611	18,664	3,089	1,245	1,136	380	223	345	948
57	19,118	2,219	1,138	436	273	204	133	609	18,570	3,074	1,239	1,130	378	222	344	943
58	19,053	2,211	1,134	435	272	203	132	607	18,469	3,057	1,232	1,124	376	220	342	938
59	18,981	2,203	1,130	433	271	202	132	605	18,358	3,039	1,224	1,117	374	219	340	933
60	18,904	752	1,390	375	93	249	114	456	18,239	1,915	1,348	1,006	236	241	306	783
61	18,819	749	1,384	374	92	248	114	454	18,109	1,901	1,339	999	234	240	304	777
62	18,726	745	1,377	372	92	247	113	451	17,967	1,887	1,328	991	232	238	301	771
63	18,625	741	1,370	370	91	245	112	449	17,813	1,870	1,317	983	230	236	299	765
64	18,514	737	1,362	368	91	244	112	446	17,646	1,853	1,305	974	228	234	296	757
65	18,392	732	1,353	365	90	242	111	443	17,464	1,834	1,291	964	226	231	293	750
66	18,259	727	1,343	363	89	240	110	440	17,267	1,813	1,277	953	223	229	290	741
67	18,113	721	1,332	360	89	238	109	437	17,052	1,791	1,261	941	220	226	286	732
68	17,954	714	1,320	357	88	236	108	433	16,819	1,766	1,243	928	217	223	282	722
69	17,778	707	1,308	353	87	234	107	428	16,565	1,739	1,225	914	214	219	278	711
70	17,586	405	1,920	381	50	344	116	509	16,290	727	935	632	89	167	192	449
71	17,375	400	1,897	377	49	340	114	503	15,992	714	918	621	88	164	189	441
72	17,144	395	1,872	372	49	335	113	497	15,668	700	900	608	86	161	185	432
73	16,890	389	1,844	366	48	330	111	489	15,318	684	880	594	84	157	181	422
74	16,612	383	1,814	360	47	325	109	481	14,939	667	858	580	82	154	176	412
75	16,307	376	1,780	353	46	319	107	472	14,530	649	834	564	80	149	171	401
76	15,973	368	1,744	346	45	312	105	463	14,090	629	809	547	77	145	166	388
77	15,608	360	1,704	338	44	305	103	452	13,616	608	782	528	75	140	161	375
78	15,209	351	1,661	330	43	297	100	441	13,107	585	753	509	72	135	155	361
79	14,774	341	1,613	320	42	289	97	428	12,564	561	721	488	69	129	148	346
80	14,300	314	2,448	334	39	438	101	578	11,984	121	1,159	688	15	207	209	431
81	13,785	303	2,360	322	37	422	98	558	11,370	114	1,099	653	14	197	198	409
82	13,228	290	2,265	309	36	405	94	535	10,720	108	1,036	615	13	186	187	386
83	12,626	277	2,162	295	34	387	90	511	10,037	101	970	576	12	174	175	361
84	11,980	263	2,051	280	32	367	85	485	9,324	94	901	535	12	161	163	336
Total	***1,237,859***	***146,854***	***86,086***	***33,160***	***18,063***	***15,409***	***10,081***	***43,553***	***1,188,974***	***207,667***	***86,048***	***76,071***	***25,543***	***15,403***	***23,126***	***64,071***

- FASD can have a significant impact on the day to day activities and quality of life of those living with the diagnosis.[1063] 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.[1064]

- The GBD study found that **mild fetal alcohol syndrome**[1065] is associated with a disutility of 0.016 (95% CI of 0.008 to 0.030), **moderate fetal alcohol syndrome**[1066] is associated with a disutility of 0.056 (95% CI of 0.035 to 0.083) and **severe fetal alcohol syndrome**[1067] is associated with a disutility of 0.179 (95% CI of 0.119 to 0.257).[1068]

- Lamsal and colleagues recently published a review of literature on the QoL in children with a variety of neurodevelopmental disorders.[1069] The study by Stade et al was the only one identified for FASD.[1070] The review found, however, that the QoL associated with attention deficit hyperactivity disorder was 0.79,[1071] autism spectrum disorder was 0.60[1072] 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, 12,593 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 11,045 in those living with FASD, excluding FAS (see Table 10 and Table 14, row *an*).

1063 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.

1064 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.

1065 **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."

1066 **Moderate fetal alcohol syndrome** – "is slow in developing physically and mentally, which causes some difficulty in daily activities."

1067 **Severe fetal alcohol syndrome** – "is very slow in developing physically and mentally, which causes great difficulty in daily activities."

1068 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.

1069 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.

1070 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.

1071 Based on a weighted average of identified studies.

1072 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	19,884	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	19,865	10.7	2.0	64.7	34.0	0.43	0.49	241.1	33.8
23	19,858	10.7	2.0	64.7	34.0	0.43	0.49	241.0	33.8
24	19,852	10.7	2.0	64.7	34.0	0.43	0.49	240.9	33.8
25	19,845	25.7	4.9	64.7	34.0	0.43	0.49	580.2	81.3
26	19,839	25.7	4.9	64.7	34.0	0.43	0.49	580.0	81.3
27	19,833	25.7	4.9	64.7	34.0	0.43	0.49	579.8	81.2
28	19,826	25.7	4.9	64.7	34.0	0.43	0.49	579.6	81.2
29	19,819	25.7	4.9	64.7	34.0	0.43	0.49	579.4	81.2
30	19,812	35.7	6.8	64.7	34.0	0.43	0.49	804.6	112.7
31	19,804	35.7	6.8	64.7	34.0	0.43	0.49	804.3	112.7
32	19,795	35.7	6.8	64.7	34.0	0.43	0.49	804.0	112.6
33	19,786	35.6	6.8	64.7	34.0	0.43	0.49	803.6	112.6
34	19,776	35.6	6.8	64.7	34.0	0.43	0.49	803.2	112.5
35	19,765	20.4	3.9	64.7	34.0	0.43	0.49	460.2	64.5
36	19,754	20.4	3.9	64.7	34.0	0.43	0.49	460.0	64.4
37	19,741	20.4	3.9	64.7	34.0	0.43	0.49	459.7	64.4
38	19,728	20.4	3.9	64.7	34.0	0.43	0.49	459.4	64.4
39	19,713	20.4	3.9	64.7	34.0	0.43	0.49	459.0	64.3
40	19,697	4.3	0.8	64.7	34.0	0.43	0.49	96.3	13.5
41	19,680	4.3	0.8	64.7	34.0	0.43	0.49	96.2	13.5
42	19,662	4.3	0.8	64.7	34.0	0.43	0.49	96.1	13.5
43	19,642	4.3	0.8	64.7	34.0	0.43	0.49	96.0	13.4
44	19,621	4.3	0.8	64.7	34.0	0.43	0.49	95.9	13.4
45	19,598	0.3	0.1	64.7	34.0	0.43	0.49	6.3	0.9
46	19,573	0.3	0.1	64.7	34.0	0.43	0.49	6.3	0.9
47	19,546	0.3	0.1	64.7	34.0	0.43	0.49	6.3	0.9
48	19,517	0.3	0.1	64.7	34.0	0.43	0.49	6.3	0.9
49	19,485	0.3	0.1	64.7	34.0	0.43	0.49	6.3	0.9
Total		**490**	**93**					**11,045**	**1,548**

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[1073] 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

[1073] 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?"[1074]

- 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.[1075]
- 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.[1076]
- 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.[1077]
- 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.[1078]
- 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.[1079]
- 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).[1080]
- There is no evidence that screening by itself leads to reduced unhealthy alcohol use.[1081]

- 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).

[1074] 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.
[1075] 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.
[1076] Ibid.
[1077] 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.
[1078] 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.
[1079] Ibid.
[1080] Ibid.
[1081] Ibid.

Screening Frequency

- The USPSTF did not find adequate evidence to recommend an optimal screening interval.[1082]
- 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."[1083] 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.[1084]
- Economic evaluations have assumed that screening would occur anywhere from at least once a year to at least once every 10 years.[1085,1086,1087]

- 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.[1088]

- 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

[1082] Ibid.
[1083] 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.
[1084] 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.
[1085] 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.
[1086] 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.
[1087] 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.
[1088] 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]).[1089]

- Brief counselling is associated with a reduction in alcohol consumption of 1.6 drinks per week (95% CI of 1.0 to 2.2).[1090]
- 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).[1091]
- 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).[1092]
- 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).[1093]

- 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.[1094]

- 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*)

[1089] 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.
[1090] 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.
[1091] 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.
[1092] Ibid.
[1093] 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.
[1094] Ibid.

Estimating QALYs Gained Due to Screening and Brief Intervention

- 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 12,930. Of the 12,930 who see a PCP, 93% or 12,025 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 10,101 (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 10,101, 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 12.8 life years lost due to unhealthy alcohol use in female 18-year olds in the cohort for a gain of 0.37(2.9% * 12.8) life years associated with the brief intervention. In addition, the 2.9% is also applied to our previous calculation (see Table 9) of 1,049 QALYs lost due to unhealthy alcohol use in the female 18-year olds in the cohort for a gain of 30 (2.9% * 1,049) 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 108 life years gained and an additional 1,527 QALYs gained (Table 12 and Table 14, rows *av* and *aw*) and males would result in 229 life years gained and an additional 1,834 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		Screened at GP		Sensitivity of Screen		Accepting 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
		% (Table 11)	#	%	#	%	#	%	#	%	#					
18	19,891	65.0%	12,930	93%	12,025	84%	10,101	41%	4,142	13.9%	575	2.9%	12.8	0.4	1,049	30
19	19,884	65.0%	12,926	93%	12,021	84%	10,098	41%	4,140	13.9%	575	2.9%	13.0	0.4	1,049	30
20	19,878	66.0%	13,117	93%	12,199	84%	10,247	41%	4,201	13.9%	584	2.9%	21.4	0.6	1,048	31
21	19,871	66.0%	13,113	93%	12,195	84%	10,244	41%	4,200	13.9%	583	2.9%	21.0	0.6	1,048	31
22	19,865	66.0%	13,109	93%	12,191	84%	10,240	41%	4,199	13.9%	583	2.9%	20.7	0.6	1,048	31
23	19,858	66.0%	13,104	93%	12,187	84%	10,237	41%	4,197	13.9%	583	2.9%	19.7	0.6	1,047	31
24	19,852	66.0%	13,100	93%	12,183	84%	10,234	41%	4,196	13.9%	583	2.9%	19.5	0.6	1,047	31
25	19,845	79.5%	15,773	93%	14,669	84%	12,322	41%	5,052	13.9%	702	3.5%	17.6	0.6	1,047	37
26	19,839	79.5%	15,768	93%	14,664	84%	12,318	41%	5,050	13.9%	701	3.5%	17.3	0.6	1,046	37
27	19,833	79.5%	15,763	93%	14,659	84%	12,314	41%	5,049	13.9%	701	3.5%	17.5	0.6	1,046	37
28	19,826	79.5%	15,757	93%	14,654	84%	12,310	41%	5,047	13.9%	701	3.5%	17.8	0.6	1,046	37
29	19,819	79.5%	15,752	93%	14,649	84%	12,305	41%	5,045	13.9%	701	3.5%	18.5	0.7	1,045	37
30	19,812	81.7%	16,186	93%	15,053	84%	12,644	41%	5,184	13.9%	720	3.6%	18.4	0.7	663	24
31	19,804	81.7%	16,179	93%	15,046	84%	12,639	41%	5,182	13.9%	720	3.6%	19.4	0.7	663	24
32	19,795	81.7%	16,172	93%	15,040	84%	12,634	41%	5,180	13.9%	719	3.6%	20.5	0.7	662	24
33	19,786	81.7%	16,164	93%	15,033	84%	12,628	41%	5,177	13.9%	719	3.6%	21.9	0.8	662	24
34	19,776	81.7%	16,156	93%	15,025	84%	12,621	41%	5,175	13.9%	719	3.6%	23.3	0.8	662	24
35	19,765	79.8%	15,780	93%	14,675	84%	12,327	41%	5,054	13.9%	702	3.6%	24.1	0.9	661	23
36	19,754	79.8%	15,770	93%	14,667	84%	12,320	41%	5,051	13.9%	702	3.6%	25.3	0.9	661	23
37	19,741	79.8%	15,761	93%	14,657	84%	12,312	41%	5,048	13.9%	701	3.6%	26.9	1.0	661	23
38	19,728	79.8%	15,750	93%	14,647	84%	12,304	41%	5,045	13.9%	701	3.6%	28.4	1.0	660	23
39	19,713	79.8%	15,738	93%	14,637	84%	12,295	41%	5,041	13.9%	700	3.6%	29.7	1.1	660	23
40	19,697	76.4%	15,040	93%	13,987	84%	11,749	41%	4,817	13.9%	669	3.4%	34.0	1.2	659	22
41	19,680	76.4%	15,027	93%	13,975	84%	11,739	41%	4,813	13.9%	668	3.4%	35.8	1.2	659	22
42	19,662	76.4%	15,013	93%	13,962	84%	11,728	41%	4,809	13.9%	668	3.4%	37.8	1.3	658	22
43	19,642	76.4%	14,998	93%	13,948	84%	11,716	41%	4,804	13.9%	667	3.4%	40.1	1.4	657	22
44	19,621	76.4%	14,982	93%	13,933	84%	11,704	41%	4,799	13.9%	666	3.4%	42.2	1.4	657	22
45	19,598	78.3%	15,338	93%	14,264	84%	11,982	41%	4,913	13.9%	682	3.5%	46.5	1.6	624	22
46	19,573	78.3%	15,319	93%	14,246	84%	11,967	41%	4,906	13.9%	681	3.5%	49.2	1.7	624	22
47	19,546	78.3%	15,297	93%	14,227	84%	11,950	41%	4,900	13.9%	681	3.5%	51.7	1.8	623	22
48	19,517	78.3%	15,275	93%	14,205	84%	11,932	41%	4,892	13.9%	679	3.5%	54.4	1.9	622	22
49	19,485	78.3%	15,250	93%	14,182	84%	11,913	41%	4,884	13.9%	678	3.5%	57.6	2.0	621	22
50	19,451	81.5%	15,851	93%	14,742	84%	12,383	41%	5,077	13.9%	705	3.6%	59.2	2.1	620	22
51	19,414	81.5%	15,822	93%	14,714	84%	12,360	41%	5,068	13.9%	704	3.6%	62.3	2.3	619	22
52	19,375	81.5%	15,789	93%	14,684	84%	12,334	41%	5,057	13.9%	702	3.6%	65.8	2.4	617	22
53	19,331	81.5%	15,754	93%	14,651	84%	12,307	41%	5,046	13.9%	701	3.6%	69.4	2.5	616	22
54	19,285	81.5%	15,716	93%	14,616	84%	12,277	41%	5,034	13.9%	699	3.6%	73.2	2.7	614	22
55	19,234	82.0%	15,763	93%	14,659	84%	12,314	41%	5,049	13.9%	701	3.6%	67.4	2.5	613	22
56	19,178	82.0%	15,718	93%	14,617	84%	12,279	41%	5,034	13.9%	699	3.6%	71.1	2.6	611	22
57	19,118	82.0%	15,668	93%	14,572	84%	12,240	41%	5,018	13.9%	697	3.6%	74.9	2.7	609	22
58	19,053	82.0%	15,615	93%	14,522	84%	12,198	41%	5,001	13.9%	695	3.6%	79.1	2.9	607	22
59	18,981	82.0%	15,556	93%	14,467	84%	12,152	41%	4,983	13.9%	692	3.6%	83.6	3.0	605	22
60	18,904	80.9%	15,289	93%	14,219	84%	11,944	41%	4,897	13.9%	680	3.6%	66.7	2.4	456	16
61	18,819	80.9%	15,220	93%	14,155	84%	11,890	41%	4,875	13.9%	677	3.6%	70.3	2.5	453	16
62	18,726	80.9%	15,145	93%	14,085	84%	11,831	41%	4,851	13.9%	674	3.6%	74.1	2.7	451	16
63	18,625	80.9%	15,063	93%	14,009	84%	11,767	41%	4,825	13.9%	670	3.6%	78.2	2.8	449	16
64	18,514	80.9%	14,973	93%	13,925	84%	11,697	41%	4,796	13.9%	666	3.6%	82.3	3.0	446	16
65	18,392	86.7%	15,952	93%	14,836	84%	12,462	41%	5,109	13.9%	710	3.9%	64.6	2.5	443	17
66	18,259	86.7%	15,837	93%	14,728	84%	12,372	41%	5,072	13.9%	705	3.9%	67.8	2.6	440	17
67	18,113	86.7%	15,710	93%	14,611	84%	12,273	41%	5,032	13.9%	699	3.9%	71.5	2.8	436	17
68	17,954	86.7%	15,572	93%	14,482	84%	12,165	41%	4,988	13.9%	693	3.9%	75.4	2.9	433	17
69	17,778	86.7%	15,420	93%	14,340	84%	12,046	41%	4,939	13.9%	686	3.9%	78.9	3.0	428	17
70	17,586	84.8%	14,911	93%	13,867	84%	11,649	41%	4,776	13.9%	663	3.8%	54.0	2.0	509	19
71	17,375	84.8%	14,733	93%	13,701	84%	11,509	41%	4,719	13.9%	655	3.8%	56.6	2.1	503	19
72	17,144	84.8%	14,536	93%	13,519	84%	11,356	41%	4,656	13.9%	647	3.8%	59.2	2.2	497	19
73	16,890	84.8%	14,321	93%	13,319	84%	11,188	41%	4,587	13.9%	637	3.8%	62.1	2.3	489	18
74	16,612	84.8%	14,085	93%	13,099	84%	11,004	41%	4,511	13.9%	627	3.8%	64.6	2.4	481	18
75	16,307	85.8%	13,997	93%	13,018	84%	10,935	41%	4,483	13.9%	623	3.8%	38.2	1.5	472	18
76	15,973	85.8%	13,711	93%	12,751	84%	10,711	41%	4,391	13.9%	610	3.8%	39.5	1.5	463	18
77	15,608	85.8%	13,397	93%	12,459	84%	10,466	41%	4,291	13.9%	596	3.8%	40.9	1.6	452	17
78	15,209	85.8%	13,055	93%	12,141	84%	10,198	41%	4,181	13.9%	581	3.8%	42.1	1.6	441	17
79	14,774	85.8%	12,681	93%	11,794	84%	9,907	41%	4,062	13.9%	564	3.8%	43.2	1.7	428	16
80	14,300	85.7%	12,253	93%	11,395	84%	9,572	41%	3,925	13.9%	545	3.8%	29.3	1.1	578	22
81	13,785	85.7%	11,812	93%	10,985	84%	9,228	41%	3,783	13.9%	525	3.8%	29.7	1.1	558	21
82	13,228	85.7%	11,334	93%	10,541	84%	8,854	41%	3,630	13.9%	504	3.8%	30.2	1.1	535	20
83	12,626	85.7%	10,819	93%	10,062	84%	8,452	41%	3,465	13.9%	481	3.8%	30.4	1.2	511	19
84	11,980	85.7%	10,265	93%	9,546	84%	8,019	41%	3,288	13.9%	457	3.8%	30.4	1.2	485	18
Total	*1,237,859*		*988,751*		*919,538*		*772,412*		*316,689*		*43,985*		*2,990*	*108*	*43,553*	*1,527*

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	QALYs Lost (Table 9)	QALYs Gained via BI
18	19,867	53.0%	10,533	93%	9,795	84%	8,228	41%	3,374	13.9%	469	2.4%	34.0	0.8	1,435	34
19	19,856	53.0%	10,527	93%	9,790	84%	8,224	41%	3,372	13.9%	468	2.4%	42.2	1.0	1,434	34
20	19,844	45.8%	9,081	93%	8,445	84%	7,094	41%	2,908	13.9%	404	2.0%	100.7	2.0	1,433	29
21	19,829	45.8%	9,074	93%	8,439	84%	7,089	41%	2,906	13.9%	404	2.0%	111.9	2.3	1,432	29
22	19,813	45.8%	9,067	93%	8,432	84%	7,083	41%	2,904	13.9%	403	2.0%	117.3	2.4	1,431	29
23	19,796	45.8%	9,059	93%	8,425	84%	7,077	41%	2,902	13.9%	403	2.0%	116.7	2.4	1,430	29
24	19,780	45.8%	9,051	93%	8,418	84%	7,071	41%	2,899	13.9%	403	2.0%	110.8	2.3	1,429	29
25	19,764	52.4%	10,351	93%	9,626	84%	8,086	41%	3,315	13.9%	460	2.3%	93.6	2.2	1,427	33
26	19,749	52.4%	10,343	93%	9,619	84%	8,080	41%	3,313	13.9%	460	2.3%	89.7	2.1	1,426	33
27	19,734	52.4%	10,335	93%	9,612	84%	8,074	41%	3,310	13.9%	460	2.3%	85.7	2.0	1,425	33
28	19,720	52.4%	10,327	93%	9,605	84%	8,068	41%	3,308	13.9%	459	2.3%	84.1	2.0	1,424	33
29	19,705	52.4%	10,320	93%	9,597	84%	8,062	41%	3,305	13.9%	459	2.3%	85.0	2.0	1,423	33
30	19,690	51.7%	10,171	93%	9,459	84%	7,946	41%	3,258	13.9%	452	2.3%	77.3	1.8	1,279	29
31	19,675	51.7%	10,163	93%	9,452	84%	7,940	41%	3,255	13.9%	452	2.3%	79.7	1.8	1,278	29
32	19,658	51.7%	10,155	93%	9,444	84%	7,933	41%	3,252	13.9%	452	2.3%	82.1	1.9	1,277	29
33	19,640	51.7%	10,146	93%	9,435	84%	7,926	41%	3,250	13.9%	451	2.3%	85.2	2.0	1,276	29
34	19,622	51.7%	10,136	93%	9,426	84%	7,918	41%	3,246	13.9%	451	2.3%	88.3	2.0	1,274	29
35	19,602	63.1%	12,377	93%	11,510	84%	9,669	41%	3,964	13.9%	551	2.8%	82.5	2.3	1,273	36
36	19,582	63.1%	12,364	93%	11,498	84%	9,659	41%	3,960	13.9%	550	2.8%	85.7	2.4	1,272	36
37	19,560	63.1%	12,350	93%	11,485	84%	9,648	41%	3,956	13.9%	549	2.8%	88.5	2.5	1,270	36
38	19,536	63.1%	12,335	93%	11,472	84%	9,636	41%	3,951	13.9%	549	2.8%	92.1	2.6	1,269	36
39	19,511	63.1%	12,319	93%	11,457	84%	9,624	41%	3,946	13.9%	548	2.8%	96.0	2.7	1,267	36
40	19,485	62.8%	12,230	93%	11,374	84%	9,554	41%	3,917	13.9%	544	2.8%	96.4	2.7	1,266	35
41	19,457	62.8%	12,213	93%	11,358	84%	9,540	41%	3,912	13.9%	543	2.8%	101.0	2.8	1,264	35
42	19,427	62.8%	12,194	93%	11,340	84%	9,526	41%	3,906	13.9%	542	2.8%	105.5	2.9	1,262	35
43	19,395	62.8%	12,173	93%	11,321	84%	9,510	41%	3,899	13.9%	542	2.8%	109.8	3.1	1,260	35
44	19,360	62.8%	12,152	93%	11,301	84%	9,493	41%	3,892	13.9%	541	2.8%	114.7	3.2	1,257	35
45	19,323	68.5%	13,230	93%	12,304	84%	10,335	41%	4,237	13.9%	589	3.0%	114.5	3.5	982	30
46	19,283	68.5%	13,203	93%	12,279	84%	10,314	41%	4,229	13.9%	587	3.0%	120.5	3.7	979	30
47	19,241	68.5%	13,174	93%	12,251	84%	10,291	41%	4,219	13.9%	586	3.0%	125.7	3.8	977	30
48	19,195	68.5%	13,142	93%	12,222	84%	10,267	41%	4,209	13.9%	585	3.0%	132.4	4.0	975	30
49	19,145	68.5%	13,108	93%	12,191	84%	10,240	41%	4,198	13.9%	583	3.0%	138.6	4.2	972	30
50	19,091	65.6%	12,528	93%	11,651	84%	9,787	41%	4,013	13.9%	557	2.9%	136.9	4.0	970	28
51	19,034	65.6%	12,490	93%	11,616	84%	9,757	41%	4,000	13.9%	556	2.9%	144.1	4.2	967	28
52	18,971	65.6%	12,449	93%	11,578	84%	9,725	41%	3,987	13.9%	554	2.9%	151.2	4.4	964	28
53	18,903	65.6%	12,405	93%	11,536	84%	9,690	41%	3,973	13.9%	552	2.9%	158.9	4.6	960	28
54	18,830	65.6%	12,356	93%	11,491	84%	9,653	41%	3,958	13.9%	550	2.9%	167.2	4.9	956	28
55	18,750	72.8%	13,658	93%	12,702	84%	10,670	41%	4,375	13.9%	608	3.2%	147.8	4.8	952	31
56	18,664	72.8%	13,595	93%	12,644	84%	10,621	41%	4,354	13.9%	605	3.2%	155.2	5.0	948	31
57	18,570	72.8%	13,527	93%	12,580	84%	10,568	41%	4,333	13.9%	602	3.2%	163.3	5.3	943	31
58	18,469	72.8%	13,453	93%	12,512	84%	10,510	41%	4,309	13.9%	598	3.2%	171.3	5.6	938	30
59	18,358	72.8%	13,373	93%	12,437	84%	10,447	41%	4,283	13.9%	595	3.2%	179.3	5.8	933	30
60	18,239	82.5%	15,043	93%	13,990	84%	11,752	41%	4,818	13.9%	669	3.7%	144.3	5.3	783	29
61	18,109	82.5%	14,936	93%	13,891	84%	11,668	41%	4,784	13.9%	664	3.7%	150.8	5.5	777	29
62	17,967	82.5%	14,819	93%	13,782	84%	11,577	41%	4,746	13.9%	659	3.7%	158.2	5.8	771	28
63	17,813	82.5%	14,693	93%	13,664	84%	11,478	41%	4,706	13.9%	654	3.7%	165.6	6.1	765	28
64	17,646	82.5%	14,555	93%	13,536	84%	11,370	41%	4,662	13.9%	647	3.7%	173.3	6.4	757	28
65	17,464	84.7%	14,787	93%	13,752	84%	11,552	41%	4,736	13.9%	658	3.8%	132.8	5.0	750	28
66	17,267	84.7%	14,620	93%	13,596	84%	11,421	41%	4,683	13.9%	650	3.8%	138.5	5.2	741	28
67	17,052	84.7%	14,438	93%	13,427	84%	11,279	41%	4,624	13.9%	642	3.8%	144.1	5.4	732	28
68	16,819	84.7%	14,241	93%	13,244	84%	11,125	41%	4,561	13.9%	633	3.8%	149.6	5.6	722	27
69	16,565	84.7%	14,026	93%	13,044	84%	10,957	41%	4,492	13.9%	624	3.8%	155.7	5.9	711	27
70	16,290	85.9%	13,989	93%	13,010	84%	10,929	41%	4,481	13.9%	622	3.8%	107.2	4.1	449	17
71	15,992	85.9%	13,733	93%	12,772	84%	10,728	41%	4,399	13.9%	611	3.8%	111.1	4.2	441	17
72	15,668	85.9%	13,455	93%	12,513	84%	10,511	41%	4,310	13.9%	599	3.8%	114.6	4.4	432	17
73	15,318	85.9%	13,154	93%	12,234	84%	10,276	41%	4,213	13.9%	585	3.8%	118.0	4.5	422	16
74	14,939	85.9%	12,829	93%	11,931	84%	10,022	41%	4,109	13.9%	571	3.8%	120.9	4.6	412	16
75	14,530	90.4%	13,129	93%	12,210	84%	10,256	41%	4,205	13.9%	584	4.0%	71.9	2.9	401	16
76	14,090	90.4%	12,731	93%	11,840	84%	9,945	41%	4,078	13.9%	566	4.0%	73.6	3.0	388	16
77	13,616	90.4%	12,303	93%	11,441	84%	9,611	41%	3,940	13.9%	547	4.0%	74.2	3.0	375	15
78	13,107	90.4%	11,843	93%	11,014	84%	9,252	41%	3,793	13.9%	527	4.0%	75.1	3.0	361	15
79	12,564	90.4%	11,352	93%	10,558	84%	8,868	41%	3,636	13.9%	505	4.0%	75.5	3.0	346	14
80	11,984	86.7%	10,395	93%	9,667	84%	8,120	41%	3,329	13.9%	462	3.9%	45.1	1.7	431	17
81	11,370	86.7%	9,861	93%	9,171	84%	7,704	41%	3,159	13.9%	439	3.9%	44.6	1.7	409	16
82	10,720	86.7%	9,298	93%	8,647	84%	7,263	41%	2,978	13.9%	414	3.9%	44.2	1.7	386	15
83	10,037	86.7%	8,706	93%	8,096	84%	6,801	41%	2,788	13.9%	387	3.9%	43.4	1.7	361	14
84	9,324	86.7%	8,087	93%	7,521	84%	6,318	41%	2,590	13.9%	360	3.9%	42.2	1.6	336	13
Total	*1,188,974*		*808,259*		*751,681*		*631,412*		*258,879*		*35,955*		*7,338*	*229*	*64,071*	*1,834*

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.[1095] The USPSTF notes that "more direct evidence is needed on the harms associated with screening and behavioral interventions."[1096]
- The USPSTF found no evidence of any unintended harmful effects associated with brief counselling interventions.[1097]

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 5,035 QALYs, 2,972 QALYs in females and 2,063 QALYs in males (Table 14, row *bg*, *bh*, *bi*). The CPB of 5,035 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.

1095 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.
1096 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.
1097 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	1,237,859	Table 1
b	Life years lived between the ages of 18 and 84 - Males	1,188,974	Table 1
c	Proportion of life years with unhealthy alcohol use (low-binge) - Females	11.9%	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	146,853	= a * c
j	Life years with unhealthy alcohol use (hazardous) - Females	86,086	= a * d
k	Life years with unhealthy alcohol use (harmful) - Females	33,160	= a * e
l	Life years with unhealthy alcohol use (low-binge) - Males	207,667	= b * f
m	Life years with unhealthy alcohol use (hazardous) - Males	86,048	= b * g
n	Life years with unhealthy alcohol use (harmful) - Males	76,071	= b * h
o	Life years lost attributable to unhealthy alcohol use - Females	2,990	Table 7
p	Life years lost attributable to unhealthy alcohol use - Males	7,338	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	18,063	= i * q
u	QALYs lost with unhealthy alcohol use (hazardous) - Females	15,409	= j * r
v	QALYs lost with unhealthy alcohol use (harmful) - Females	10,081	= k * s
w	QALYs lost with unhealthy alcohol use - Total females	43,553	= t + u + v
x	QALYs lost with unhealthy alcohol use (low-binge) - Males	25,543	= l * q
y	QALYs lost with unhealthy alcohol use (hazardous) - Males	15,403	= m * r
z	QALYs lost with unhealthy alcohol use (harmful) - Males	23,126	= n * s
aa	QALYs lost with unhealthy alcohol use - Total males	64,071	= x + y + z
ab	Total QALYs lost - Females	46,543	= o + w
ac	Total QALYs lost - Males	71,409	= p + aa
ad	***Total QALYs lost in general population***	***117,952***	= ab + ac
	Total Burden of FASD in Children Born to Females in the Birth Cohort		
ae	Expected births to females in birth cohort	27,066	Table 5
af	Proportion with FASD	1.8%	√
ag	Proportion of FASD with FAS	19.0%	√
ah	Number of births with FASD	490	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	4,477	Table 8
al	Life years lost due to FASD, excluding FAS	6,948	Table 8
am	QALYs lost due to FAS	1,548	Table 10
an	QALYs lost due to FASD, excluding FAS	11,045	Table 10
ao	***Total QALYs lost, FASD***	***24,018***	= 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	74.0%	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	108	Table 12
aw	QALYs recovered (gained), females	1,527	Table 12
ax	Life-years lost, avoided, males	229	Table 13
ay	QALYs recovered (gained), males	1,834	Table 13
az	**Total QALYs gained, general population**	**3,698**	= 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**	**1,337**	= ao * be
	Clinically Preventable Burden (CPB)		
bg	QALYs gained - Females	2,972	= av + aw + bf
bh	QALYs gained - Males	2,063	= ax + ay
bi	**Total QALYs gained (CPB)**	**5,035**	= 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 = 3,929
- 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 = 6,411
- Assume that the proportion of births with FASD increases from 1.81% to 2.93% (Table 14, row *af*): CPB = 5,863
- Assume that the screening sensitivity decreases from 84% to 67% (Table 14, row *as*): CPB = 4,016
- Assume that the screening sensitivity increases from 84% to 94% (Table 14, row *as*): CPB = 5,635

- 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 = 2,957
- 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 = 6,160
- Assume that the impacts of FASD are excluded (Table, row *bf*): CPB = 3,698
- Comparison to previous LPS alcohol screening model. Assume that the proportion accepting treatment decreases from 41% to 30% (Table 14, row *at*) and that impacts of FASD are excluded: CPB = 2,706. *(Our previous model, which estimated that 30% would accept treatment and did not include the impact of FASD, had a CPB of 2,175)*

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 919,538 lifetime screens conducted on females and 751,681 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 26,254 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.[1098] Another source from 2007/08 suggests 7.2%.[1099] 2017/18 CCHS data suggests that 3.0% of women consumed alcohol after finding out they were pregnant.[1100] 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).

[1098] 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.
[1099] 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.
[1100] 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		Screening Frequency	Proportion Annually	GP Screening Rate	Screens Conducted	Unhealthy Alcohol Use (UAU)	Screens Conducted	Sensitivity of Screen		Accepting BI		Frequency of BI	Proportion Annually	BI Conducted
		% (Table 11)	#	Years	%	%	# (General)	% (Table 2)	# (UAU)	%	# (UAU)	%	# (UAU)	Years	%	# (UAU)
18	19,891	65.0%	12,930	1	100%	93%	12,025	35%	4,209	84%	3,535	41%	1,449	3	33%	483
19	19,884	65.0%	12,926	1	100%	93%	12,021	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	19,865	66.0%	13,109	1	100%	93%	12,191	35%	4,267	84%	3,584	41%	1,469	3	33%	490
23	19,858	66.0%	13,104	1	100%	93%	12,187	35%	4,265	84%	3,583	41%	1,469	3	33%	490
24	19,852	66.0%	13,100	1	100%	93%	12,183	35%	4,264	84%	3,582	41%	1,468	3	33%	489
25	19,845	79.5%	15,773	1	100%	93%	14,669	35%	5,134	84%	4,312	41%	1,768	3	33%	589
26	19,839	79.5%	15,768	1	100%	93%	14,664	35%	5,132	84%	4,311	41%	1,768	3	33%	589
27	19,833	79.5%	15,763	1	100%	93%	14,659	35%	5,131	84%	4,310	41%	1,767	3	33%	589
28	19,826	79.5%	15,757	1	100%	93%	14,654	35%	5,129	84%	4,308	41%	1,766	3	33%	589
29	19,819	79.5%	15,752	1	100%	93%	14,649	35%	5,127	84%	4,307	41%	1,766	3	33%	589
30	19,812	81.7%	16,186	1	100%	93%	15,053	21%	3,113	84%	2,615	41%	1,072	3	33%	357
31	19,804	81.7%	16,179	1	100%	93%	15,046	21%	3,111	84%	2,614	41%	1,072	3	33%	357
32	19,795	81.7%	16,172	1	100%	93%	15,040	21%	3,110	84%	2,612	41%	1,071	3	33%	357
33	19,786	81.7%	16,164	1	100%	93%	15,033	21%	3,109	84%	2,611	41%	1,071	3	33%	357
34	19,776	81.7%	16,156	1	100%	93%	15,025	21%	3,107	84%	2,610	41%	1,070	3	33%	357
35	19,765	79.8%	15,780	1	100%	93%	14,675	21%	3,035	84%	2,549	41%	1,045	3	33%	348
36	19,754	79.8%	15,770	1	100%	93%	14,667	21%	3,033	84%	2,548	41%	1,044	3	33%	348
37	19,741	79.8%	15,761	1	100%	93%	14,657	21%	3,031	84%	2,546	41%	1,044	3	33%	348
38	19,728	79.8%	15,750	1	100%	93%	14,647	21%	3,029	84%	2,544	41%	1,043	3	33%	348
39	19,713	79.8%	15,738	1	100%	93%	14,637	21%	3,027	84%	2,542	41%	1,042	3	33%	347
40	19,697	76.4%	15,040	1	100%	93%	13,987	21%	2,892	84%	2,430	41%	996	3	33%	332
41	19,680	76.4%	15,027	1	100%	93%	13,975	21%	2,890	84%	2,427	41%	995	3	33%	332
42	19,662	76.4%	15,013	1	100%	93%	13,962	21%	2,887	84%	2,425	41%	994	3	33%	331
43	19,642	76.4%	14,998	1	100%	93%	13,948	21%	2,884	84%	2,423	41%	993	3	33%	331
44	19,621	76.4%	14,982	1	100%	93%	13,933	21%	2,881	84%	2,420	41%	992	3	33%	331
45	19,598	78.3%	15,338	1	100%	93%	14,264	20%	2,830	84%	2,377	41%	975	3	33%	325
46	19,573	78.3%	15,319	1	100%	93%	14,246	20%	2,826	84%	2,374	41%	973	3	33%	324
47	19,546	78.3%	15,297	1	100%	93%	14,227	20%	2,822	84%	2,371	41%	972	3	33%	324
48	19,517	78.3%	15,275	1	100%	93%	14,205	20%	2,818	84%	2,367	41%	970	3	33%	323
49	19,485	78.3%	15,250	1	100%	93%	14,182	20%	2,813	84%	2,363	41%	969	3	33%	323
50	19,451	81.5%	15,851	1	100%	93%	14,742	20%	2,924	84%	2,456	41%	1,007	3	33%	336
51	19,414	81.5%	15,822	1	100%	93%	14,714	20%	2,919	84%	2,452	41%	1,005	3	33%	335
52	19,375	81.5%	15,789	1	100%	93%	14,684	20%	2,913	84%	2,447	41%	1,003	3	33%	334
53	19,331	81.5%	15,754	1	100%	93%	14,651	20%	2,906	84%	2,441	41%	1,001	3	33%	334
54	19,285	81.5%	15,716	1	100%	93%	14,616	20%	2,899	84%	2,435	41%	999	3	33%	333
55	19,234	82.0%	15,763	1	100%	93%	14,659	20%	2,908	84%	2,443	41%	1,002	3	33%	334
56	19,178	82.0%	15,718	1	100%	93%	14,617	20%	2,900	84%	2,436	41%	999	3	33%	333
57	19,118	82.0%	15,668	1	100%	93%	14,572	20%	2,891	84%	2,428	41%	996	3	33%	332
58	19,053	82.0%	15,615	1	100%	93%	14,522	20%	2,881	84%	2,420	41%	992	3	33%	331
59	18,981	82.0%	15,556	1	100%	93%	14,467	20%	2,870	84%	2,411	41%	988	3	33%	329
60	18,904	80.9%	15,289	1	100%	93%	14,219	13%	1,894	84%	1,591	41%	652	3	33%	217
61	18,819	80.9%	15,220	1	100%	93%	14,155	13%	1,885	84%	1,584	41%	649	3	33%	216
62	18,726	80.9%	15,145	1	100%	93%	14,085	13%	1,876	84%	1,576	41%	646	3	33%	215
63	18,625	80.9%	15,063	1	100%	93%	14,009	13%	1,866	84%	1,567	41%	643	3	33%	214
64	18,514	80.9%	14,973	1	100%	93%	13,925	13%	1,855	84%	1,558	41%	639	3	33%	213
65	18,392	86.7%	15,952	1	100%	93%	14,836	13%	1,976	84%	1,660	41%	681	3	33%	227
66	18,259	86.7%	15,837	1	100%	93%	14,728	13%	1,962	84%	1,648	41%	676	3	33%	225
67	18,113	86.7%	15,710	1	100%	93%	14,611	13%	1,946	84%	1,635	41%	670	3	33%	223
68	17,954	86.7%	15,572	1	100%	93%	14,482	13%	1,929	84%	1,620	41%	664	3	33%	221
69	17,778	86.7%	15,420	1	100%	93%	14,340	13%	1,910	84%	1,605	41%	658	3	33%	219
70	17,586	84.8%	14,911	1	100%	93%	13,867	15%	2,134	84%	1,793	41%	735	3	33%	245
71	17,375	84.8%	14,733	1	100%	93%	13,701	15%	2,109	84%	1,771	41%	726	3	33%	242
72	17,144	84.8%	14,536	1	100%	93%	13,519	15%	2,080	84%	1,748	41%	717	3	33%	239
73	16,890	84.8%	14,321	1	100%	93%	13,319	15%	2,050	84%	1,722	41%	706	3	33%	235
74	16,612	84.8%	14,085	1	100%	93%	13,099	15%	2,016	84%	1,693	41%	694	3	33%	231
75	16,307	85.8%	13,997	1	100%	93%	13,018	15%	2,003	84%	1,683	41%	690	3	33%	230
76	15,973	85.8%	13,711	1	100%	93%	12,751	15%	1,962	84%	1,648	41%	676	3	33%	225
77	15,608	85.8%	13,397	1	100%	93%	12,459	15%	1,917	84%	1,611	41%	660	3	33%	220
78	15,209	85.8%	13,055	1	100%	93%	12,141	15%	1,868	84%	1,569	41%	643	3	33%	214
79	14,774	85.8%	12,681	1	100%	93%	11,794	15%	1,815	84%	1,525	41%	625	3	33%	208
80	14,300	85.7%	12,253	1	100%	93%	11,395	22%	2,467	84%	2,072	41%	850	3	33%	283
81	13,785	85.7%	11,812	1	100%	93%	10,985	22%	2,378	84%	1,998	41%	819	3	33%	273
82	13,228	85.7%	11,334	1	100%	93%	10,541	22%	2,282	84%	1,917	41%	786	3	33%	262
83	12,626	85.7%	10,819	1	100%	93%	10,062	22%	2,178	84%	1,830	41%	750	3	33%	250
84	11,980	85.7%	10,265	1	100%	93%	9,546	22%	2,067	84%	1,736	41%	712	3	33%	237
Total	***1,237,859***		***988,751***				***919,538***		***194,087***		***163,033***		***66,844***			***22,281***

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 # (General)	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	19,867	53.0%	10,533	1	100%	93%	9,795	45%	4,389	84%	3,687	41%	1,511	3	33%	504
19	19,856	53.0%	10,527	1	100%	93%	9,790	45%	4,386	84%	3,685	41%	1,511	3	33%	504
20	19,844	45.8%	9,081	1	100%	93%	8,445	45%	3,784	84%	3,178	41%	1,303	3	33%	434
21	19,829	45.8%	9,074	1	100%	93%	8,439	45%	3,781	84%	3,176	41%	1,302	3	33%	434
22	19,813	45.8%	9,067	1	100%	93%	8,432	45%	3,778	84%	3,173	41%	1,301	3	33%	434
23	19,796	45.8%	9,059	1	100%	93%	8,425	45%	3,775	84%	3,171	41%	1,300	3	33%	433
24	19,780	45.8%	9,051	1	100%	93%	8,418	45%	3,772	84%	3,168	41%	1,299	3	33%	433
25	19,764	52.4%	10,351	1	100%	93%	9,626	45%	4,313	84%	3,623	41%	1,485	3	33%	495
26	19,749	52.4%	10,343	1	100%	93%	9,619	45%	4,310	84%	3,620	41%	1,484	3	33%	495
27	19,734	52.4%	10,335	1	100%	93%	9,612	45%	4,306	84%	3,617	41%	1,483	3	33%	494
28	19,720	52.4%	10,327	1	100%	93%	9,605	45%	4,303	84%	3,615	41%	1,482	3	33%	494
29	19,705	52.4%	10,320	1	100%	93%	9,597	45%	4,300	84%	3,612	41%	1,481	3	33%	494
30	19,690	51.7%	10,171	1	100%	93%	9,459	37%	3,546	84%	2,979	41%	1,221	3	33%	407
31	19,675	51.7%	10,163	1	100%	93%	9,452	37%	3,543	84%	2,976	41%	1,220	3	33%	407
32	19,658	51.7%	10,155	1	100%	93%	9,444	37%	3,540	84%	2,974	41%	1,219	3	33%	406
33	19,640	51.7%	10,146	1	100%	93%	9,435	37%	3,537	84%	2,971	41%	1,218	3	33%	406
34	19,622	51.7%	10,136	1	100%	93%	9,426	37%	3,534	84%	2,968	41%	1,217	3	33%	406
35	19,602	63.1%	12,377	1	100%	93%	11,510	37%	4,315	84%	3,624	41%	1,486	3	33%	495
36	19,582	63.1%	12,364	1	100%	93%	11,498	37%	4,310	84%	3,621	41%	1,484	3	33%	495
37	19,560	63.1%	12,350	1	100%	93%	11,485	37%	4,305	84%	3,616	41%	1,483	3	33%	494
38	19,536	63.1%	12,335	1	100%	93%	11,472	37%	4,300	84%	3,612	41%	1,481	3	33%	494
39	19,511	63.1%	12,319	1	100%	93%	11,457	37%	4,295	84%	3,608	41%	1,479	3	33%	493
40	19,485	62.8%	12,230	1	100%	93%	11,374	37%	4,264	84%	3,581	41%	1,468	3	33%	489
41	19,457	62.8%	12,213	1	100%	93%	11,358	37%	4,257	84%	3,576	41%	1,466	3	33%	489
42	19,427	62.8%	12,194	1	100%	93%	11,340	37%	4,251	84%	3,571	41%	1,464	3	33%	488
43	19,395	62.8%	12,173	1	100%	93%	11,321	37%	4,244	84%	3,565	41%	1,462	3	33%	487
44	19,360	62.8%	12,152	1	100%	93%	11,301	37%	4,236	84%	3,558	41%	1,459	3	33%	486
45	19,323	68.5%	13,230	1	100%	93%	12,304	29%	3,606	84%	3,029	41%	1,242	3	33%	414
46	19,283	68.5%	13,203	1	100%	93%	12,279	29%	3,598	84%	3,023	41%	1,239	3	33%	413
47	19,241	68.5%	13,174	1	100%	93%	12,251	29%	3,590	84%	3,016	41%	1,237	3	33%	412
48	19,195	68.5%	13,142	1	100%	93%	12,222	29%	3,582	84%	3,009	41%	1,234	3	33%	411
49	19,145	68.5%	13,108	1	100%	93%	12,191	29%	3,573	84%	3,001	41%	1,230	3	33%	410
50	19,091	65.6%	12,528	1	100%	93%	11,651	29%	3,414	84%	2,868	41%	1,176	3	33%	392
51	19,034	65.6%	12,490	1	100%	93%	11,616	29%	3,404	84%	2,859	41%	1,172	3	33%	391
52	18,971	65.6%	12,449	1	100%	93%	11,578	29%	3,393	84%	2,850	41%	1,169	3	33%	390
53	18,903	65.6%	12,405	1	100%	93%	11,536	29%	3,381	84%	2,840	41%	1,164	3	33%	388
54	18,830	65.6%	12,356	1	100%	93%	11,491	29%	3,368	84%	2,829	41%	1,160	3	33%	387
55	18,750	72.8%	13,658	1	100%	93%	12,702	29%	3,722	84%	3,127	41%	1,282	3	33%	427
56	18,664	72.8%	13,595	1	100%	93%	12,644	29%	3,705	84%	3,112	41%	1,276	3	33%	425
57	18,570	72.8%	13,527	1	100%	93%	12,580	29%	3,687	84%	3,097	41%	1,270	3	33%	423
58	18,469	72.8%	13,453	1	100%	93%	12,512	29%	3,667	84%	3,080	41%	1,263	3	33%	421
59	18,358	72.8%	13,373	1	100%	93%	12,437	29%	3,645	84%	3,062	41%	1,255	3	33%	418
60	18,239	82.5%	15,043	1	100%	93%	13,990	23%	3,275	84%	2,751	41%	1,128	3	33%	376
61	18,109	82.5%	14,936	1	100%	93%	13,891	23%	3,252	84%	2,732	41%	1,120	3	33%	373
62	17,967	82.5%	14,819	1	100%	93%	13,782	23%	3,226	84%	2,710	41%	1,111	3	33%	370
63	17,813	82.5%	14,693	1	100%	93%	13,664	23%	3,199	84%	2,687	41%	1,102	3	33%	367
64	17,646	82.5%	14,555	1	100%	93%	13,536	23%	3,169	84%	2,662	41%	1,091	3	33%	364
65	17,464	84.7%	14,787	1	100%	93%	13,752	23%	3,219	84%	2,704	41%	1,109	3	33%	370
66	17,267	84.7%	14,620	1	100%	93%	13,596	23%	3,183	84%	2,674	41%	1,096	3	33%	365
67	17,052	84.7%	14,438	1	100%	93%	13,427	23%	3,143	84%	2,641	41%	1,083	3	33%	361
68	16,819	84.7%	14,241	1	100%	93%	13,244	23%	3,100	84%	2,604	41%	1,068	3	33%	356
69	16,565	84.7%	14,026	1	100%	93%	13,044	23%	3,054	84%	2,565	41%	1,052	3	33%	351
70	16,290	85.9%	13,989	1	100%	93%	13,010	14%	1,833	84%	1,540	41%	631	3	33%	210
71	15,992	85.9%	13,733	1	100%	93%	12,772	14%	1,799	84%	1,511	41%	620	3	33%	207
72	15,668	85.9%	13,455	1	100%	93%	12,513	14%	1,763	84%	1,481	41%	607	3	33%	202
73	15,318	85.9%	13,154	1	100%	93%	12,234	14%	1,723	84%	1,448	41%	594	3	33%	198
74	14,939	85.9%	12,829	1	100%	93%	11,931	14%	1,681	84%	1,412	41%	579	3	33%	193
75	14,530	90.4%	13,129	1	100%	93%	12,210	14%	1,720	84%	1,445	41%	592	3	33%	197
76	14,090	90.4%	12,731	1	100%	93%	11,840	14%	1,668	84%	1,401	41%	574	3	33%	191
77	13,616	90.4%	12,303	1	100%	93%	11,441	14%	1,612	84%	1,354	41%	555	3	33%	185
78	13,107	90.4%	11,843	1	100%	93%	11,014	14%	1,552	84%	1,303	41%	534	3	33%	178
79	12,564	90.4%	11,352	1	100%	93%	10,558	14%	1,487	84%	1,249	41%	512	3	33%	171
80	11,984	86.7%	10,395	1	100%	93%	9,667	16%	1,587	84%	1,333	41%	547	3	33%	182
81	11,370	86.7%	9,861	1	100%	93%	9,171	16%	1,505	84%	1,265	41%	518	3	33%	173
82	10,720	86.7%	9,298	1	100%	93%	8,647	16%	1,419	84%	1,192	41%	489	3	33%	163
83	10,037	86.7%	8,706	1	100%	93%	8,096	16%	1,329	84%	1,116	41%	458	3	33%	153
84	9,324	86.7%	8,087	1	100%	93%	7,521	16%	1,235	84%	1,037	41%	425	3	33%	142
Total	***1,188,974***		***808,259***				***751,681***		***218,742***		***183,744***		***75,335***			***25,112***

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 # (General)	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	1,422	97%	1,379	9.0%	124	84%	104	41%	43	3	33%	14
26	1,421	97%	1,379	9.0%	124	84%	104	41%	43	3	33%	14
27	1,421	97%	1,378	9.0%	124	84%	104	41%	43	3	33%	14
28	1,420	97%	1,378	9.0%	124	84%	104	41%	43	3	33%	14
29	1,420	97%	1,377	9.0%	124	84%	104	41%	43	3	33%	14
30	1,972	97%	1,913	9.0%	172	84%	145	41%	59	3	33%	20
31	1,971	97%	1,912	9.0%	172	84%	145	41%	59	3	33%	20
32	1,970	97%	1,911	9.0%	172	84%	144	41%	59	3	33%	20
33	1,969	97%	1,910	9.0%	172	84%	144	41%	59	3	33%	20
34	1,968	97%	1,909	9.0%	172	84%	144	41%	59	3	33%	20
35	1,128	97%	1,094	9.0%	98	84%	83	41%	34	3	33%	11
36	1,127	97%	1,093	9.0%	98	84%	83	41%	34	3	33%	11
37	1,126	97%	1,093	9.0%	98	84%	83	41%	34	3	33%	11
38	1,126	97%	1,092	9.0%	98	84%	83	41%	34	3	33%	11
39	1,125	97%	1,091	9.0%	98	84%	82	41%	34	3	33%	11
40	236	97%	229	9.0%	21	84%	17	41%	7	3	33%	2
41	236	97%	229	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%	21	84%	17	41%	7	3	33%	2
44	235	97%	228	9.0%	21	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	***27,066***		***26,254***		***2,363***		***1,985***		***814***			***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 2017 ($25.16[1101]) plus 18% benefits for an average cost per hour of $29.69. 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 $34.85 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).[1102]
- 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).[1103]
- 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 healthcare costs, $744 million (38%) for indirect costs, $349 million (18%) for criminal justice costs and $169 million (9%) for 'other' costs.[1104]
- 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. 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

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[1101] Statistics Canada. *Average Hourly Wages of Employees by Selected Characteristics and Occupation, Unadjusted Data, by Province (monthly) (British Columbia)*. 2017. Available at http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/labr69k-eng.htm. Accessed July 2017.
[1102] 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.
[1103] 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.
[1104] 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.

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.[1105]

- 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.[1106]
- 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 2017 CAD.

Table 18: Summary of Annual Cost of Unhealthy Alcohol Use
British Columbia, 2017 CAD

	Direct Healthcare Costs		Criminal Justice Costs		'Other' Costs		**Total Costs**	
	Female	Male	Female	Male	Female	Male	**Female**	**Male**
Low Alcohol Use	$52	$111	$26	$57	$13	$28	**$91**	**$195**
Hazardous Alcohol Use	$402	$703	$205	$359	$101	$176	**$708**	**$1,238**
Harmful Alcohol Use	$1,662	$1,780	$848	$908	$415	$445	**$2,925**	**$3,133**

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.
- 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 $91 (see Table 18). This results in total cost avoided of $13,729 for low-binge 18 year-old females who have ceased unhealthy alcohol use (see Table 19).

1105 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.
1106 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.

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	$91	$708	$2,925	$13,729	$20,674	$63,698	**$98,102**
19	1,449	75%	15%	11%	13.9%	150	29	22	$91	$708	$2,925	$13,725	$20,667	$63,678	**$98,070**
20	1,470	75%	15%	11%	13.9%	152	30	22	$91	$708	$2,925	$13,927	$20,973	$64,618	**$99,518**
21	1,470	75%	15%	11%	13.9%	152	30	22	$91	$708	$2,925	$13,923	$20,966	$64,597	**$99,486**
22	1,469	75%	15%	11%	13.9%	152	30	22	$91	$708	$2,925	$13,918	$20,959	$64,576	**$99,453**
23	1,469	75%	15%	11%	13.9%	152	30	22	$91	$708	$2,925	$13,914	$20,952	$64,554	**$99,420**
24	1,468	75%	15%	11%	13.9%	152	30	22	$91	$708	$2,925	$13,909	$20,945	$64,534	**$99,388**
25	1,768	75%	15%	11%	13.9%	183	36	27	$91	$708	$2,925	$16,747	$25,219	$77,700	**$119,666**
26	1,768	75%	15%	11%	13.9%	183	36	27	$91	$708	$2,925	$16,742	$25,210	$77,675	**$119,627**
27	1,767	75%	15%	11%	13.9%	183	36	27	$91	$708	$2,925	$16,736	$25,202	$77,650	**$119,589**
28	1,766	75%	15%	11%	13.9%	183	36	27	$91	$708	$2,925	$16,731	$25,194	$77,624	**$119,548**
29	1,766	75%	15%	11%	13.9%	183	36	27	$91	$708	$2,925	$16,725	$25,185	$77,597	**$119,507**
30	1,072	63%	31%	6%	13.9%	93	46	9	$91	$708	$2,925	$8,526	$32,874	$26,966	**$68,366**
31	1,072	63%	31%	6%	13.9%	93	46	9	$91	$708	$2,925	$8,522	$32,861	$26,955	**$68,339**
32	1,071	63%	31%	6%	13.9%	93	46	9	$91	$708	$2,925	$8,518	$32,847	$26,944	**$68,309**
33	1,071	63%	31%	6%	13.9%	93	46	9	$91	$708	$2,925	$8,514	$32,832	$26,931	**$68,277**
34	1,070	63%	31%	6%	13.9%	93	46	9	$91	$708	$2,925	$8,510	$32,815	$26,918	**$68,243**
35	1,045	63%	31%	6%	13.9%	91	45	9	$91	$708	$2,925	$8,312	$32,050	$26,290	**$66,652**
36	1,044	63%	31%	6%	13.9%	91	45	9	$91	$708	$2,925	$8,307	$32,031	$26,275	**$66,613**
37	1,044	63%	31%	6%	13.9%	91	45	9	$91	$708	$2,925	$8,302	$32,011	$26,258	**$66,571**
38	1,043	63%	31%	6%	13.9%	91	45	9	$91	$708	$2,925	$8,296	$31,989	$26,240	**$66,525**
39	1,042	63%	31%	6%	13.9%	91	45	9	$91	$708	$2,925	$8,290	$31,966	$26,221	**$66,477**
40	996	63%	31%	6%	13.9%	87	43	9	$91	$708	$2,925	$7,922	$30,548	$25,058	**$63,528**
41	995	63%	31%	6%	13.9%	87	43	9	$91	$708	$2,925	$7,915	$30,521	$25,036	**$63,473**
42	994	63%	31%	6%	13.9%	87	43	9	$91	$708	$2,925	$7,908	$30,493	$25,013	**$63,414**
43	993	63%	31%	6%	13.9%	87	43	9	$91	$708	$2,925	$7,900	$30,462	$24,988	**$63,350**
44	992	63%	31%	6%	13.9%	86	43	9	$91	$708	$2,925	$7,891	$30,429	$24,961	**$63,281**
45	975	59%	30%	11%	13.9%	79	41	16	$91	$708	$2,925	$7,232	$28,739	$45,527	**$81,498**
46	973	59%	30%	11%	13.9%	79	41	16	$91	$708	$2,925	$7,222	$28,703	$45,469	**$81,394**
47	972	59%	30%	11%	13.9%	79	40	16	$91	$708	$2,925	$7,212	$28,663	$45,407	**$81,282**
48	970	59%	30%	11%	13.9%	79	40	16	$91	$708	$2,925	$7,202	$28,620	$45,339	**$81,161**
49	969	59%	30%	11%	13.9%	79	40	15	$91	$708	$2,925	$7,190	$28,574	$45,266	**$81,030**
50	1,007	59%	30%	11%	13.9%	82	42	16	$91	$708	$2,925	$7,474	$29,701	$47,051	**$84,226**
51	1,005	59%	30%	11%	13.9%	82	42	16	$91	$708	$2,925	$7,460	$29,645	$46,962	**$84,067**
52	1,003	59%	30%	11%	13.9%	82	42	16	$91	$708	$2,925	$7,444	$29,584	$46,866	**$83,894**
53	1,001	59%	30%	11%	13.9%	81	42	16	$91	$708	$2,925	$7,428	$29,518	$46,761	**$83,707**
54	999	59%	30%	11%	13.9%	81	42	16	$91	$708	$2,925	$7,410	$29,447	$46,648	**$83,505**
55	1,002	59%	30%	11%	13.9%	81	42	16	$91	$708	$2,925	$7,432	$29,535	$46,788	**$83,755**
56	999	59%	30%	11%	13.9%	81	42	16	$91	$708	$2,925	$7,411	$29,450	$46,654	**$83,515**
57	996	59%	30%	11%	13.9%	81	41	16	$91	$708	$2,925	$7,387	$29,358	$46,508	**$83,253**
58	992	59%	30%	11%	13.9%	81	41	16	$91	$708	$2,925	$7,362	$29,258	$46,348	**$82,968**
59	988	59%	30%	11%	13.9%	80	41	16	$91	$708	$2,925	$7,335	$29,148	$46,175	**$82,657**
60	652	30%	55%	15%	13.9%	27	50	14	$91	$708	$2,925	$2,471	$35,405	$39,516	**$77,393**
61	649	30%	55%	15%	13.9%	27	50	13	$91	$708	$2,925	$2,460	$35,247	$39,339	**$77,046**
62	646	30%	55%	15%	13.9%	27	50	13	$91	$708	$2,925	$2,448	$35,073	$39,145	**$76,666**
63	643	30%	55%	15%	13.9%	27	49	13	$91	$708	$2,925	$2,435	$34,883	$38,933	**$76,251**
64	639	30%	55%	15%	13.9%	27	49	13	$91	$708	$2,925	$2,420	$34,675	$38,701	**$75,797**
65	681	30%	55%	15%	13.9%	28	52	14	$91	$708	$2,925	$2,579	$36,942	$41,231	**$80,752**
66	676	30%	55%	15%	13.9%	28	52	14	$91	$708	$2,925	$2,560	$36,675	$40,933	**$80,168**
67	670	30%	55%	15%	13.9%	28	51	14	$91	$708	$2,925	$2,540	$36,382	$40,606	**$79,528**
68	664	30%	55%	15%	13.9%	28	51	14	$91	$708	$2,925	$2,517	$36,061	$40,248	**$78,826**
69	658	30%	55%	15%	13.9%	27	50	14	$91	$708	$2,925	$2,493	$35,709	$39,855	**$78,057**
70	735	15%	71%	14%	13.9%	15	72	14	$91	$708	$2,925	$1,396	$51,260	$42,048	**$94,704**
71	726	15%	71%	14%	13.9%	15	72	14	$91	$708	$2,925	$1,379	$50,645	$41,544	**$93,568**
72	717	15%	71%	14%	13.9%	15	71	14	$91	$708	$2,925	$1,361	$49,971	$40,990	**$92,322**
73	706	15%	71%	14%	13.9%	15	70	14	$91	$708	$2,925	$1,341	$49,232	$40,384	**$90,957**
74	694	15%	71%	14%	13.9%	14	68	14	$91	$708	$2,925	$1,319	$48,421	$39,719	**$89,458**
75	690	15%	71%	14%	13.9%	14	68	13	$91	$708	$2,925	$1,310	$48,118	$39,471	**$88,899**
76	676	15%	71%	14%	13.9%	14	67	13	$91	$708	$2,925	$1,284	$47,133	$38,662	**$87,078**
77	660	15%	71%	14%	13.9%	14	65	13	$91	$708	$2,925	$1,254	$46,055	$37,778	**$85,088**
78	643	15%	71%	14%	13.9%	13	63	13	$91	$708	$2,925	$1,222	$44,878	$36,812	**$82,912**
79	625	15%	71%	14%	13.9%	13	62	12	$91	$708	$2,925	$1,187	$43,594	$35,759	**$80,540**
80	850	10%	79%	11%	13.9%	12	93	13	$91	$708	$2,925	$1,092	$66,056	$37,217	**$104,365**
81	819	10%	79%	11%	13.9%	12	90	12	$91	$708	$2,925	$1,053	$63,679	$35,877	**$100,609**
82	786	10%	79%	11%	13.9%	11	86	12	$91	$708	$2,925	$1,010	$61,103	$34,426	**$96,540**
83	750	10%	79%	11%	13.9%	11	82	11	$91	$708	$2,925	$965	$58,325	$32,861	**$92,150**
84	712	10%	79%	11%	13.9%	10	78	11	$91	$708	$2,925	$915	$55,338	$31,178	**$87,431**
Total	***66,844***											***$457,574***	***$2,327,677***	***$2,886,558***	***$5,671,808***

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	1,511	68%	16%	16%	13.9%	143	33	34	$195	$1,238	$3,133	$27,926	$40,619	$107,010	**$175,555**
19	1,511	68%	16%	16%	13.9%	143	33	34	$195	$1,238	$3,133	$27,912	$40,598	$106,954	**$175,463**
20	1,303	68%	16%	16%	13.9%	123	28	29	$195	$1,238	$3,133	$24,076	$35,019	$92,257	**$151,353**
21	1,302	68%	16%	16%	13.9%	123	28	29	$195	$1,238	$3,133	$24,059	$34,994	$92,189	**$151,242**
22	1,301	68%	16%	16%	13.9%	123	28	29	$195	$1,238	$3,133	$24,039	$34,965	$92,115	**$151,120**
23	1,300	68%	16%	16%	13.9%	123	28	29	$195	$1,238	$3,133	$24,019	$34,936	$92,037	**$150,992**
24	1,299	68%	16%	16%	13.9%	123	28	29	$195	$1,238	$3,133	$23,999	$34,907	$91,961	**$150,866**
25	1,485	68%	16%	16%	13.9%	140	32	34	$195	$1,238	$3,133	$27,443	$39,917	$105,159	**$172,519**
26	1,484	68%	16%	16%	13.9%	140	32	34	$195	$1,238	$3,133	$27,422	$39,886	$105,079	**$172,388**
27	1,483	68%	16%	16%	13.9%	140	32	34	$195	$1,238	$3,133	$27,402	$39,857	$105,001	**$172,260**
28	1,482	68%	16%	16%	13.9%	140	32	33	$195	$1,238	$3,133	$27,382	$39,828	$104,925	**$172,134**
29	1,481	68%	16%	16%	13.9%	140	32	33	$195	$1,238	$3,133	$27,362	$39,798	$104,847	**$172,007**
30	1,221	57%	22%	21%	13.9%	97	37	36	$195	$1,238	$3,133	$18,933	$45,853	$111,689	**$176,476**
31	1,220	57%	22%	21%	13.9%	97	37	36	$195	$1,238	$3,133	$18,918	$45,817	$111,600	**$176,336**
32	1,219	57%	22%	21%	13.9%	97	37	36	$195	$1,238	$3,133	$18,902	$45,778	$111,505	**$176,185**
33	1,218	57%	22%	21%	13.9%	97	37	36	$195	$1,238	$3,133	$18,885	$45,737	$111,406	**$176,029**
34	1,217	57%	22%	21%	13.9%	97	37	36	$195	$1,238	$3,133	$18,867	$45,694	$111,301	**$175,863**
35	1,486	57%	22%	21%	13.9%	118	45	43	$195	$1,238	$3,133	$23,038	$55,796	$135,906	**$214,740**
36	1,484	57%	22%	21%	13.9%	118	45	43	$195	$1,238	$3,133	$23,014	$55,737	$135,763	**$214,515**
37	1,483	57%	22%	21%	13.9%	118	45	43	$195	$1,238	$3,133	$22,988	$55,674	$135,611	**$214,274**
38	1,481	57%	22%	21%	13.9%	118	45	43	$195	$1,238	$3,133	$22,961	$55,608	$135,449	**$214,017**
39	1,479	57%	22%	21%	13.9%	117	45	43	$195	$1,238	$3,133	$22,932	$55,537	$135,277	**$213,746**
40	1,468	57%	22%	21%	13.9%	117	45	43	$195	$1,238	$3,133	$22,766	$55,135	$134,297	**$212,198**
41	1,466	57%	22%	21%	13.9%	116	44	43	$195	$1,238	$3,133	$22,733	$55,055	$134,103	**$211,891**
42	1,464	57%	22%	21%	13.9%	116	44	43	$195	$1,238	$3,133	$22,698	$54,970	$133,896	**$211,564**
43	1,462	57%	22%	21%	13.9%	116	44	43	$195	$1,238	$3,133	$22,660	$54,879	$133,674	**$211,213**
44	1,459	57%	22%	21%	13.9%	116	44	43	$195	$1,238	$3,133	$22,620	$54,781	$133,436	**$210,837**
45	1,242	56%	23%	21%	13.9%	97	39	36	$195	$1,238	$3,133	$19,028	$48,594	$112,202	**$179,824**
46	1,239	56%	23%	21%	13.9%	97	39	36	$195	$1,238	$3,133	$18,989	$48,495	$111,972	**$179,456**
47	1,237	56%	23%	21%	13.9%	97	39	36	$195	$1,238	$3,133	$18,947	$48,387	$111,723	**$179,057**
48	1,234	56%	23%	21%	13.9%	97	39	36	$195	$1,238	$3,133	$18,902	$48,272	$111,456	**$178,629**
49	1,230	56%	23%	21%	13.9%	97	39	35	$195	$1,238	$3,133	$18,853	$48,147	$111,168	**$178,168**
50	1,176	56%	23%	21%	13.9%	92	37	34	$195	$1,238	$3,133	$18,019	$46,016	$106,249	**$170,284**
51	1,172	56%	23%	21%	13.9%	92	37	34	$195	$1,238	$3,133	$17,964	$45,877	$105,927	**$169,768**
52	1,169	56%	23%	21%	13.9%	92	37	34	$195	$1,238	$3,133	$17,905	$45,726	$105,579	**$169,210**
53	1,164	56%	23%	21%	13.9%	91	37	34	$195	$1,238	$3,133	$17,841	$45,563	$105,202	**$168,605**
54	1,160	56%	23%	21%	13.9%	91	37	33	$195	$1,238	$3,133	$17,772	$45,386	$104,793	**$167,951**
55	1,282	56%	23%	21%	13.9%	101	41	37	$195	$1,238	$3,133	$19,644	$50,168	$115,835	**$185,647**
56	1,276	56%	23%	21%	13.9%	100	40	37	$195	$1,238	$3,133	$19,554	$49,937	$115,301	**$184,791**
57	1,270	56%	23%	21%	13.9%	100	40	37	$195	$1,238	$3,133	$19,456	$49,687	$114,724	**$183,866**
58	1,263	56%	23%	21%	13.9%	99	40	36	$195	$1,238	$3,133	$19,349	$49,415	$114,096	**$182,860**
59	1,255	56%	23%	21%	13.9%	98	40	36	$195	$1,238	$3,133	$19,234	$49,120	$113,414	**$181,767**
60	1,128	45%	32%	24%	13.9%	70	49	37	$195	$1,238	$3,133	$13,726	$61,250	$115,690	**$190,667**
61	1,120	45%	32%	24%	13.9%	70	49	37	$195	$1,238	$3,133	$13,628	$60,814	$114,866	**$189,308**
62	1,111	45%	32%	24%	13.9%	69	49	36	$195	$1,238	$3,133	$13,521	$60,338	$113,968	**$187,827**
63	1,102	45%	32%	24%	13.9%	69	48	36	$195	$1,238	$3,133	$13,406	$59,823	$112,993	**$186,222**
64	1,091	45%	32%	24%	13.9%	68	48	36	$195	$1,238	$3,133	$13,280	$59,261	$111,933	**$184,474**
65	1,109	45%	32%	24%	13.9%	69	49	36	$195	$1,238	$3,133	$13,492	$60,207	$113,719	**$187,418**
66	1,096	45%	32%	24%	13.9%	68	48	36	$195	$1,238	$3,133	$13,339	$59,526	$112,434	**$185,300**
67	1,083	45%	32%	24%	13.9%	67	47	35	$195	$1,238	$3,133	$13,174	$58,786	$111,035	**$182,995**
68	1,068	45%	32%	24%	13.9%	67	47	35	$195	$1,238	$3,133	$12,993	$57,982	$109,517	**$180,492**
69	1,052	45%	32%	24%	13.9%	66	46	34	$195	$1,238	$3,133	$12,797	$57,108	$107,865	**$177,770**
70	631	32%	41%	28%	13.9%	28	36	24	$195	$1,238	$3,133	$5,429	$44,236	$75,666	**$125,330**
71	620	32%	41%	28%	13.9%	27	35	24	$195	$1,238	$3,133	$5,329	$43,425	$74,279	**$123,033**
72	607	32%	41%	28%	13.9%	27	34	23	$195	$1,238	$3,133	$5,221	$42,547	$72,777	**$120,545**
73	594	32%	41%	28%	13.9%	26	34	23	$195	$1,238	$3,133	$5,105	$41,595	$71,150	**$117,849**
74	579	32%	41%	28%	13.9%	25	33	22	$195	$1,238	$3,133	$4,978	$40,566	$69,390	**$114,935**
75	592	32%	41%	28%	13.9%	26	34	23	$195	$1,238	$3,133	$5,095	$41,515	$71,012	**$117,621**
76	574	32%	41%	28%	13.9%	25	33	22	$195	$1,238	$3,133	$4,940	$40,256	$68,859	**$114,054**
77	555	32%	41%	28%	13.9%	24	31	21	$195	$1,238	$3,133	$4,774	$38,901	$66,542	**$110,217**
78	534	32%	41%	28%	13.9%	24	30	20	$195	$1,238	$3,133	$4,596	$37,449	$64,058	**$106,104**
79	512	32%	41%	28%	13.9%	23	29	20	$195	$1,238	$3,133	$4,405	$35,896	$61,402	**$101,703**
80	547	6%	59%	35%	13.9%	5	45	27	$195	$1,238	$3,133	$910	$55,343	$83,160	**$139,412**
81	518	6%	59%	35%	13.9%	4	42	25	$195	$1,238	$3,133	$863	$52,504	$78,894	**$132,261**
82	489	6%	59%	35%	13.9%	4	40	24	$195	$1,238	$3,133	$814	$49,503	$74,385	**$124,702**
83	458	6%	59%	35%	13.9%	4	37	22	$195	$1,238	$3,133	$762	$46,350	$69,647	**$116,759**
84	425	6%	59%	35%	13.9%	4	35	21	$195	$1,238	$3,133	$708	$43,057	$64,698	**$108,462**
Total	***75,335***											***$1,104,695***	***$3,204,405***	***$6,954,024***	***$11,263,124***

- 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.[1107] Inflated to 2017, the equivalent costs are $21,772 and $5,547.

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

[1107] 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.[1108] 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 2017 CAD costs

Table 22: Lifetime Cost of FAS / FASD
Canada, 2017

	Annual Cost (2007 CAD)				Severity Adjustment		Annual Cost (2017 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	1.16	0.80	1.93	$28,100	$67,512	3	$84,301	$202,536
3 - 6	$26,544	$23,666	$30,328	1.16	0.80	1.93	$24,680	$59,296	4	$98,722	$237,183
7 - 12	$28,666	$25,446	$32,832	1.16	0.80	1.93	$26,653	$64,036	6	$159,921	$384,217
13 - 17	$20,201	$16,997	$24,885	1.16	0.80	1.93	$18,783	$45,126	5	$93,914	$225,632
18 - 21	$16,544	$14,888	$18,234	1.16	0.80	1.93	$15,382	$36,957	4	$61,530	$147,829
22 - 25	$16,232	$14,666	$18,002	1.16	0.80	1.93	$15,092	$36,260	4	$60,370	$145,041
26 - 35	$15,998	$14,021	$18,112	1.16	0.80	1.93	$14,875	$35,737	10	$148,748	$321,637
36 - 45	$14,689	$12,888	$16,681	1.16	0.80	1.93	$13,658	$32,813	10	$136,577	
46 - 53	$14,810	$12,664	$16,988	1.16	0.80	1.93	$13,770	$33,084	8	$110,162	
54 - 65	$14,750	n/a	n/a	1.16	0.80	1.93	$13,714	$32,948	12	$164,568	
										$1,118,811	**$1,664,074**

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 $1,118,811 per individual (Table 23, row *be*). The lifetime cost of FAS is $1,664,074 per individual (Table 23, row *bf*).

[1108] 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 $9,609 (Table 23, row *bx*). The CE of $9,609 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.

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	919,538	Table 15
c	Lifetime short screens conducted, males	751,681	Table 16
d	Lifetime short screens conducted, pregnant females	26,254	Table 17
e	Proportion of office visit required for short screen	20.0%	√
f	Cost of 10-minute office visit	$34.85	Ref. Doc.
g	Patient time costs / office visit	$59.38	Ref. Doc.
h	Lifetime cost of short screens	$31,990,589	= (b + c + d) * e * (f + g)
i	Lifetime short screens, females with unhealthy alcohol use	194,087	Table 15
j	Lifetime short screens, males with unhealthy alcohol use	218,742	Table 16
k	Lifetime short screens, pregnant females with unhealthy alcohol use	2,363	Table 17
l	Screening sensitivity	84%	√
m	Lifetime short screen true positives, female	163,033	= i * l
n	Lifetime short screen true positives, male	183,744	= j * l
o	Lifetime short screen true positives, pregnant females	1,985	= k * l
p	Lifetime short screens, females ***without*** unhealthy alcohol use	725,451	= b - i
q	Lifetime short screens, males ***without*** unhealthy alcohol use	532,939	= c - j
r	Lifetime short screens, pregnant females ***without*** unhealthy alcohol use	23,892	= d - k
s	Screening specificity	74.0%	√
t	Lifetime short screen false positives, female	188,617	= (1 - s) * p
u	Lifetime short screen false positives, male	138,564	= (1 - s) * q
v	Lifetime short screen false positives, pregnant females	6,212	= (1 - s) * r
w	Lifetime in-depth screens delivered, female	351,651	= m + t
x	Lifetime in-depth screens delivered, male	322,308	= n + u
y	Lifetime in-depth screens delivered, pregnant females	8,197	= o + v
z	Proportion of office visit required for in-depth screen	80.0%	√
aa	Cost of 10-minute office visit	$34.85	Ref. Doc.
ab	Patient time costs / office visit	$59.38	Ref. Doc.
ac	Lifetime cost of in-depth screen	$51,423,555	= (w + x + y) * z * (aa + ab)
ad	**Total cost of lifetime screening**	**$83,414,144**	= h + ac
	Cost of Brief Intervention		
ae	Frequency of brief intervention, years	3	√
af	Lifetime number of brief interventions, female	22,281	Table 15
ag	Lifetime number of brief interventions, male	25,112	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	$34.85	Ref. Doc.
al	Patient time costs / office visit	$59.38	Ref. Doc.
am	**Lifetime cost of office-based interventions**	**$13,474,162**	= (af + ag + ah) * ai * aj * (ak + al)
an	**Total lifetime cost of screening and brief interventions, cohort**	**$96,888,307**	= 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	$457,574	Table 19
ap	Cost avoided, hazardous drinking, female	$2,327,677	Table 19
aq	Cost avoided, harmful drinking, female	$2,886,558	Table 19
ar	Cost avoided, total, female	$5,671,808	= ao + ap + aq
as	Cost avoided, low-binge drinking, male	$1,104,695	Table 20
at	Cost avoided, hazardous drinking, male	$3,204,405	Table 20
au	Cost avoided, harmful drinking, male	$6,954,024	Table 20
av	Cost avoided, total, male	$11,263,124	= as + at + au
aw	**Total cost avoided, general population**	**$16,934,932**	= ar + av
	Costs Avoided due to Brief Intervention - FASD		
ax	Number of births with FASD	490	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	$1,118,811	Table 22
bf	Lifetime cost, FAS	$1,664,074	Table 22
bg	Lifetime patient cost, FASD excluding FAS	$285,042	bd * be
bh	Lifetime health care and social services cost, FASD excluding FAS	$833,769	= be - bg
bi	Cost avoided, patient cost, FASD excluding FAS	$6,300,803	= bb * bg
bj	Cost avoided, health care and social services, FASD excluding FAS	$18,430,319	= bb * bh
bk	**Total cost avoided, FASD excluding FAS**	**$24,731,123**	= bi + bj
bl	Lifetime patient cost, FAS	$423,960	= bd * bf
bm	Lifetime health care and social services cost, FAS	$1,240,114	= bf * bl
bn	Cost avoided, patient cost, FAS	$2,192,704	= bc * bl
bo	Cost avoided, health care and social services, FAS	$6,413,823	= bc * bm
bp	**Total cost avoided, FAS**	**$8,606,527**	= bn + bo
bq	**Total cost avoided, all FASD**	**$33,337,649**	= bk + bp
br	**Lifetime cost avoided, brief intervention**	**$50,272,582**	= aw + bq
	Net Cost of Screening and Brief Intervention		
bs	Net Cost of Screening and Brief Intervention	$46,615,725	= an - br
bt	QALYs saved	5,035	Table 14
bu	CE ($/QALY Saved)	$9,258	= bs / bt
bv	Net Cost of Brief Intervention, 1.5% Discount	$32,392,758	Calculated
bw	QALYs saved, 1.5% Discount	3,371	Calculated
bx	**CE ($/QALY Saved), 1.5% Discount**	**$9,609**	= 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 = -$375 (*cost saving*)
- 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 = $12,336
- 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 = $7,534

- Assume that the proportion of births with FASD increases from 1.81% to 2.93% (Table 14, row *af*): CE = $5,113
- Assume that the number of pregnant women with any alcohol use decreases from 9.0% to 3.0% (Table 17): CE = $9,580
- Assume that the screening sensitivity decreases from 84% to 67% (Table 14, row *as*): CE = $12,316
- Assume that the screening sensitivity increases from 84% to 94% (Table 14, row *as*): CE = $8,474
- Assume that the screening specificity decreases from 74% to 46% (Table 23, row *s*): CE = $14,593
- Assume that the screening sensitivity increases from 74% to 88% (Table 23, row *s*): CE = $7,117
- Assume that the frequency of the brief intervention changes from once every 3 years to once every 2 years (Table 23, row *ae*): CE = $10,979
- Assume that the frequency of the brief intervention changes from once every 3 years to once every 4 years (Table 23, row *ae*): CE = $8,924
- 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 = $23,676
- 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 = $5,518
- Assume that the impacts of FASD are excluded (Table, row *bf*): CE = $21,229
- Comparison to previous LPS alcohol screening model. Assume that the proportion accepting treatment decreases from 41% to 30% (Table 14, row *at*) and that impacts of FASD are excluded: CE = $29,276. *(Our previous model, which estimated that 30% would accept treatment and did not include the impact of FASD, had a CE of $23,607).*

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 3,371 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to be $9,609 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	**3,371**	**1,977**	**4,300**
3% Discount Rate	2,432	1,425	3,107
0% Discount Rate	5,035	2,957	6,411
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$9,609**	**-$375**	**$23,676**
3% Discount Rate	$9,901	$278	$23,572
0% Discount Rate	$9,258	-$1,128	$23,767
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	-$710	-$2,759	$4,755
3% Discount Rate	-$304	-$2,263	$4,970
0% Discount Rate	-$2,432	-$4,578	$3,477

Screening and Interventions to Reduce Unhealthy Drug Use

United States Preventive Services Task Force Recommendations (2020)[1109]

> *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.[1110]
- 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.[1111]
- 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.[1112]
- 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.[1113]

[1109] US Preventive Services Task Force. Screening for Unhealthy Drug Use: US Preventive Services Task Force Recommendation Statement. *JAMA*. 2020; 323(22): 2301-2309.
[1110] Levy S, Williams J; Committee on Substance Use and Prevention. Substance use screening, brief intervention, and referral to treatment. *Pediatrics*. 2016; 138(1): e20161211.
[1111] 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.
[1112] 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.
[1113] 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.[1114]

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)."[1115] 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).[1116] 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.*

1114 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.

1115 US Preventive Services Task Force. Screening for Unhealthy Drug Use: US Preventive Services Task Force Recommendation Statement. *JAMA*. 2020; 323(22): 2301-2309.

1116 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**.[1117] 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).[1118] **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.[1119] 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

1117 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.
1118 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.
1119 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%).[1120]
- 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.[1121] See footnote for a definition of cannabis use disorder.[1122]

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.[1123]
- 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%.

[1120] 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.

[1121] 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.

[1122] 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."

[1123] 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%[1124] and 60.5%[1125]) 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%[1126] 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%[1127] 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.[1128]
- We proportionally distributed unhealthy drug use by age group using the evidence from the 2015/16 CCHS.[1129]

- 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.[1130] 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[1131] while SAMHSA's estimate is 12.73% (Table 1).[1132] **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)**.**

[1124] 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.
[1125] 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.
[1126] Ibid.
[1127] 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.
[1128] 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.
[1129] 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.
[1130] 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.
[1131] US Preventive Services Task Force. Screening for Unhealthy Drug Use: US Preventive Services Task Force Recommendation Statement. *JAMA*. 2020; 323(22): 2301-2309.
[1132] 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 1,997,884 life years lived between the ages of 18 and 69 in a BC birth cohort of 40,000, an estimated 121,904 (6.10%) would be years lived with unhealthy drug use (excluding cannabis use disorder) and a further 92,445 (4.63%) 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 (excluding Cannabis)		Cannabis Use Disorder			Unhealthy Drug Use (excluding Cannabis)		Cannabis Use Disorder			Unhealthy Drug Use (excluding Cannabis)		Cannabis Use Disorder	
Age	Total Life Years	%	#	%	#	Total Life Years	%	#	%	#	Total Life Years	%	#	%	#
18	19,891	2.79%	554	2.77%	551	19,867	7.59%	1,508	5.10%	1,013	39,757	5.19%	2,062	3.93%	1,564
19	19,884	2.79%	554	2.77%	551	19,856	7.59%	1,508	5.10%	1,012	39,740	5.19%	2,061	3.93%	1,563
20	19,878	6.48%	1,288	6.44%	1,281	19,844	17.67%	3,506	11.87%	2,354	39,721	12.07%	4,794	9.15%	3,636
21	19,871	6.48%	1,287	6.44%	1,280	19,829	17.67%	3,504	11.87%	2,353	39,700	12.07%	4,792	9.15%	3,634
22	19,865	6.48%	1,287	6.44%	1,280	19,813	17.68%	3,502	11.87%	2,352	39,678	12.07%	4,789	9.15%	3,632
23	19,858	6.47%	1,286	6.44%	1,279	19,796	17.68%	3,500	11.87%	2,350	39,654	12.07%	4,786	9.15%	3,629
24	19,852	6.47%	1,285	6.44%	1,278	19,780	17.69%	3,498	11.88%	2,349	39,631	12.07%	4,783	9.15%	3,627
25	19,845	6.47%	1,284	6.44%	1,277	19,764	17.69%	3,496	11.88%	2,348	39,609	12.07%	4,781	9.15%	3,625
26	19,839	6.47%	1,284	6.44%	1,277	19,749	17.69%	3,494	11.88%	2,347	39,588	12.07%	4,778	9.15%	3,623
27	19,833	6.47%	1,283	6.43%	1,276	19,734	17.70%	3,493	11.88%	2,345	39,567	12.07%	4,775	9.15%	3,621
28	19,826	6.47%	1,282	6.43%	1,275	19,720	17.70%	3,491	11.89%	2,344	39,546	12.07%	4,773	9.15%	3,619
29	19,819	6.47%	1,282	6.43%	1,275	19,705	17.70%	3,489	11.89%	2,343	39,524	12.07%	4,770	9.15%	3,618
30	19,812	4.37%	867	4.35%	862	19,690	11.98%	2,359	8.05%	1,584	39,502	8.17%	3,226	6.19%	2,446
31	19,804	4.37%	866	4.35%	861	19,675	11.98%	2,358	8.05%	1,583	39,478	8.17%	3,224	6.19%	2,445
32	19,795	4.37%	866	4.35%	861	19,658	11.99%	2,356	8.05%	1,582	39,453	8.17%	3,222	6.19%	2,443
33	19,786	4.37%	865	4.35%	860	19,640	11.99%	2,355	8.05%	1,581	39,426	8.17%	3,220	6.19%	2,442
34	19,776	4.37%	864	4.35%	860	19,622	11.99%	2,353	8.05%	1,580	39,398	8.17%	3,217	6.19%	2,440
35	19,765	4.37%	864	4.35%	859	19,602	11.99%	2,351	8.05%	1,579	39,367	8.17%	3,215	6.19%	2,438
36	19,754	4.37%	863	4.35%	858	19,582	12.00%	2,349	8.06%	1,578	39,335	8.17%	3,212	6.19%	2,436
37	19,741	4.37%	862	4.34%	858	19,560	12.00%	2,347	8.06%	1,576	39,301	8.17%	3,209	6.19%	2,434
38	19,728	4.37%	861	4.34%	857	19,536	12.00%	2,345	8.06%	1,575	39,264	8.17%	3,206	6.19%	2,431
39	19,713	4.37%	861	4.34%	856	19,511	12.01%	2,343	8.06%	1,573	39,225	8.17%	3,203	6.19%	2,429
40	19,697	2.20%	433	2.18%	430	19,485	6.04%	1,177	4.06%	791	39,182	4.11%	1,610	3.12%	1,221
41	19,680	2.20%	432	2.18%	430	19,457	6.04%	1,176	4.06%	790	39,137	4.11%	1,608	3.12%	1,219
42	19,662	2.19%	431	2.18%	429	19,427	6.05%	1,175	4.06%	789	39,089	4.11%	1,606	3.12%	1,218
43	19,642	2.19%	431	2.18%	429	19,395	6.05%	1,173	4.06%	788	39,037	4.11%	1,604	3.12%	1,216
44	19,621	2.19%	430	2.18%	428	19,360	6.05%	1,171	4.06%	787	38,981	4.11%	1,602	3.12%	1,215
45	19,598	2.19%	430	2.18%	427	19,323	6.05%	1,170	4.06%	785	38,921	4.11%	1,599	3.12%	1,213
46	19,573	2.19%	429	2.18%	427	19,283	6.05%	1,168	4.07%	784	38,856	4.11%	1,596	3.12%	1,211
47	19,546	2.19%	428	2.18%	426	19,241	6.06%	1,165	4.07%	783	38,787	4.11%	1,594	3.12%	1,209
48	19,517	2.19%	427	2.18%	425	19,195	6.06%	1,163	4.07%	781	38,711	4.11%	1,591	3.12%	1,206
49	19,485	2.19%	426	2.18%	424	19,145	6.06%	1,161	4.07%	780	38,630	4.11%	1,587	3.12%	1,204
50	19,451	2.00%	388	1.99%	386	19,091	5.54%	1,057	3.72%	710	38,543	3.75%	1,445	2.84%	1,096
51	19,414	1.99%	387	1.98%	385	19,034	5.54%	1,054	3.72%	708	38,448	3.75%	1,441	2.84%	1,093
52	19,375	1.99%	386	1.98%	384	18,971	5.54%	1,051	3.72%	706	38,346	3.75%	1,438	2.84%	1,090
53	19,331	1.99%	385	1.98%	383	18,903	5.55%	1,048	3.72%	704	38,235	3.75%	1,433	2.84%	1,087
54	19,285	1.99%	384	1.98%	382	18,830	5.55%	1,045	3.73%	702	38,114	3.75%	1,429	2.84%	1,084
55	19,234	1.99%	383	1.98%	381	18,750	5.55%	1,041	3.73%	699	37,984	3.75%	1,424	2.84%	1,080
56	19,178	1.99%	381	1.98%	379	18,664	5.56%	1,038	3.73%	697	37,842	3.75%	1,419	2.84%	1,076
57	19,118	1.99%	380	1.98%	378	18,570	5.56%	1,033	3.74%	694	37,689	3.75%	1,413	2.84%	1,072
58	19,053	1.98%	378	1.97%	376	18,469	5.57%	1,029	3.74%	691	37,522	3.75%	1,407	2.84%	1,067
59	18,981	1.98%	376	1.97%	374	18,358	5.58%	1,024	3.75%	688	37,340	3.75%	1,400	2.84%	1,062
Total to Age 59	**824,375**	**3.73%**	**30,719**	**3.71%**	**30,556**	**814,483**	**10.27%**	**83,625**	**6.89%**	**56,156**	**1,638,859**	**6.98%**	**114,344**	**5.29%**	**86,712**
60	18,904	1.11%	210	1.11%	209	18,239	3.14%	572	2.11%	384	37,142	2.11%	782	1.60%	593
61	18,819	1.11%	209	1.10%	208	18,109	3.14%	569	2.11%	382	36,927	2.11%	778	1.60%	590
62	18,726	1.11%	208	1.10%	206	17,967	3.15%	565	2.11%	379	36,693	2.11%	773	1.60%	586
63	18,625	1.11%	206	1.10%	205	17,813	3.15%	561	2.12%	377	36,438	2.11%	767	1.60%	582
64	18,514	1.10%	205	1.10%	203	17,646	3.16%	557	2.12%	374	36,160	2.11%	761	1.60%	577
65	18,392	1.10%	203	1.10%	202	17,464	3.16%	552	2.12%	371	35,857	2.11%	755	1.60%	573
66	18,259	1.10%	201	1.09%	200	17,267	3.17%	547	2.13%	367	35,526	2.11%	748	1.60%	567
67	18,113	1.10%	199	1.09%	198	17,052	3.18%	542	2.13%	364	35,166	2.11%	740	1.60%	562
68	17,954	1.10%	197	1.09%	196	16,819	3.18%	535	2.14%	360	34,773	2.11%	732	1.60%	555
69	17,778	1.09%	194	1.09%	193	16,565	3.19%	529	2.14%	355	34,344	2.11%	723	1.60%	548
Total to Age 69	**1,008,459**	**3.25%**	**32,750**	**3.23%**	**32,576**	**989,425**	**9.01%**	**89,154**	**6.05%**	**59,869**	**1,997,884**	**6.10%**	**121,904**	**4.63%**	**92,445**
70	17,586	0.27%	47	0.26%	46	16,290	0.78%	127	0.52%	85	33,877	0.51%	174	0.39%	132
71	17,375	0.26%	46	0.26%	46	15,992	0.78%	125	0.53%	84	33,367	0.51%	171	0.39%	130
72	17,144	0.26%	45	0.26%	45	15,668	0.79%	123	0.53%	83	32,812	0.51%	169	0.39%	128
73	16,890	0.26%	44	0.26%	44	15,318	0.79%	121	0.53%	81	32,208	0.51%	165	0.39%	125
74	16,612	0.26%	44	0.26%	43	14,939	0.79%	119	0.53%	80	31,551	0.51%	162	0.39%	123
75	16,307	0.26%	43	0.26%	42	14,530	0.80%	116	0.54%	78	30,838	0.51%	158	0.39%	120
76	15,973	0.26%	41	0.26%	41	14,090	0.80%	113	0.54%	76	30,063	0.51%	154	0.39%	117
77	15,608	0.26%	40	0.26%	40	13,616	0.81%	110	0.54%	74	29,224	0.51%	150	0.39%	114
78	15,209	0.26%	39	0.26%	39	13,107	0.81%	106	0.54%	71	28,317	0.51%	145	0.39%	110
79	14,774	0.26%	38	0.25%	38	12,564	0.82%	103	0.55%	69	27,338	0.51%	140	0.39%	106
Total to Age 79	***1,171,939***	***2.83%***	***33,178***	***2.82%***	***33,001***	***1,135,540***	***7.95%***	***90,317***	***5.34%***	***60,650***	***2,307,479***	***5.35%***	***123,494***	***4.06%***	***93,651***

Estimating the Quality of Life Reduction

- Disability weights assigned by the Global Burden of Diseases (GBD) study for unhealthy drug use are as follows:[1133]
    - **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).[1134,1135]
- 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

[1133] 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.
[1134] 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.
[1135] 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.[1136] 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.[1137]

- 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).[1138]
- 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.[1139]
- 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.

1136 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.
1137 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.
1138 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.
1139 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 62,241 QALYs lost between the ages of 18 and 69, 18,010 (28.9%) in females and 44,231 (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.[1140,1141] 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.[1142]
- 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.[1143] This impairment is intensified by contextual factors such as exposure to intimate partner violence, trauma, homelessness and social expectations (e.g. as caretakers).[1144]
- 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.[1145]

[1140] McHugh R, Votaw V, Sugarman D et al. Sex and gender differences in substance use disorders. *Clinical Psychology Review*. 2018; 66: 12-23.
[1141] 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.
[1142] Fonseca F, Robles-Martinez M, Tirado-Munoz J et al. A gender perspective on addictive disorders. *Current Addiction Reports*. 2021; 8: 89-99.
[1143] McHugh R, Votaw V, Sugarman D et al. Sex and gender differences in substance use disorders. *Clinical Psychology Review*. 2018; 66: 12-23.
[1144] 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.
[1145] 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 Unhealthy Drug Use				**Unhealthy Drug Use**			
Age	**Mean QoL***	Excl CUD	CUD	**QALYs Lost**	**Mean QoL***	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	1,287	1,280	733	0.914	3,502	2,352	1,801	2,535
23	0.914	1,286	1,279	733	0.914	3,500	2,350	1,800	2,533
24	0.914	1,285	1,278	733	0.914	3,498	2,349	1,799	2,532
25	0.914	1,284	1,277	732	0.914	3,496	2,348	1,798	2,530
26	0.914	1,284	1,277	732	0.914	3,494	2,347	1,797	2,529
27	0.914	1,283	1,276	731	0.914	3,493	2,345	1,796	2,528
28	0.914	1,282	1,275	731	0.914	3,491	2,344	1,795	2,526
29	0.914	1,282	1,275	731	0.914	3,489	2,343	1,794	2,525
30	0.890	867	862	481	0.890	2,359	1,584	1,181	1,663
31	0.890	866	861	481	0.890	2,358	1,583	1,181	1,662
32	0.890	866	861	480	0.890	2,356	1,582	1,180	1,660
33	0.890	865	860	480	0.890	2,355	1,581	1,179	1,659
34	0.890	864	860	480	0.890	2,353	1,580	1,178	1,658
35	0.890	864	859	479	0.890	2,351	1,579	1,177	1,657
36	0.890	863	858	479	0.890	2,349	1,578	1,176	1,656
37	0.890	862	858	479	0.890	2,347	1,576	1,175	1,654
38	0.890	861	857	478	0.890	2,345	1,575	1,174	1,653
39	0.890	861	856	478	0.890	2,343	1,573	1,173	1,651
40	0.854	433	430	230	0.854	1,177	791	566	796
41	0.854	432	430	230	0.854	1,176	790	565	795
42	0.854	431	429	230	0.854	1,175	789	564	794
43	0.854	431	429	230	0.854	1,173	788	564	793
44	0.854	430	428	229	0.854	1,171	787	563	792
45	0.854	430	427	229	0.854	1,170	785	562	791
46	0.854	429	427	228	0.854	1,168	784	561	790
47	0.854	428	426	228	0.854	1,165	783	560	788
48	0.854	427	425	228	0.854	1,163	781	559	787
49	0.854	426	424	227	0.854	1,161	780	558	785
50	0.820	388	386	199	0.820	1,057	710	488	686
51	0.820	387	385	198	0.820	1,054	708	486	684
52	0.820	386	384	198	0.820	1,051	706	485	683
53	0.820	385	383	197	0.820	1,048	704	484	681
54	0.820	384	382	196	0.820	1,045	702	482	679
55	0.820	383	381	196	0.820	1,041	699	481	676
56	0.820	381	379	195	0.820	1,038	697	479	674
57	0.820	380	378	194	0.820	1,033	694	477	671
58	0.820	378	376	193	0.820	1,029	691	475	668
59	0.820	376	374	192	0.820	1,024	688	472	665
Total to Age 59		**30,719**	**30,556**	**16,998**		**83,625**	**56,156**	**41,745**	**58,743**
60	0.799	210	209	105	0.799	572	384	257	362
61	0.799	209	208	104	0.799	569	382	256	360
62	0.799	208	206	103	0.799	565	379	254	358
63	0.799	206	205	103	0.799	561	377	252	355
64	0.799	205	203	102	0.799	557	374	250	352
65	0.799	203	202	101	0.799	552	371	248	349
66	0.799	201	200	100	0.799	547	367	246	346
67	0.799	199	198	99	0.799	542	364	243	343
68	0.799	197	196	98	0.799	535	360	241	339
69	0.799	194	193	97	0.799	529	355	238	335
Total to Age 69		**32,750**	**32,576**	**18,010**		**89,154**	**59,869**	**44,231**	**62,241**
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	52	73
74	0.757	44	43	21	0.757	119	80	50	71
75	0.757	43	42	20	0.757	116	78	49	69
76	0.757	41	41	20	0.757	113	76	48	68
77	0.757	40	40	19	0.757	110	74	47	66
78	0.757	39	39	18	0.757	106	71	45	64
79	0.757	38	38	18	0.757	103	69	44	62
Total to Age 79		***33,178***	***33,001***	***18,212***		***90,317***	***60,650***	***44,726***	***62,938***

**** See Reference document "Calculating Changes in Quality of Life". CUD=cannabis use disorder***

Calculating Life Years Lost

- 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[1146] in BC deaths in BC increased from 295 in 2011 to 2,232 in 2021 (an increase of 657%) (Table 6).[1147]

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%).[1148]
- 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.[1149] 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).

[1146] 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.

[1147] 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.

[1148] Ibid.

[1149] 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 96 deaths (21 in females and 75 in males) due to unhealthy drug use between the ages of 18 to 69 resulting in 3,889 life years lost (946 in females and 2,942 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	66.6	3.8	19,867	0.25	0.05	62.7	3.1	0.1	7
19	19,884	2.42	0.48	65.7	31.6	19,856	6.94	1.38	61.7	85.0	1.9	117
20	19,878	2.42	0.48	64.7	31.1	19,844	6.94	1.38	60.8	83.7	1.9	115
21	19,871	2.42	0.48	63.7	30.6	19,829	6.94	1.38	59.8	82.2	1.9	113
22	19,865	2.42	0.48	62.7	30.1	19,813	6.94	1.37	58.9	80.9	1.9	111
23	19,858	2.42	0.48	61.7	29.7	19,796	6.94	1.37	57.9	79.5	1.9	109
24	19,852	2.42	0.48	60.8	29.2	19,780	6.94	1.37	57.0	78.2	1.9	107
25	19,845	2.42	0.48	59.8	28.7	19,764	6.94	1.37	56.0	76.8	1.9	105
26	19,839	2.42	0.48	58.8	28.2	19,749	6.94	1.37	55.1	75.5	1.8	104
27	19,833	2.42	0.48	57.8	27.7	19,734	6.94	1.37	54.1	74.0	1.8	102
28	19,826	2.42	0.48	56.8	27.3	19,720	6.94	1.37	53.1	72.6	1.8	100
29	19,819	2.42	0.48	55.9	26.8	19,705	6.94	1.37	52.2	71.3	1.8	98
30	19,812	2.42	0.48	54.9	26.3	19,690	6.94	1.37	51.2	69.9	1.8	96
31	19,804	2.42	0.48	53.9	25.8	19,675	6.94	1.36	50.2	68.5	1.8	94
32	19,795	2.42	0.48	52.9	25.3	19,658	6.94	1.36	49.3	67.2	1.8	93
33	19,786	2.42	0.48	51.9	24.9	19,640	6.94	1.36	48.3	65.8	1.8	91
34	19,776	2.42	0.48	51.0	24.4	19,622	6.94	1.36	47.4	64.5	1.8	89
35	19,765	2.42	0.48	50.0	23.9	19,602	6.94	1.36	46.4	63.1	1.8	87
36	19,754	2.42	0.48	49.0	23.4	19,582	6.94	1.36	45.5	61.8	1.8	85
37	19,741	2.42	0.48	48.1	23.0	19,560	6.94	1.36	44.5	60.4	1.8	83
38	19,728	2.42	0.48	47.1	22.5	19,536	6.94	1.35	43.6	59.1	1.8	82
39	19,713	2.42	0.48	46.1	22.0	19,511	6.94	1.35	42.6	57.6	1.8	80
40	19,697	2.56	0.50	45.1	22.7	19,485	10.57	2.06	41.7	85.9	2.6	109
41	19,680	2.56	0.50	44.2	22.3	19,457	10.57	2.06	40.7	83.7	2.6	106
42	19,662	2.56	0.50	43.2	21.7	19,427	10.57	2.05	39.8	81.8	2.6	104
43	19,642	2.56	0.50	42.3	21.3	19,395	10.57	2.05	38.9	79.8	2.6	101
44	19,621	2.56	0.50	41.3	20.7	19,360	10.57	2.05	37.9	77.6	2.5	98
45	19,598	2.56	0.50	40.4	20.3	19,323	10.57	2.04	37.0	75.6	2.5	96
46	19,573	2.56	0.50	39.4	19.7	19,283	10.57	2.04	36.1	73.6	2.5	93
47	19,546	2.56	0.50	38.5	19.3	19,241	10.57	2.03	35.1	71.4	2.5	91
48	19,517	2.56	0.50	37.5	18.7	19,195	10.57	2.03	34.2	69.4	2.5	88
49	19,485	2.56	0.50	36.6	18.3	19,145	10.57	2.02	33.3	67.4	2.5	86
50	19,451	2.56	0.50	35.6	17.7	19,091	10.57	2.02	32.4	65.4	2.5	83
51	19,414	2.56	0.50	34.7	17.2	19,034	10.57	2.01	31.5	63.4	2.5	81
52	19,375	2.56	0.50	33.8	16.8	18,971	10.57	2.01	30.6	61.4	2.5	78
53	19,331	2.56	0.49	32.8	16.2	18,903	10.57	2.00	29.7	59.4	2.5	76
54	19,285	2.56	0.49	31.9	15.7	18,830	10.57	1.99	28.8	57.3	2.5	73
55	19,234	2.56	0.49	31.0	15.3	18,750	10.57	1.98	27.9	55.3	2.5	71
56	19,178	2.56	0.49	30.1	14.8	18,664	10.57	1.97	27.0	53.3	2.5	68
57	19,118	2.56	0.49	29.2	14.3	18,570	10.57	1.96	26.2	51.4	2.5	66
58	19,053	2.56	0.49	28.3	13.8	18,469	10.57	1.95	25.3	49.4	2.4	63
59	18,981	2.56	0.49	27.4	13.3	18,358	10.57	1.94	24.4	47.4	2.4	61
Total to Age 59	**824,375**	**2.43**	**20**	**46.2**	**927**	**814,483**	**8.47**	**69**	**41.0**	**2,831**	**89**	**3,757**
60	18,904	0.47	0.09	26.5	2.4	18,239	3.20	0.58	23.6	13.8	0.7	16
61	18,819	0.47	0.09	25.6	2.3	18,109	3.20	0.58	22.7	13.1	0.7	15
62	18,726	0.47	0.09	24.7	2.2	17,967	3.20	0.57	21.9	12.6	0.7	15
63	18,625	0.47	0.09	23.8	2.1	17,813	3.20	0.57	21.1	12.0	0.7	14
64	18,514	0.47	0.09	22.9	2.0	17,646	3.20	0.56	20.3	11.4	0.7	13
65	18,392	0.47	0.09	22.1	1.9	17,464	3.20	0.56	19.5	10.9	0.6	13
66	18,259	0.47	0.09	21.2	1.8	17,267	3.20	0.55	18.7	10.3	0.6	12
67	18,113	0.47	0.09	20.4	1.7	17,052	3.20	0.54	17.9	9.8	0.6	11
68	17,954	0.47	0.08	19.6	1.7	16,819	3.20	0.54	17.1	9.2	0.6	11
69	17,778	0.47	0.08	18.7	1.6	16,565	3.20	0.53	16.4	8.7	0.6	10
Total to Age 69	**1,008,459**	**2.08**	**21**	**45.2**	**946**	**989,425**	**7.54**	**75**	**39.4**	**2,942**	**96**	**3,889**
70	17,586	0.47	0.08	17.9	1.5	16,290	3.20	0.52	15.6	8.1	0.6	10
71	17,375	0.47	0.08	17.1	1.4	15,992	3.20	0.51	14.9	7.6	0.6	9
72	17,144	0.47	0.08	16.3	1.3	15,668	3.20	0.50	14.2	7.1	0.6	8
73	16,890	0.47	0.08	15.6	1.2	15,318	3.20	0.49	13.5	6.6	0.6	8
74	16,612	0.47	0.08	14.8	1.2	14,939	3.20	0.48	12.8	6.1	0.6	7
75	16,307	0.47	0.08	14.1	1.1	14,530	3.20	0.46	12.1	5.6	0.5	7
76	15,973	0.47	0.08	13.3	1.0	14,090	3.20	0.45	11.5	5.2	0.5	6
77	15,608	0.47	0.07	12.6	0.9	13,616	3.20	0.44	10.8	4.7	0.5	6
78	15,209	0.47	0.07	11.9	0.9	13,107	3.20	0.42	10.2	4.3	0.5	5
79	14,774	0.47	0.07	11.2	0.8	12,564	3.20	0.40	9.6	3.9	0.5	5
Total to Age 79	***1,171,939***	***1.55***	***22***	***44.1***	***958***	***1,135,540***	***5.31***	***79***	***37.9***	***3,002***	***101***	***3,959***

Annual Visits to a General Practitioner

- 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[1150] 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.

[1150] 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%."[1151] 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%.[1152] 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%.[1153] 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

[1151] 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.
[1152] 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.
[1153] 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…"[1154]

- 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.[1155,1156] Specific screening tests may be considered when screening for unhealthy drug use during pregnancy.[1157]

Screening Frequency / Outcomes

- "There is little evidence about … the optimal interval for screening in adults older than 18 years."[1158]
- 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%).[1159]
- 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.[1160] 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.[1161]

[1154] 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.

[1155] 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.

[1156] 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.

[1157] Chang G. Maternal substance use: Consequences, identification, and interventions. *Alcohol Research*. 2020; 40(2):

[1158] US Preventive Services Task Force. Screening for Unhealthy Drug Use: US Preventive Services Task Force Recommendation Statement. *JAMA*. 2020: 323(22); 2301-9.

[1159] 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.

[1160] 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).

[1161] 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[1162] and those identified by Hargraves et al.[1163] 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.[1164] We use the emergency department number of 65.5%[1165] 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.[1166]

- "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."[1167]

- "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."[1168]

- For example, in the study by Bernstein et al[1169] a trained peer interventionist initiated a motivational interview which involved the following steps: establishing rapport,

[1162] 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.
[1163] 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).
[1164] Ibid.
[1165] 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.
[1166] 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.
[1167] US Preventive Services Task Force. Screening for Unhealthy Drug Use: US Preventive Services Task Force Recommendation Statement. *JAMA*. 2020: 323(22); 2301-2309.
[1168] Ibid.
[1169] 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[1170] 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[1171] 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).[1172]
- 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

[1170] 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.
[1171] 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.
[1172] 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.[1173]

- 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 (114 QALYs) and males (213 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.

[1173] 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%	718	54.3%	390	90.4%	353	80.0%	282	33.1%	93	6.0%	5.6	1.601	0.019	1.62
19	19,884	1,105	65.0%	718	54.3%	390	90.4%	353	80.0%	282	33.1%	93	6.0%	5.6	1.601	0.160	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	0.160	3.94
21	19,871	2,568	66.0%	1,694	54.3%	920	90.4%	832	80.0%	665	33.1%	220	6.0%	13.2	3.777	0.158	3.93
22	19,865	2,566	66.0%	1,693	54.3%	920	90.4%	831	80.0%	665	33.1%	220	6.0%	13.2	3.775	0.155	3.93
23	19,858	2,565	66.0%	1,692	54.3%	919	90.4%	831	80.0%	665	33.1%	220	6.0%	13.2	3.772	0.153	3.92
24	19,852	2,563	66.0%	1,691	54.3%	918	90.4%	830	80.0%	664	33.1%	220	6.0%	13.2	3.770	0.150	3.92
25	19,845	2,562	79.5%	2,036	54.3%	1,106	90.4%	999	80.0%	800	33.1%	265	6.0%	15.9	4.538	0.178	4.72
26	19,839	2,560	79.5%	2,035	54.3%	1,105	90.4%	999	80.0%	799	33.1%	265	6.0%	15.9	4.536	0.175	4.71
27	19,833	2,559	79.5%	2,034	54.3%	1,104	90.4%	998	80.0%	799	33.1%	264	6.0%	15.9	4.533	0.172	4.71
28	19,826	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	0.169	4.70
29	19,819	2,556	79.5%	2,032	54.3%	1,103	90.4%	997	80.0%	798	33.1%	264	6.0%	15.8	4.529	0.166	4.69
30	19,812	1,729	81.7%	1,412	54.3%	767	90.4%	693	80.0%	555	33.1%	184	6.0%	11.0	3.065	0.168	3.23
31	19,804	1,728	81.7%	1,411	54.3%	766	90.4%	693	80.0%	554	33.1%	183	6.0%	11.0	3.063	0.165	3.23
32	19,795	1,726	81.7%	1,410	54.3%	766	90.4%	692	80.0%	554	33.1%	183	6.0%	11.0	3.061	0.161	3.22
33	19,786	1,725	81.7%	1,410	54.3%	765	90.4%	692	80.0%	554	33.1%	183	6.0%	11.0	3.059	0.158	3.22
34	19,776	1,724	81.7%	1,409	54.3%	765	90.4%	691	80.0%	553	33.1%	183	6.0%	11.0	3.057	0.156	3.21
35	19,765	1,723	79.8%	1,375	54.3%	747	90.4%	675	80.0%	540	33.1%	179	6.0%	10.7	2.985	0.149	3.13
36	19,754	1,721	79.8%	1,374	54.3%	746	90.4%	675	80.0%	540	33.1%	179	6.0%	10.7	2.983	0.146	3.13
37	19,741	1,720	79.8%	1,373	54.3%	746	90.4%	674	80.0%	539	33.1%	178	6.0%	10.7	2.980	0.143	3.12
38	19,728	1,718	79.8%	1,372	54.3%	745	90.4%	673	80.0%	539	33.1%	178	6.0%	10.7	2.977	0.140	3.12
39	19,713	1,716	79.8%	1,370	54.3%	744	90.4%	673	80.0%	538	33.1%	178	6.0%	10.7	2.974	0.137	3.11
40	19,697	863	76.4%	659	54.3%	358	90.4%	323	80.0%	259	33.1%	86	6.0%	5.1	1.372	0.135	1.51
41	19,680	862	76.4%	658	54.3%	357	90.4%	323	80.0%	258	33.1%	86	6.0%	5.1	1.370	0.133	1.50
42	19,662	861	76.4%	657	54.3%	357	90.4%	323	80.0%	258	33.1%	85	6.0%	5.1	1.369	0.129	1.50
43	19,642	860	76.4%	656	54.3%	356	90.4%	322	80.0%	258	33.1%	85	6.0%	5.1	1.367	0.127	1.49
44	19,621	858	76.4%	655	54.3%	356	90.4%	322	80.0%	257	33.1%	85	6.0%	5.1	1.365	0.124	1.49
45	19,598	857	78.3%	671	54.3%	364	90.4%	329	80.0%	263	33.1%	87	6.0%	5.2	1.397	0.124	1.52
46	19,573	856	78.3%	670	54.3%	364	90.4%	329	80.0%	263	33.1%	87	6.0%	5.2	1.394	0.121	1.51
47	19,546	854	78.3%	668	54.3%	363	90.4%	328	80.0%	262	33.1%	87	6.0%	5.2	1.392	0.118	1.51
48	19,517	852	78.3%	667	54.3%	362	90.4%	327	80.0%	262	33.1%	87	6.0%	5.2	1.389	0.114	1.50
49	19,485	851	78.3%	666	54.3%	361	90.4%	327	80.0%	261	33.1%	87	6.0%	5.2	1.386	0.111	1.50
50	19,451	774	81.5%	631	54.3%	343	90.4%	310	80.0%	248	33.1%	82	6.0%	4.9	1.262	0.113	1.37
51	19,414	772	81.5%	630	54.3%	342	90.4%	309	80.0%	247	33.1%	82	6.0%	4.9	1.259	0.110	1.37
52	19,375	770	81.5%	628	54.3%	341	90.4%	308	80.0%	247	33.1%	82	6.0%	4.9	1.255	0.107	1.36
53	19,331	768	81.5%	626	54.3%	340	90.4%	307	80.0%	246	33.1%	81	6.0%	4.9	1.252	0.103	1.36
54	19,285	766	81.5%	624	54.3%	339	90.4%	306	80.0%	245	33.1%	81	6.0%	4.9	1.248	0.100	1.35
55	19,234	763	82.0%	625	54.3%	340	90.4%	307	80.0%	246	33.1%	81	6.0%	4.9	1.251	0.098	1.35
56	19,178	760	82.0%	623	54.3%	338	90.4%	306	80.0%	245	33.1%	81	6.0%	4.9	1.246	0.094	1.34
57	19,118	757	82.0%	621	54.3%	337	90.4%	305	80.0%	244	33.1%	81	6.0%	4.8	1.241	0.091	1.33
58	19,053	754	82.0%	618	54.3%	335	90.4%	303	80.0%	243	33.1%	80	6.0%	4.8	1.235	0.088	1.32
59	18,981	750	82.0%	615	54.3%	334	90.4%	302	80.0%	241	33.1%	80	6.0%	4.8	1.229	0.085	1.31
Total to Age 59	**824,375**	**61,275**	**76.5%**	**46,857**	**54.3%**	**25,444**		**23,001**		**18,401**	**33.1%**	**6,091**	**6.0%**	**365**	***101.2***	***5.6***	***106.8***
60	18,904	419	80.9%	339	54.3%	184	90.4%	166	80.0%	133	33.1%	44	6.0%	2.6	0.660	0.015	0.68
61	18,819	417	80.9%	337	54.3%	183	90.4%	165	80.0%	132	33.1%	44	6.0%	2.6	0.657	0.014	0.67
62	18,726	414	80.9%	335	54.3%	182	90.4%	164	80.0%	132	33.1%	44	6.0%	2.6	0.652	0.014	0.67
63	18,625	411	80.9%	333	54.3%	181	90.4%	163	80.0%	131	33.1%	43	6.0%	2.6	0.648	0.013	0.66
64	18,514	408	80.9%	330	54.3%	179	90.4%	162	80.0%	130	33.1%	43	6.0%	2.6	0.643	0.013	0.66
65	18,392	405	86.7%	351	54.3%	191	90.4%	172	80.0%	138	33.1%	46	6.0%	2.7	0.684	0.013	0.70
66	18,259	401	86.7%	348	54.3%	189	90.4%	171	80.0%	137	33.1%	45	6.0%	2.7	0.677	0.012	0.69
67	18,113	397	86.7%	344	54.3%	187	90.4%	169	80.0%	135	33.1%	45	6.0%	2.7	0.671	0.012	0.68
68	17,954	392	86.7%	340	54.3%	185	90.4%	167	80.0%	134	33.1%	44	6.0%	2.7	0.663	0.011	0.67
69	17,778	388	86.7%	336	54.3%	183	90.4%	165	80.0%	132	33.1%	44	6.0%	2.6	0.655	0.011	0.67
Total to Age 69	**1,008,459**	**65,326**	**76.9%**	**50,250**	**54.3%**	**27,286**		**24,666**		**19,733**	**33.1%**	**6,532**	**6.0%**	**392**	***107.8***	***5.7***	***113.5***
70	17,586	93	84.8%	79	54.3%	43	90.4%	39	80.0%	31	33.1%	10	6.0%	0.6	0.146	0.010	0.16
71	17,375	92	84.8%	78	54.3%	42	90.4%	38	80.0%	31	33.1%	10	6.0%	0.6	0.144	0.009	0.15
72	17,144	90	84.8%	77	54.3%	42	90.4%	38	80.0%	30	33.1%	10	6.0%	0.6	0.141	0.009	0.15
73	16,890	89	84.8%	75	54.3%	41	90.4%	37	80.0%	30	33.1%	10	6.0%	0.6	0.139	0.008	0.15
74	16,612	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	16,307	85	85.8%	73	54.3%	40	90.4%	36	80.0%	29	33.1%	9	6.0%	0.6	0.134	0.007	0.14
76	15,973	83	85.8%	71	54.3%	39	90.4%	35	80.0%	28	33.1%	9	6.0%	0.6	0.131	0.007	0.14
77	15,608	80	85.8%	69	54.3%	37	90.4%	34	80.0%	27	33.1%	9	6.0%	0.5	0.127	0.006	0.13
78	15,209	78	85.8%	67	54.3%	36	90.4%	33	80.0%	26	33.1%	9	6.0%	0.5	0.123	0.006	0.13
79	14,774	75	85.8%	65	54.3%	35	90.4%	32	80.0%	25	33.1%	8	6.0%	0.5	0.119	0.005	0.12
Total to Age 79	**1,171,939**	**66,178**	***77.0%***	**50,977**	***54.3%***	**27,680**		**25,023**		**20,018**	**33.1%**	**6,626**	***6.0%***	**398**	***109.2***	***5.8***	***114.9***

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	19,867	2,521	53.0%	1,337	54.3%	726	90.4%	656	80.0%	525	33.1%	174	6.0%	10	3.207	0.013	3.22
19	19,856	2,520	53.0%	1,336	54.3%	725	90.4%	656	80.0%	525	33.1%	174	6.0%	10	3.206	0.351	3.56
20	19,844	5,861	45.8%	2,682	54.3%	1,456	90.4%	1,316	80.0%	1,053	33.1%	349	6.0%	21	6.436	0.299	6.73
21	19,829	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	0.293	6.73
22	19,813	5,854	45.8%	2,679	54.3%	1,455	90.4%	1,315	80.0%	1,052	33.1%	348	6.0%	21	6.428	0.289	6.72
23	19,796	5,851	45.8%	2,677	54.3%	1,454	90.4%	1,314	80.0%	1,051	33.1%	348	6.0%	21	6.425	0.284	6.71
24	19,780	5,847	45.8%	2,676	54.3%	1,453	90.4%	1,313	80.0%	1,051	33.1%	348	6.0%	21	6.421	0.279	6.70
25	19,764	5,844	52.4%	3,061	54.3%	1,662	90.4%	1,502	80.0%	1,202	33.1%	398	6.0%	24	7.344	0.313	7.66
26	19,749	5,841	52.4%	3,059	54.3%	1,661	90.4%	1,502	80.0%	1,201	33.1%	398	6.0%	24	7.340	0.308	7.65
27	19,734	5,838	52.4%	3,057	54.3%	1,660	90.4%	1,501	80.0%	1,201	33.1%	397	6.0%	24	7.336	0.302	7.64
28	19,720	5,835	52.4%	3,056	54.3%	1,659	90.4%	1,500	80.0%	1,200	33.1%	397	6.0%	24	7.332	0.297	7.63
29	19,705	5,832	52.4%	3,054	54.3%	1,658	90.4%	1,499	80.0%	1,199	33.1%	397	6.0%	24	7.329	0.291	7.62
30	19,690	3,943	51.7%	2,037	54.3%	1,106	90.4%	1,000	80.0%	800	33.1%	265	6.0%	16	4.760	0.282	5.04
31	19,675	3,941	51.7%	2,036	54.3%	1,105	90.4%	999	80.0%	799	33.1%	265	6.0%	16	4.757	0.276	5.03
32	19,658	3,938	51.7%	2,034	54.3%	1,105	90.4%	999	80.0%	799	33.1%	264	6.0%	16	4.754	0.271	5.02
33	19,640	3,936	51.7%	2,033	54.3%	1,104	90.4%	998	80.0%	798	33.1%	264	6.0%	16	4.751	0.265	5.02
34	19,622	3,933	51.7%	2,032	54.3%	1,103	90.4%	997	80.0%	798	33.1%	264	6.0%	16	4.747	0.260	5.01
35	19,602	3,930	63.1%	2,481	54.3%	1,347	90.4%	1,218	80.0%	974	33.1%	323	6.0%	19	5.798	0.311	6.11
36	19,582	3,927	63.1%	2,479	54.3%	1,346	90.4%	1,217	80.0%	974	33.1%	322	6.0%	19	5.793	0.304	6.10
37	19,560	3,923	63.1%	2,477	54.3%	1,345	90.4%	1,216	80.0%	973	33.1%	322	6.0%	19	5.788	0.297	6.09
38	19,536	3,920	63.1%	2,475	54.3%	1,344	90.4%	1,215	80.0%	972	33.1%	322	6.0%	19	5.783	0.291	6.07
39	19,511	3,916	63.1%	2,472	54.3%	1,342	90.4%	1,214	80.0%	971	33.1%	321	6.0%	19	5.777	0.284	6.06
40	19,485	1,968	62.8%	1,235	54.3%	671	90.4%	606	80.0%	485	33.1%	161	6.0%	10	2.770	0.421	3.19
41	19,457	1,966	62.8%	1,234	54.3%	670	90.4%	606	80.0%	485	33.1%	160	6.0%	10	2.766	0.410	3.18
42	19,427	1,963	62.8%	1,232	54.3%	669	90.4%	605	80.0%	484	33.1%	160	6.0%	10	2.763	0.400	3.16
43	19,395	1,961	62.8%	1,231	54.3%	668	90.4%	604	80.0%	483	33.1%	160	6.0%	10	2.759	0.391	3.15
44	19,360	1,958	62.8%	1,229	54.3%	667	90.4%	603	80.0%	483	33.1%	160	6.0%	10	2.755	0.380	3.14
45	19,323	1,955	68.5%	1,338	54.3%	727	90.4%	657	80.0%	526	33.1%	174	6.0%	10	3.001	0.404	3.40
46	19,283	1,952	68.5%	1,336	54.3%	726	90.4%	656	80.0%	525	33.1%	174	6.0%	10	2.996	0.393	3.39
47	19,241	1,948	68.5%	1,334	54.3%	724	90.4%	655	80.0%	524	33.1%	173	6.0%	10	2.991	0.381	3.37
48	19,195	1,944	68.5%	1,331	54.3%	723	90.4%	653	80.0%	523	33.1%	173	6.0%	10	2.985	0.371	3.36
49	19,145	1,940	68.5%	1,328	54.3%	721	90.4%	652	80.0%	522	33.1%	173	6.0%	10	2.979	0.360	3.34
50	19,091	1,767	65.6%	1,159	54.3%	629	90.4%	569	80.0%	455	33.1%	151	6.0%	9	2.496	0.335	2.83
51	19,034	1,762	65.6%	1,156	54.3%	628	90.4%	568	80.0%	454	33.1%	150	6.0%	9	2.489	0.324	2.81
52	18,971	1,757	65.6%	1,153	54.3%	626	90.4%	566	80.0%	453	33.1%	150	6.0%	9	2.483	0.314	2.80
53	18,903	1,752	65.6%	1,150	54.3%	624	90.4%	564	80.0%	452	33.1%	149	6.0%	9	2.476	0.304	2.78
54	18,830	1,747	65.6%	1,146	54.3%	622	90.4%	563	80.0%	450	33.1%	149	6.0%	9	2.468	0.293	2.76
55	18,750	1,741	72.8%	1,268	54.3%	689	90.4%	622	80.0%	498	33.1%	165	6.0%	10	2.730	0.314	3.04
56	18,664	1,734	72.8%	1,263	54.3%	686	90.4%	620	80.0%	496	33.1%	164	6.0%	10	2.720	0.303	3.02
57	18,570	1,727	72.8%	1,258	54.3%	683	90.4%	618	80.0%	494	33.1%	164	6.0%	10	2.709	0.292	3.00
58	18,469	1,720	72.8%	1,253	54.3%	680	90.4%	615	80.0%	492	33.1%	163	6.0%	10	2.697	0.281	2.98
59	18,358	1,711	72.8%	1,247	54.3%	677	90.4%	612	80.0%	490	33.1%	162	6.0%	10	2.684	0.269	2.95
Total to Age 59	**814,483**	**139,781**	**56.4%**	**78,794**	**54.3%**	**42,785**		**38,678**		**30,942**	**33.1%**	**10,242**	**6.0%**	**615**	***182.7***	***13.1***	***195.8***
60	18,239	956	82.5%	789	54.3%	428	90.4%	387	80.0%	310	33.1%	103	6.0%	6	1.654	0.088	1.74
61	18,109	951	82.5%	784	54.3%	426	90.4%	385	80.0%	308	33.1%	102	6.0%	6	1.645	0.085	1.73
62	17,967	945	82.5%	779	54.3%	423	90.4%	382	80.0%	306	33.1%	101	6.0%	6	1.634	0.081	1.72
63	17,813	938	82.5%	774	54.3%	420	90.4%	380	80.0%	304	33.1%	101	6.0%	6	1.623	0.077	1.70
64	17,646	931	82.5%	768	54.3%	417	90.4%	377	80.0%	301	33.1%	100	6.0%	6	1.610	0.074	1.68
65	17,464	923	84.7%	782	54.3%	424	90.4%	384	80.0%	307	33.1%	102	6.0%	6	1.639	0.072	1.71
66	17,267	914	84.7%	774	54.3%	420	90.4%	380	80.0%	304	33.1%	101	6.0%	6	1.624	0.068	1.69
67	17,052	905	84.7%	766	54.3%	416	90.4%	376	80.0%	301	33.1%	100	6.0%	6	1.608	0.064	1.67
68	16,819	895	84.7%	758	54.3%	412	90.4%	372	80.0%	298	33.1%	99	6.0%	6	1.590	0.061	1.65
69	16,565	884	84.7%	749	54.3%	406	90.4%	367	80.0%	294	33.1%	97	6.0%	6	1.570	0.057	1.63
Total to Age 69	**989,425**	**149,023**	**58.1%**	**86,516**	**54.3%**	**46,978**		**42,468**		**33,975**	**33.1%**	**11,246**	**6.0%**	**675**	***198.9***	***13.8***	***212.7***
70	16,290	213	85.9%	183	54.3%	99	90.4%	90	80.0%	72	33.1%	24	6.0%	1	0.363	0.054	0.42
71	15,992	209	85.9%	180	54.3%	98	90.4%	88	80.0%	71	33.1%	23	6.0%	1	0.358	0.051	0.41
72	15,668	206	85.9%	177	54.3%	96	90.4%	87	80.0%	69	33.1%	23	6.0%	1	0.352	0.048	0.40
73	15,318	202	85.9%	174	54.3%	94	90.4%	85	80.0%	68	33.1%	23	6.0%	1	0.345	0.044	0.39
74	14,939	198	85.9%	170	54.3%	92	90.4%	84	80.0%	67	33.1%	22	6.0%	1	0.338	0.041	0.38
75	14,530	194	90.4%	175	54.3%	95	90.4%	86	80.0%	69	33.1%	23	6.0%	1	0.348	0.040	0.39
76	14,090	189	90.4%	171	54.3%	93	90.4%	84	80.0%	67	33.1%	22	6.0%	1	0.339	0.036	0.38
77	13,616	183	90.4%	166	54.3%	90	90.4%	81	80.0%	65	33.1%	22	6.0%	1	0.329	0.033	0.36
78	13,107	178	90.4%	161	54.3%	87	90.4%	79	80.0%	63	33.1%	21	6.0%	1	0.319	0.030	0.35
79	12,564	172	90.4%	155	54.3%	84	90.4%	76	80.0%	61	33.1%	20	6.0%	1	0.308	0.027	0.34
Total	**1,135,540**	**150,967**	***58.4%***	**88,226**	**54.3%**	**47,907**		**43,308**		**34,646**	**33.1%**	**11,468**	***6.0%***	**688**	***202.3***	***14.2***	***216.5***

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."[1174]
- Four studies of psychosocial interventions reported no adverse events, in either the experimental of control groups.[1175]

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 326 QALYs, 114 QALYs in females and 213 QALYs in males (Table 12, rows *w, x, y*). The CPB of 326 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	1,008,459	Table 3
c	Life years lived between the ages of 18 and 69 - Males	989,425	Table 3
d	Life years with unhealthy drug use (excluding cannabis) - Females	32,750	Table 3
e	Life years with cannabis use disorder - Females	32,576	Table 3
f	Life years with unhealthy drug use (excluding cannabis) - Males	89,154	Table 3
g	Life years with cannabis use disorder - Males	59,869	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	18,010	Table 5
k	QALYs lost with unhealthy drug use - Males	44,231	Table 5
l	Life years lost attributable to unhealthy drug use - Females	946	Table 8
m	Life years lost attributable to unhealthy drug use - Males	2,942	Table 8
n	Total QALYs lost - Females	18,956	= j + l
o	Total QALYs lost - Males	47,173	= k + m
p	***Total QALYs lost***	***66,129***	
	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	114	Table 10
x	QALYs gained - Males	213	Table 11
y	**Total QALYs gained (CPB)**	**326**	= w + x

√ = Estimates from the literature

[1174] US Preventive Services Task Force. Screening for Unhealthy Drug Use: US Preventive Services Task Force Recommendation Statement. *JAMA*. 2020: 323(22); 2301-2309.
[1175] 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 = 233
- 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 = 418
- Assume that the proportion of positively screened individuals receiving behavioural intervention increases from 33.1% to 65.5% (Table 12, row *u*): CPB = 646
- Assume that the drug use cessation rate resulting from behavioural intervention decreases from 6% to 2% (Table 12, row *v*): CPB = 109
- Assume that the drug use cessation rate resulting from behavioural intervention increases from 6% to 10% (Table 12, row *v*): CPB = 544
- Model from ages 18 through 79 (an additional 10 years modelled above the baseline age of 69 – Table 12, row *a*): CPB = 331
- Model from ages 18 through 59 (a reduction of 10 years modelled compared to baseline age of 69 – Table 12, row *a*): CPB = 303

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 114 QALYs. (Table 13, row *p*). The CPB of 114 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	1,008,459	Table 3
c	Life years with unhealthy drug use (excluding cannabis) - Females	32,750	Table 3
d	Life years with cannabis use disorder - Females	32,576	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	18,010	Table 5
h	Life years lost attributable to unhealthy drug use - Females	946	Table 8
i	Total QALYs lost - Females	18,956	= 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	114	Table 10
q	**Total QALYs gained (CPB)**	**114**	= 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 = 81
- 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 = 225
- 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 = 107

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 213 QALYs. (Table 14, row *p*). The CPB of 213 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	989,425	Table 3
c	Life years with unhealthy drug use (excluding cannabis) - Males	89,154	Table 3
d	Life years with cannabis use disorder - Males	59,869	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	44,231	Table 5
h	Life years lost attributable to unhealthy drug use - Males	2,942	Table 8
i	Total QALYs lost - Males	47,173	= 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	213	Table 11
q	**Total QALYs gained (CPB)**	**213**	= 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 = 272

- Assume that the proportion of positively screened individuals receiving behavioural intervention increases from 33.1% to 65.5% (Table 14, row *n*): CPB = 421
- 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 = 354
- 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 = 196

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 40,000 430,512 basic screens would be completed in females and 343,933 in males followed by 24,666 detailed screens in females and 42,468 in males. The detailed screening would result in 20,948 positive (both true- and false-positive) screens in females and 36,066 in males. The positive screens would be followed by 7,798 brief interventions in females and 11,938 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 # (General)	True Positive Basic Screens # (Table 10)	Pos. Pred. Value Basic Screen %	Total Positive Basic Screens #	True Positive Detailed Screens # (Table 10)	Detailed Screen PPV %	Total Detailed Positive Screens #	Total Accepting BI %	Total Accepting BI #
18	19,891	65.0%	12,930	54%	7,021	353	55%	640	282	94%	299	33%	99
19	19,884	65.0%	12,926	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%	1,510	665	94%	706	33%	234
22	19,865	66.0%	13,109	54%	7,118	831	55%	1,509	665	94%	706	33%	234
23	19,858	66.0%	13,104	54%	7,116	831	55%	1,508	665	94%	706	33%	234
24	19,852	66.0%	13,100	54%	7,113	830	55%	1,507	664	94%	705	33%	233
25	19,845	79.5%	15,773	54%	8,565	999	55%	1,814	800	94%	849	33%	281
26	19,839	79.5%	15,768	54%	8,562	999	55%	1,813	799	94%	848	33%	281
27	19,833	79.5%	15,763	54%	8,559	998	55%	1,812	799	94%	848	33%	281
28	19,826	79.5%	15,757	54%	8,556	998	55%	1,811	798	94%	847	33%	281
29	19,819	79.5%	15,752	54%	8,553	997	55%	1,810	798	94%	847	33%	280
30	19,812	81.7%	16,186	54%	8,789	693	55%	1,258	555	94%	589	33%	195
31	19,804	81.7%	16,179	54%	8,785	693	55%	1,257	554	94%	588	33%	195
32	19,795	81.7%	16,172	54%	8,781	692	55%	1,257	554	94%	588	33%	195
33	19,786	81.7%	16,164	54%	8,777	692	55%	1,256	554	94%	588	33%	194
34	19,776	81.7%	16,156	54%	8,773	691	55%	1,255	553	94%	587	33%	194
35	19,765	79.8%	15,780	54%	8,568	675	55%	1,225	540	94%	573	33%	190
36	19,754	79.8%	15,770	54%	8,563	675	55%	1,224	540	94%	573	33%	190
37	19,741	79.8%	15,761	54%	8,558	674	55%	1,223	539	94%	572	33%	189
38	19,728	79.8%	15,750	54%	8,552	673	55%	1,222	539	94%	572	33%	189
39	19,713	79.8%	15,738	54%	8,546	673	55%	1,221	538	94%	571	33%	189
40	19,697	76.4%	15,040	54%	8,167	323	55%	587	259	94%	275	33%	91
41	19,680	76.4%	15,027	54%	8,160	323	55%	586	258	94%	274	33%	91
42	19,662	76.4%	15,013	54%	8,152	323	55%	585	258	94%	274	33%	91
43	19,642	76.4%	14,998	54%	8,144	322	55%	585	258	94%	274	33%	91
44	19,621	76.4%	14,982	54%	8,135	322	55%	584	257	94%	273	33%	90
45	19,598	78.3%	15,338	54%	8,329	329	55%	597	263	94%	280	33%	93
46	19,573	78.3%	15,319	54%	8,318	329	55%	597	263	94%	279	33%	92
47	19,546	78.3%	15,297	54%	8,306	328	55%	595	262	94%	279	33%	92
48	19,517	78.3%	15,275	54%	8,294	327	55%	594	262	94%	278	33%	92
49	19,485	78.3%	15,250	54%	8,281	327	55%	593	261	94%	278	33%	92
50	19,451	81.5%	15,851	54%	8,607	310	55%	562	248	94%	263	33%	87
51	19,414	81.5%	15,822	54%	8,591	309	55%	561	247	94%	262	33%	87
52	19,375	81.5%	15,789	54%	8,573	308	55%	559	247	94%	262	33%	87
53	19,331	81.5%	15,754	54%	8,554	307	55%	558	246	94%	261	33%	86
54	19,285	81.5%	15,716	54%	8,534	306	55%	556	245	94%	260	33%	86
55	19,234	82.0%	15,763	54%	8,559	307	55%	557	246	94%	261	33%	86
56	19,178	82.0%	15,718	54%	8,535	306	55%	555	245	94%	260	33%	86
57	19,118	82.0%	15,668	54%	8,508	305	55%	553	244	94%	259	33%	86
58	19,053	82.0%	15,615	54%	8,479	303	55%	550	243	94%	258	33%	85
59	18,981	82.0%	15,556	54%	8,447	302	55%	548	241	94%	256	33%	85
Total to Age 59	**824,375**		**638,658**		**346,791**	**23,001**		**41,744**	**18,401**		**19,534**		**6,466**
60	18,904	80.9%	15,289	54%	8,302	166	55%	302	133	94%	141	94%	133
61	18,819	80.9%	15,220	54%	8,265	165	55%	300	132	94%	140	94%	132
62	18,726	80.9%	15,145	54%	8,224	164	55%	298	132	94%	140	94%	132
63	18,625	80.9%	15,063	54%	8,179	163	55%	296	131	94%	139	94%	131
64	18,514	80.9%	14,973	54%	8,131	162	55%	294	130	94%	138	94%	130
65	18,392	86.7%	15,952	54%	8,662	172	55%	313	138	94%	146	94%	138
66	18,259	86.7%	15,837	54%	8,599	171	55%	310	137	94%	145	94%	137
67	18,113	86.7%	15,710	54%	8,531	169	55%	307	135	94%	143	94%	135
68	17,954	86.7%	15,572	54%	8,455	167	55%	303	134	94%	142	94%	134
69	17,778	86.7%	15,420	54%	8,373	165	55%	299	132	94%	140	94%	132
Total to Age 69	**1,008,459**		**792,840**		**430,512**	**24,666**		**44,766**	**19,733**		**20,948**		**7,798**
70	17,586	84.8%	14,911	54%	8,097	39	55%	70	31	94%	33	94%	31
71	17,375	84.8%	14,733	54%	8,000	38	55%	69	31	94%	32	94%	31
72	17,144	84.8%	14,536	54%	7,893	38	55%	68	30	94%	32	94%	30
73	16,890	84.8%	14,321	54%	7,776	37	55%	67	30	94%	31	94%	30
74	16,612	84.8%	14,085	54%	7,648	36	55%	66	29	94%	31	94%	29
75	16,307	85.8%	13,997	54%	7,601	36	55%	65	29	94%	30	94%	29
76	15,973	85.8%	13,711	54%	7,445	35	55%	63	28	94%	30	94%	28
77	15,608	85.8%	13,397	54%	7,275	34	55%	62	27	94%	29	94%	27
78	15,209	85.8%	13,055	54%	7,089	33	55%	60	26	94%	28	94%	26
79	14,774	85.8%	12,681	54%	6,886	32	55%	58	25	94%	27	94%	25
Total to Age 79	***1,171,939***		***932,268***		***506,221***	***25,023***		***45,414***	***20,018***		***21,251***		***8,083***

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 # (General)	True Positive Basic Screens # (Table 11)	Pos. Pred. Value Basic Screen %	Total Positive Basic Screens #	True Positive Detailed Screens # (Table 11)	Detailed Screen PPV %	Total Detailed Positive Screens #	Total Accepting BI %	Total Accepting BI #
18	19,867	53.0%	10,533	54%	5,719	656	55%	1,191	525	94%	557	33%	184
19	19,856	53.0%	10,527	54%	5,716	656	55%	1,190	525	94%	557	33%	184
20	19,844	45.8%	9,081	54%	4,931	1,316	55%	2,389	1,053	94%	1,118	33%	370
21	19,829	45.8%	9,074	54%	4,927	1,316	55%	2,388	1,053	94%	1,117	33%	370
22	19,813	45.8%	9,067	54%	4,923	1,315	55%	2,387	1,052	94%	1,117	33%	370
23	19,796	45.8%	9,059	54%	4,919	1,314	55%	2,385	1,051	94%	1,116	33%	369
24	19,780	45.8%	9,051	54%	4,915	1,313	55%	2,384	1,051	94%	1,115	33%	369
25	19,764	52.4%	10,351	54%	5,620	1,502	55%	2,727	1,202	94%	1,276	33%	422
26	19,749	52.4%	10,343	54%	5,616	1,502	55%	2,725	1,201	94%	1,275	33%	422
27	19,734	52.4%	10,335	54%	5,612	1,501	55%	2,724	1,201	94%	1,275	33%	422
28	19,720	52.4%	10,327	54%	5,608	1,500	55%	2,722	1,200	94%	1,274	33%	422
29	19,705	52.4%	10,320	54%	5,604	1,499	55%	2,721	1,199	94%	1,273	33%	421
30	19,690	51.7%	10,171	54%	5,523	1,000	55%	1,815	800	94%	849	33%	281
31	19,675	51.7%	10,163	54%	5,519	999	55%	1,814	799	94%	849	33%	281
32	19,658	51.7%	10,155	54%	5,514	999	55%	1,812	799	94%	848	33%	281
33	19,640	51.7%	10,146	54%	5,509	998	55%	1,811	798	94%	848	33%	281
34	19,622	51.7%	10,136	54%	5,504	997	55%	1,810	798	94%	847	33%	280
35	19,602	63.1%	12,377	54%	6,721	1,218	55%	2,211	974	94%	1,034	33%	342
36	19,582	63.1%	12,364	54%	6,714	1,217	55%	2,209	974	94%	1,034	33%	342
37	19,560	63.1%	12,350	54%	6,706	1,216	55%	2,207	973	94%	1,033	33%	342
38	19,536	63.1%	12,335	54%	6,698	1,215	55%	2,205	972	94%	1,032	33%	341
39	19,511	63.1%	12,319	54%	6,689	1,214	55%	2,203	971	94%	1,031	33%	341
40	19,485	62.8%	12,230	54%	6,641	606	55%	1,100	485	94%	515	33%	170
41	19,457	62.8%	12,213	54%	6,631	606	55%	1,099	485	94%	514	33%	170
42	19,427	62.8%	12,194	54%	6,621	605	55%	1,098	484	94%	514	33%	170
43	19,395	62.8%	12,173	54%	6,610	604	55%	1,096	483	94%	513	33%	170
44	19,360	62.8%	12,152	54%	6,598	603	55%	1,095	483	94%	512	33%	170
45	19,323	68.5%	13,230	54%	7,184	657	55%	1,192	526	94%	558	33%	185
46	19,283	68.5%	13,203	54%	7,169	656	55%	1,190	525	94%	557	33%	184
47	19,241	68.5%	13,174	54%	7,153	655	55%	1,188	524	94%	556	33%	184
48	19,195	68.5%	13,142	54%	7,136	653	55%	1,186	523	94%	555	33%	184
49	19,145	68.5%	13,108	54%	7,118	652	55%	1,184	522	94%	554	33%	183
50	19,091	65.6%	12,528	54%	6,803	569	55%	1,033	455	94%	483	33%	160
51	19,034	65.6%	12,490	54%	6,782	568	55%	1,030	454	94%	482	33%	160
52	18,971	65.6%	12,449	54%	6,760	566	55%	1,027	453	94%	481	33%	159
53	18,903	65.6%	12,405	54%	6,736	564	55%	1,024	452	94%	479	33%	159
54	18,830	65.6%	12,356	54%	6,710	563	55%	1,021	450	94%	478	33%	158
55	18,750	72.8%	13,658	54%	7,416	622	55%	1,130	498	94%	529	33%	175
56	18,664	72.8%	13,595	54%	7,382	620	55%	1,126	496	94%	527	33%	174
57	18,570	72.8%	13,527	54%	7,345	618	55%	1,121	494	94%	525	33%	174
58	18,469	72.8%	13,453	54%	7,305	615	55%	1,116	492	94%	522	33%	173
59	18,358	72.8%	13,373	54%	7,261	612	55%	1,111	490	94%	520	33%	172
Total to Age 59	**814,483**		**487,236**		**264,569**	**38,678**		**70,196**	**30,942**		**32,847**		**10,872**
60	18,239	82.5%	15,043	54%	8,169	387	55%	703	310	94%	329	33%	109
61	18,109	82.5%	14,936	54%	8,110	385	55%	698	308	94%	327	33%	108
62	17,967	82.5%	14,819	54%	8,047	382	55%	694	306	94%	325	33%	107
63	17,813	82.5%	14,693	54%	7,978	380	55%	689	304	94%	323	33%	107
64	17,646	82.5%	14,555	54%	7,903	377	55%	684	301	94%	320	33%	106
65	17,464	84.7%	14,787	54%	8,029	384	55%	696	307	94%	326	33%	108
66	17,267	84.7%	14,620	54%	7,939	380	55%	690	304	94%	323	33%	107
67	17,052	84.7%	14,438	54%	7,840	376	55%	683	301	94%	320	33%	106
68	16,819	84.7%	14,241	54%	7,733	372	55%	675	298	94%	316	33%	105
69	16,565	84.7%	14,026	54%	7,616	367	55%	667	294	94%	312	33%	103
Total to Age 69	**989,425**		**633,393**		**343,933**	**42,468**		**77,075**	**33,975**		**36,066**		**11,938**
70	16,290	85.9%	13,989	54%	7,596	90	55%	163	72	94%	76	33%	25
71	15,992	85.9%	13,733	54%	7,457	88	55%	160	71	94%	75	33%	25
72	15,668	85.9%	13,455	54%	7,306	87	55%	158	69	94%	74	33%	24
73	15,318	85.9%	13,154	54%	7,143	85	55%	155	68	94%	72	33%	24
74	14,939	85.9%	12,829	54%	6,966	84	55%	152	67	94%	71	33%	23
75	14,530	90.4%	13,129	54%	7,129	86	55%	156	69	94%	73	33%	24
76	14,090	90.4%	12,731	54%	6,913	84	55%	152	67	94%	71	33%	24
77	13,616	90.4%	12,303	54%	6,680	81	55%	148	65	94%	69	33%	23
78	13,107	90.4%	11,843	54%	6,431	79	55%	143	63	94%	67	33%	22
79	12,564	90.4%	11,352	54%	6,164	76	55%	138	61	94%	65	33%	21
Total	***1,135,540***		***761,912***		***413,718***	***43,308***		***78,598***	***34,646***		***36,779***		***12,174***

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.[1176]
- 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 ($98 [2017 CAD], ranging from $65 to $123). 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.[1177]
- 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).[1178]
- 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 $6.93 and $11.99 respectively in 2017 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."[1179]
- We use the time estimates by Cowell et al[1180] 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.

[1176] 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.
[1177] 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.
[1178] 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.
[1179] US Preventive Services Task Force. Screening for Unhealthy Drug Use: US Preventive Services Task Force Recommendation Statement. *JAMA*. 2020: 323(22); 2301- 09.
[1180] 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 $34.85 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 $3.485 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 2017 ($25.16[1181]) plus 18% benefits for an average cost per hour of $29.69. 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).[1182]
- 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 $1,142 million[1183] in 2017 C$).[1184] Of this total, €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 $2,281 and $2,686 million[1185] in 2017 C$).[1186] 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 $12,615[1187] in 2017 C$).[1188] Of the total, €4,860 (61% or $7,758 in 2017 C$)

1181 Statistics Canada. *Average Hourly Wages of Employees by Selected Characteristics and Occupation, Unadjusted Data, by Province (monthly) (British Columbia)*. 2017. Available at http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/labr69k-eng.htm. Accessed July 2017.

1182 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.

1183 CCEMG - EPPI-Centre Cost Converter. Available online at https://eppi.ioe.ac.uk/costconversion/default.aspx. Accessed November 2021.

1184 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.

1185 CCEMG - EPPI-Centre Cost Converter. Available online at https://eppi.ioe.ac.uk/costconversion/default.aspx. Accessed November 2021.

1186 Rivera B, Casal B, Currais L. The social cost of illicit drug use in Spain. *International Journal of Drug Policy*. 2017; 44: 92-104.

1187 CCEMG - EPPI-Centre Cost Converter. Available online at https://eppi.ioe.ac.uk/costconversion/default.aspx. Accessed November 2021.

1188 Kopp P & Ogrodnik M. The social cost of drugs in France in 2010. *The European Journal of Health Economics*. 2017; 18: 883-92.

was for excess healthcare costs and €3,043 (39% or $4,857 in 2017 C$) 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 healthcare costs, $718 million (43%) for criminal justice costs, $147 million (8.8%) for motor vehicle damage and $580 million (35%) for indirect costs.[1189]
- 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.[1190] 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 ($3,094 in 2017 C$[1191]). This $3,094 annual excess cost consists of $643 (21%) for healthcare costs, $2,035 (66%) for criminal justice costs and $417 (13%) for motor vehicle damage costs.
- For modelling purposes, we assume that a year without unhealthy drug use is associated with $7,855 (($3,094 + $12,615)/2) in direct costs avoided, including healthcare and criminal justice costs. We modify this to $3,094 and $12,615 in the sensitivity analysis.[1192]
- 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.[1193,1194]
- 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).[1195] When adverse birth outcomes are observed, questions arise as to whether

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[1189] 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.
[1190] 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.
[1191] CCEMG - EPPI-Centre Cost Converter. Available online at https://eppi.ioe.ac.uk/costconversion/default.aspx. Accessed November 2021.
[1192] Kopp P & Ogrodnik M. The social cost of drugs in France in 2010. *The European Journal of Health Economics*. 2017; 18: 883-92.
[1193] 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.
[1194] 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.
[1195] Dr. Nancy Poole. Director, BC Centre of Excellence for Women's Health and Prevention Lead, CanFASD Research Network. Personal communication. January 2022.

these outcomes result from the substances used or from the context within which the pregnancy occurs and the child is raised.[1196,1197]

- 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.

[1196] 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.
[1197] Louw K. Substance use in pregnancy: The medical challenge. *Obstetric Medicine*. 2018; 11(2): 54 - 66.

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	$7,855	$44,012	10.4	$7,855	$81,882
19	5.6	$7,855	$43,994	10.4	$7,855	$81,847
20	13.2	$7,855	$103,857	20.9	$7,855	$164,294
21	13.2	$7,855	$103,802	20.9	$7,855	$164,207
22	13.2	$7,855	$103,743	20.9	$7,855	$164,113
23	13.2	$7,855	$103,682	20.9	$7,855	$164,017
24	13.2	$7,855	$103,622	20.9	$7,855	$163,922
25	15.9	$7,855	$124,734	23.9	$7,855	$187,494
26	15.9	$7,855	$124,666	23.9	$7,855	$187,393
27	15.9	$7,855	$124,600	23.8	$7,855	$187,293
28	15.9	$7,855	$124,533	23.8	$7,855	$187,193
29	15.8	$7,855	$124,466	23.8	$7,855	$187,092
30	11.0	$7,855	$86,515	15.9	$7,855	$124,789
31	11.0	$7,855	$86,463	15.9	$7,855	$124,714
32	11.0	$7,855	$86,407	15.9	$7,855	$124,634
33	11.0	$7,855	$86,349	15.9	$7,855	$124,550
34	11.0	$7,855	$86,287	15.8	$7,855	$124,460
35	10.7	$7,855	$84,256	19.4	$7,855	$152,009
36	10.7	$7,855	$84,187	19.3	$7,855	$151,885
37	10.7	$7,855	$84,113	19.3	$7,855	$151,752
38	10.7	$7,855	$84,034	19.3	$7,855	$151,609
39	10.7	$7,855	$83,950	19.3	$7,855	$151,458
40	5.1	$7,855	$40,354	9.6	$7,855	$75,674
41	5.1	$7,855	$40,308	9.6	$7,855	$75,587
42	5.1	$7,855	$40,258	9.6	$7,855	$75,494
43	5.1	$7,855	$40,205	9.6	$7,855	$75,393
44	5.1	$7,855	$40,147	9.6	$7,855	$75,285
45	5.2	$7,855	$41,087	10.4	$7,855	$81,996
46	5.2	$7,855	$41,019	10.4	$7,855	$81,860
47	5.2	$7,855	$40,945	10.4	$7,855	$81,713
48	5.2	$7,855	$40,865	10.4	$7,855	$81,554
49	5.2	$7,855	$40,780	10.4	$7,855	$81,384
50	4.9	$7,855	$38,659	9.0	$7,855	$71,014
51	4.9	$7,855	$38,565	9.0	$7,855	$70,840
52	4.9	$7,855	$38,462	9.0	$7,855	$70,651
53	4.9	$7,855	$38,351	9.0	$7,855	$70,446
54	4.9	$7,855	$38,230	8.9	$7,855	$70,225
55	4.9	$7,855	$38,315	9.9	$7,855	$77,687
56	4.9	$7,855	$38,172	9.9	$7,855	$77,397
57	4.8	$7,855	$38,017	9.8	$7,855	$77,083
58	4.8	$7,855	$37,848	9.8	$7,855	$76,741
59	4.8	$7,855	$37,665	9.7	$7,855	$76,369
Total to Age 59	**365**		**$2,870,522**	**615**		**$4,826,998**
60	2.6	$7,855	$20,766	6.2	$7,855	$48,310
61	2.6	$7,855	$20,646	6.1	$7,855	$48,031
62	2.6	$7,855	$20,515	6.1	$7,855	$47,726
63	2.6	$7,855	$20,372	6.0	$7,855	$47,394
64	2.6	$7,855	$20,216	6.0	$7,855	$47,032
65	2.7	$7,855	$21,498	6.1	$7,855	$47,875
66	2.7	$7,855	$21,300	6.0	$7,855	$47,434
67	2.7	$7,855	$21,084	6.0	$7,855	$46,953
68	2.7	$7,855	$20,849	5.9	$7,855	$46,428
69	2.6	$7,855	$20,591	5.8	$7,855	$45,856
Total to Age 69	**392**		**$3,078,360**	**675**		**$5,300,037**
70	0.6	$7,855	$4,843	1.4	$7,855	$11,189
71	0.6	$7,855	$4,770	1.4	$7,855	$11,021
72	0.6	$7,855	$4,691	1.4	$7,855	$10,838
73	0.6	$7,855	$4,604	1.4	$7,855	$10,638
74	0.6	$7,855	$4,511	1.3	$7,855	$10,421
75	0.6	$7,855	$4,463	1.4	$7,855	$10,717
76	0.6	$7,855	$4,351	1.3	$7,855	$10,448
77	0.5	$7,855	$4,229	1.3	$7,855	$10,156
78	0.5	$7,855	$4,098	1.3	$7,855	$9,841
79	0.5	$7,855	$3,956	1.2	$7,855	$9,501
Total to Age 79	***398***		***$3,122,876***	***688***		***$5,404,807***

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 $52,369 / 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	430,512	Table 15
c	Lifetime basic screens conducted, males	343,933	Table 16
d	Lifetime detailed screens conducted, females	24,666	Table 15
e	Lifetime detailed screens conducted, males	42,468	Table 16
f	Cost of 10-minute office visit	$34.85	Ref. Doc.
g	Cost per minute of GP time	$3.49	= f / 10
h	Patient time costs / hour	$29.69	Ref. Doc.
i	Lifetime basic screens only, females	405,846	= b - d
j	Lifetime basic screens only, males	301,464	= c - e
k	Total lifetime basic screens only	707,310	= 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	$11,645,565	= (k * l * g) + (k * m * h)
o	GP time for basic and detailed screen (in minutes)	15.28	√
p	Total lifetime detailed screens	67,134	= d + e
q	Patient time, detailed screen (in hours)	2	√
r	Total cost of basic and detailed screens	$7,562,187	= (p * o * g) + (p * q * h)
s	Total cost of screening, lifetime	$19,207,752	= n + r
	Cost of Brief Intervention		
t	Lifetime brief interventions, female	7,798	Table 15
u	Lifetime brief interventions, male	11,938	Table 16
v	Total lifetime brief interventions	19,736	= 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	$2,340,027	= (v * w * g) + (v * x * h)
	Costs Avoided due to Brief Intervention		
z	Annual Cost of Unhealthy Drug Use	$7,855	√
aa	Lifetime cost savings, female	$3,078,360	Table 17
ab	Lifetime cost savings, male	$5,300,037	Table 17
ac	Lifetime cost savings, total	$8,378,396	= aa + ab
	Net Cost of Screening and Brief Intervention		
ad	Net Cost of Screening and Brief Intervention	$13,169,382	= s + y - ac
ae	QALYs saved	326	Table 12
af	CE ($/QALY Saved)	$40,371	= ad / ae
ag	Net Cost of Screening and Brief Intervention, 1.5% Discount	$13,221,616	Calculated
ah	QALYs saved, 1.5% Discount	252	Calculated
ai	**CE ($/QALY Saved), 1.5% Discount**	**$52,369**	= 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 = $73,430
- 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 = $40,841
- 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 = $17,142
- Assume that the drug use cessation rate resulting from a brief behavioural intervention decreases from 6% to 2% (Table 12, row *v*): CE = $208,226
- Assume that the drug use cessation rate resulting from a brief behavioural intervention increases from 6% to 10% (Table 12, row *v*): CE = $21,197
- Assume that the annual costs avoided as a result of a 'successful' brief intervention decreases from $7,855 to $3,094 (Table 18, row *z*): CE = $67,861
- Assume that the annual costs avoided as a result of a 'successful' brief intervention increases from $7,855 to $12,615 (Table 18, row *z*): CE = $36,880
- Model from ages 18 through 79 (an additional 10 years modelled above the baseline age of 69 – Table 12, row *a*): CE = $56,327
- Model from ages 18 through 59 (a reduction of 10 years modelled compared to the baseline age of 69 – Table 12, row *a*): CE = $48,083
- Assume screening and intervention occur every three years rather than every year (Table 18, row *a*): CE = $24,249
- Assume screening and intervention occur every five years rather than every year (Table 18, row *a*): CE = $18,625

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 $74,465 / 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	430,512	Table 15
c	Lifetime in depth screens conducted, females	24,666	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	$29.69	Ref. Doc.
g	Lifetime basic screens only, females	405,846	= 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	$6,682,078	= (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	24,666	= c
m	Patient time, in depth screen (in hours)	2	√
n	Total cost of basic and in depth screens	$2,778,471	= (l * k * e) + (l * m * f)
o	Total cost of screening, lifetime	$9,460,549	= j + n
	Cost of Brief Intervention		
p	Lifetime brief interventions, female	7,798	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	$924,578	= (p * q * e) + (p * r * f)
	Costs Avoided due to Brief Intervention		
t	Annual Cost of Unhealthy Drug Use	$7,855	√
u	Lifetime cost savings, female	$3,078,360	Table 17
	Net Cost of Screening and Brief Intervention		
v	Net Cost of Screening and Brief Intervention	$7,306,768	= o + s - u
w	QALYs saved	114	Table 13
x	CE ($/QALY Saved)	$64,361	= v / w
y	Net Cost of Screening and Brief Intervention, 1.5% Discount	$6,634,352	Calculated
z	QALYs saved, 1.5% Discount	89	Calculated
aa	**CE ($/QALY Saved), 1.5% Discount**	**$74,465**	= 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 = $105,067
- 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 = $57,734
- 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 = $27,700
- Assume that the drug use cessation rate resulting from a brief behavioural intervention decreases from 6% to 2% (Table 13, row *o*): CE = $277,302
- Assume that the drug use cessation rate resulting from a brief behavioural intervention increases from 6% to 10% (Table 13, row *o*): CE = $33,898
- Assume that the annual costs avoided as a result of a 'successful' brief intervention decreases from $7,855 to $3,094 (Table 19, row *t*): CE = $90,802
- Assume that the annual costs avoided as a result of a 'successful' brief intervention increases from $7,855 to $12,615 (Table 19, row *t*): CE = $58,132
- Model from ages 18 through 79 (an additional 10 years modelled above the baseline age of 69 – Table 13, row *a*): CE = $80,439
- Model from ages 18 through 59 (a reduction of 10 years modelled compared to the baseline age of 69 – Table 13, row *a*): CE = $67,754
- Assume screening and intervention occur every three years rather than every year (Table 19, row *a*): CE = $31,985
- Assume screening and intervention occur every five years rather than every year (Table 19, row *a*): CE = $23,489

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 $40,388 / 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	343,933	Table 16
c	Lifetime in depth screens conducted, males	42,468	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	$29.69	Ref. Doc.
g	Lifetime basic screens only, males	301,464	= 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	$4,963,486	= (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	42,468	= c
m	Patient time, in depth screen (in hours)	2	√
n	Total cost of basic and in depth screens	$4,783,716	= (l * k * e) + (l * m * f)
o	Total cost of screening, lifetime	$9,747,203	= j + n
	Cost of Brief Intervention		
p	Lifetime brief interventions, male	11,938	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	$1,415,448	= (p * q * e) + (p * r * f)
	Costs Avoided due to Brief Intervention		
z	Annual Cost of Unhealthy Drug Use	$7,855	√
ab	Lifetime cost savings, male	$5,300,037	Table 17
	Net Cost of Screening and Brief Intervention		
v	Net Cost of Screening and Brief Intervention	$5,862,614	= o + s - u
w	QALYs saved	213	Table 14
x	CE ($/QALY Saved)	$27,565	= v / w
y	Net Cost of Screening and Brief Intervention, 1.5% Discount	$6,587,265	Calculated
z	QALYs saved, 1.5% Discount	163	Calculated
aa	**CE ($/QALY Saved), 1.5% Discount**	**$40,319**	= 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 = $56,343
- 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 = $31,545
- 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 = $11,384
- Assume that the drug use cessation rate resulting from a brief behavioural intervention decreases from 6% to 2% (Table 14, row *o*: CE = $170,557
- Assume that the drug use cessation rate resulting from a brief behavioural intervention increases from 6% to 10% (Table 12, row *o*): CE = $14,272
- Assume that the annual costs avoided as a result of a 'successful' brief intervention decreases from $7,855 to $3,094 (Table 20, row *z*): CE = $55,351
- Assume that the annual costs avoided as a result of a 'successful' brief intervention increases from $7,855 to $12,615 (Table 20, row *z*): CE = $25,291
- Model from ages 18 through 79 (an additional 10 years modelled above the baseline age of 69 – Table 14, row *a*): CE = $43,221
- Model from ages 18 through 59 (a reduction of 10 years modelled compared to the baseline age of 69 – Table 14, row *a*): CE = $37,193
- Assume screening and intervention occur every three years rather than every year (Table 20, row *a*): CE = $20,031
- Assume screening and intervention occur every five years rather than every year (Table 20, row *a*): CE = $15,973

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 $52,369 / 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**	**500**
3% Discount Rate	201	67	397
0% Discount Rate	326	109	646
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$52,369**	**$17,142**	**$208,226**
3% Discount Rate	$48,892	$15,443	$197,594
0% Discount Rate	$40,371	$11,005	$172,479
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	**$5,839**	**-$8,035**	**$68,635**
3% Discount Rate	$4,887	-$8,462	$65,578
0% Discount Rate	-$1,192	-$11,656	$47,790

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 $74,465 / 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	72	24	142
0% Discount Rate	114	38	225
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$74,465**	**$27,700**	**$277,302**
3% Discount Rate	$68,754	$24,924	$259,900
0% Discount Rate	$64,361	$22,452	$247,315
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	**$11,601**	**-$5,772**	**$88,710**
3% Discount Rate	$10,005	-$6,490	$83,654
0% Discount Rate	$4,926	-$9,256	$69,009

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 $40,319 / 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**	**323**
3% Discount Rate	129	43	255
0% Discount Rate	213	71	421
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$40,319**	**$11,384**	**$170,557**
3% Discount Rate	$37,859	$10,176	$162,984
0% Discount Rate	$27,565	$4,895	$132,534
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	**$2,696**	**-$9,270**	**$57,688**
3% Discount Rate	$2,044	-$9,558	$55,538
0% Discount Rate	-$4,458	-$12,936	$36,464

Screening for and Management of Obesity

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)[1198]

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).[1199]

[1198] 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.

[1199] 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,[1200] a total of 344,743 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	Mean Survival Rate	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	0.993	19,867	39,733	19.3%	4.8%	0.3%	0.2%	7,653	1,903	118	61
20-24	0.991	19,813	99,065	31.2%	7.7%	0.7%	0.2%	30,913	7,629	660	211
25-29	0.987	19,734	98,672	36.6%	9.3%	2.4%	0.8%	36,082	9,191	2,372	746
30-34	0.983	19,658	98,289	42.7%	14.4%	4.6%	0.0%	41,927	14,137	4,493	0
35-39	0.978	19,560	97,798	27.8%	21.0%	3.6%	0.1%	27,234	20,573	3,500	118
40-44	0.971	19,427	97,134	37.4%	20.2%	3.5%	0.1%	36,284	19,656	3,396	56
45-49	0.962	19,241	96,203	45.4%	10.4%	5.5%	0.2%	43,678	9,991	5,304	195
50-54	0.949	18,971	94,855	37.1%	25.8%	1.3%	0.3%	35,186	24,473	1,232	290
55-59	0.929	18,570	92,852	47.3%	11.4%	2.0%	1.6%	43,958	10,565	1,855	1,476
60-64	0.898	17,967	89,835	41.2%	15.8%	3.1%	1.7%	36,989	14,225	2,822	1,567
65-69	0.853	17,052	85,261	44.9%	16.2%	4.2%	0.2%	38,256	13,818	3,565	158
70-74	0.783	15,668	78,342	47.7%	17.4%	3.6%	0.4%	37,342	13,633	2,802	308
75-79	0.681	13,616	68,078	34.3%	8.0%	3.0%	0.7%	23,374	5,439	2,072	478
Total Ages 18-79			**1,136,117**	**38.6%**	**14.5%**	**3.0%**	**0.5%**	**438,876**	**165,233**	**34,191**	**5,665**

Table 2: Prevalence of Excess Weight in a *Female* Birth Cohort of 20,000

Age Group	Mean Survival Rate	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	0.995	19,891	39,781	10.2%	3.5%	0.0%	0.0%	4,050	1,403	0	0
20-24	0.993	19,865	99,323	17.7%	3.5%	1.0%	0.0%	17,582	3,488	957	0
25-29	0.992	19,833	99,163	15.2%	4.0%	4.2%	0.2%	15,082	3,928	4,117	150
30-34	0.990	19,795	98,975	20.2%	5.7%	3.7%	1.9%	19,963	5,645	3,675	1,918
35-39	0.987	19,741	98,706	21.7%	11.0%	5.5%	2.0%	21,463	10,849	5,436	2,021
40-44	0.983	19,662	98,311	23.9%	10.7%	1.2%	4.0%	23,531	10,500	1,215	3,947
45-49	0.977	19,546	97,730	29.4%	6.2%	0.5%	0.9%	28,771	6,083	516	919
50-54	0.969	19,375	96,873	30.3%	15.4%	2.2%	1.3%	29,385	14,871	2,166	1,264
55-59	0.956	19,118	95,591	28.1%	8.2%	3.1%	2.1%	26,884	7,853	2,944	2,008
60-64	0.936	18,726	93,630	27.3%	14.4%	6.0%	3.0%	25,572	13,491	5,630	2,777
65-69	0.906	18,113	90,567	34.5%	11.6%	5.0%	1.2%	31,222	10,482	4,517	1,059
70-74	0.857	17,144	85,720	24.6%	9.4%	5.9%	1.9%	21,068	8,054	5,070	1,625
75-79	0.780	15,608	78,041	28.0%	14.3%	1.6%	0.9%	21,847	11,153	1,265	702
Total Ages 18-79			**1,172,411**	**24.4%**	**9.2%**	**3.2%**	**1.6%**	**286,419**	**107,802**	**37,508**	**18,390**

- 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

[1200] 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.

weight loss in the control group participants.[1201] Research for the CTFPHC found similar results with an average weight loss of 3.02 kg (95% CI of 2.52 to 3.52).[1202] 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 2,287 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	344,733	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	22,752	= (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	1,584	= d * e
g	Reduction in years of life lived - Class I / II obesity vs. overweight	3.09%	Ref Doc
h	QALYs gained	703	= d * g
i	**Potential QALYs gained, management increasing from 0% to 33%**	**2,287**	= 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 = 2,858 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 = 1,633 QALYs.

[1201] 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.
[1202] 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 $269 to $3,267 (converted to 2017 CAD).[1203,1204,1205,1206] The difference in costs is largely attributable to the ratio of facilitators to clients. The intervention costing $3,267 per person involved case managers teaching a 16-week curriculum on a one-to-one basis.[1207] The intervention costing $269 per person was set up for 16 group sessions of up to 18 persons.[1208] We used the mean cost of three of the four interventions (excluding the $3,267 per person intervention) for an estimated cost of $607 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 $12,160 per QALY (Table 4, row *ff*).

[1203] 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.
[1204] 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.
[1205] 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.
[1206] 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.
[1207] Ibid.
[1208] 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	39,089	Tables 1 & 2
b	Total life years between age 18 and 70	1,998,347	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	344,733	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	729,397	= (b * e) / g
i	Cost of 10-minute office visit	$34.85	Ref Doc
j	Value of patient time and travel for office visit	$59.38	Ref Doc
k	Portion of 10-minute office visit for screen	50%	Ref Doc
l	Cost of screening	$34,365,530	= h * (I + j) * k
m	Costs per person of an intensive, multicomponent behavioral intervention	$607	√
n	Individuals eligible for an intensive, multicomponent behavioral intervention	5,837	= a * c
o	Individuals enrolled in an intensive, multicomponent behavioral intervention	1,926	= n * f
p	Costs of an intensive, multicomponent behavioral intervention	$1,169,244	= o * m
q	# of treatments per intensive, multicomponent behavioral intervention	18	√
r	Value of patient time and travel for per intervention treatment	$89.07	√
s	Value of patient time and travel for intervention	$3,088,306	= 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)	385	= o / t
v	Years with Class I / II obesity avoided with intervention	22,752	= (u / n) * d
w	Excess direct costs per year attributable to obesity	$805	Ref Doc
x	Excess direct costs per year attributable to overweight	$227	Ref Doc
w	Costs avoided	$13,150,883	=(w - x) *v
	CE calculation		
z	Cost of intervention over lifetime of birth cohort	$38,623,081	= l + p + s
aa	Costs avoided	$13,150,883	= w
bb	QALYs saved	2,287	Table 3, row i
cc	Cost of intervention over lifetime of birth cohort (1.5% discount)	$26,777,542	Calculated
dd	Costs avoided (1.5% discount)	$9,117,562	Calculated
ee	QALYs saved (1.5% discount)	1,452	Calculated
ff	**CE ($/QALY saved)**	**$12,160**	= (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 = $8,472 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 = $19,535 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 = $28,565 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 = $6,691 per QALY.
- Assume the proportion of an office visit required for screening/referral is reduced from 50% to 33% (Table 4, row *k)*: CE = $6,582 per QALY.
- Assume the proportion of an office visit required for screening/referral is increased from 50% to 67% (Table 4, row *k)*: CE = $17,738 per QALY.
- Assume that the costs per person of an intensive, multicomponent behavioral intervention are reduced from $607 to $269 (Table 4, row *m*): CE = $11,849 per QALY.
- Assume that the costs per person of an intensive, multicomponent behavioral intervention are increased from $607 to $3,267 (Table 4, row *m*): CE = $14,606 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 1,452 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to result in cost savings of $12,160 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	**1,452**	1,037	1,815
3% Discount Rate	959	685	1,199
0% Discount Rate	2,287	1,633	2,858
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$12,160**	$6,582	$28,565
3% Discount Rate	$13,219	$7,155	$31,053
0% Discount Rate	$11,140	$6,030	$26,169
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$348	-$1,715	$6,415
3% Discount Rate	$378	-$1,865	$6,974
0% Discount Rate	$318	-$1,571	$5,877

Falls in Community–Dwelling Elderly

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)*[1209]

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.[1210]

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.[1211]

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 765,288 life years lived was used to populate row *a* of Table 2 while the average life expectancy of 12.5 years was used to populate row *c* of Table 2.

[1209] 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.
[1210] Ibid.
[1211] 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	*Mean Survival Rate*	*Individuals in Birth Cohort*	*Life Years Lived*	Life Expectancy
60-64	0.920	36,800		
65-69	0.883	35,332	176,658	19.2
70-74	0.827	33,072	165,362	15.3
75-79	0.741	29,628	148,142	11.8
80-84	0.614	24,551	122,756	8.7
85-89	0.441	17,632	88,158	6.1
90+	0.321	12,842	64,212	4.8
Total			**765,288**	**12.5**

- An estimated 94.3% of life years in this cohort are lived in the community (Table 1, row *b*).[1212]
- Fall-related hospitalizations occur at a rate of 14.19 per 1,000 elderly in BC (Table 1, row *d*).[1213]
- An estimated 30% of individuals die within one year after a fall-related hospitalization (Table 1, row *f*).[1214]
- Individuals who survive a fall-related hospitalization have a 20% reduced life expectancy (Table 1, row *h*).[1215]
- 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*).[1216]
- 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*).[1217]
- 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*).

[1212] 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.
[1213] 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.
[1214] Ibid.
[1215] 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.
[1216] Ibid.
[1217] 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.

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

The role of vitamin D in fracture prevention is contentious.[1218,1219,1220] 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]).[1221] 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."[1222] 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.[1223,1224] 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 429 (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.

1218 Rosen CJ. Vitamin D supplementation: bones of contention. *The Lancet*. 2014; 383(9912): 108-10.
1219 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.
1220 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.
1221 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.
1222 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
1223 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.
1224 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+	765,288	Table 1
b	Adjusted for community-dwelling elderly	0.943	√
c	Average life expectancy	12.5	Table 1
d	Fall-related hospitalizations /1,000	14.19	√
e	Fall-related hospitalizations	10,240	=(a*b)/1000*d
f	Deaths in year following hospital admission	0.30	√
g	Fall-related hospitalization LYs lost due to deaths	38,473	=e*f*c
h	Reduced life expectancy for survivors of fall-related hospitalization	0.20	√
i	Fall-related hospitalization LYs lost in survivors	17,954	=e*(1-f)*c*h
j	Fall-related hospitalization LYs lived in survivors	71,817	=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	1,434	=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	3,232	=(j-(1-f)-i)*m
o	Total QALYs lost	61,093	=g+i+k+n
p	Effectiveness of exercise at reducing falls	13.0%	√
q	QALYs gained based on 100% adherence	7,942	= o * p
r	Delivery of screening and counseling	18.0%	Ref Doc
s	Adherence with exercise	30.0%	Assumed
t	**QALYs gained, CPB**	**429**	= 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 = 395.
- 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 = 463.
- Assume the effectiveness of exercise interventions is decreased from 13% to 6% (Table 2, row *p*): CPB = 198.
- Assume the effectiveness of exercise interventions is increased from 13% to 19% (Table 2, row *p*): CPB = 627.

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 $15 (e.g., the cost per hour for a commercially-based group exercise program).[1225]
- **Falls-related hospitalization** – The cost of a falls-related hospitalization is taken from the Canadian Institute of Health Information Patient Cost Estimator.[1226] We used the average cost in British Columbia associated with a hospitalization for a primary procedure of case-mix group 727 *Fixation/repair hip/femur* of $11,897 (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 $35,213/QALY (see Table 3, row z).

[1225] Mr. Jeordie Kerr. Owner, Cross-fit South Delta. Personal communication. February 2018.
[1226] Canadian Institute for Health Information. *Patient Cost Estimator*. 2014. Available at http://www.cihi.ca/cihi-ext-portal/internet/en/applicationnew/spending+and+health+workforce/spending/cihi020209. Accessed February 2018.

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	721,667	Table 2, row a * Table 2, row b
	Costs of screening		
b	Cost of 10-minute office visit	$34.85	Ref Doc
c	Value of patient time and travel for office visit	$59.38	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	$6,120,238	= (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	$1,836,071	= (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	11,691	= a * e * g * j
l	Hours of exercise (3 times per week for 1 hour)	1,823,796	= k * 52 * 3
m	Cost per hour of exercise	$5.00	√
n	Cost of intervention (exercise)	$9,118,979	= l * m
	Costs avoided		
o	Reduction in fall-related hospitalizations	166	= (k / a) * Table 2, row e
p	Cost of a fall-related hospitalization	$11,897	√
q	Cost avoided	$1,973,656	= o * p
	CE calculation		
r	Cost of initial screen	$6,120,238	= f
s	Costs of referral and intervention	$10,955,050	= i + n
t	Costs avoided	$1,973,656	= q
u	QALYs saved	429	Table 2, row t
v	Cost of initial screen (1.5% discount rate)	$5,226,698	Calculated
w	Costs of referral and intervention (1.5% discount rate)	$9,355,639	Calculated
x	Costs avoided (1.5% discount rate)	$1,685,507	Calculated
y	QALYs saved (1.5% discount rate)	366	Calculated
z	**CE ($/QALY saved)**	**$35,213**	= (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 = $38,213 / 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 = $32,649 / QALY.
- Assume the effectiveness of exercise interventions is decreased from 13% to 6% (Table 2, row *p*): CE = $76,294 / QALY.
- Assume the effectiveness of exercise interventions is increased from 13% to 19% (Table 2, row *p*): CE = $24,093 / QALY.

- Assume the cost of an hour of exercise is decreased from $5 to $0 (Table 3, row *m*): CE = $13,950 / QALY.
- Assume the cost of an hour of exercise is increased from $5 to $15 (Table 3, row *m*): CE = $77,738 / 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 366 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to result in cost savings of $35,213 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	**366**	169	535
3% Discount Rate	315	145	460
0% Discount Rate	429	198	627
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	**$35,213**	$13,950	$77,738
3% Discount Rate	$35,213	$13,950	$77,738
0% Discount Rate	$35,213	$13,950	$77,738
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$23,522	$2,259	$66,048
3% Discount Rate	$23,522	$2,259	$66,048
0% Discount Rate	$23,522	$2,259	$66,048

Preventive Medication / Devices

Routine Aspirin Use for the Prevention of Cardiovascular Disease and Colorectal Cancer

Background

In 2007, the USPSTF recommended "against the routine use of aspirin… to prevent colorectal cancer in individuals at average risk for colorectal cancer" with a D recommendation.[1227] 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.[1228]

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[1229,1230,1231] calling into question the clinical effectiveness of low-dose aspirin in primary prevention.[1232,1233,1234] 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). 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).[1235]

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

[1227] 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.
[1228] 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.
[1229] 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.
[1230] 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.
[1231] 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.
[1232] 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.
[1233] Raju NC and Eikelboom JW. The aspirin controversy in primary prevention. *Current Opinion in Cardiology*. 2012; 27(5): 499-507.
[1234] Patrono C. Low-dose aspirin in primary prevention: cardioprotection, chemoprevention, both, or neither? *European Heart Journal*. 2013; 34(44): 3403-11.
[1235] H. Krueger & Associates Inc. *Establishing Priorities among Effective Clinical Prevention Services in British Columbia: Summary and Technical Report*. July 16, 2014.

three systematic evidence reviews[1236,1237,1238] and one decision analysis using simulation modelling.[1239]

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.[1240]

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.[1241]

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 27% (RR of 1.27, 95% CI of 0.96 – 1.68).[1242]

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.[1243] 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 recommendation by the USPSTF.

[1236] 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.
[1237] 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.
[1238] 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.
[1239] 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.
[1240] 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.
[1241] 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.
[1242] 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.
[1243] 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.

United States Preventive Services Task Force Recommendations (2016)[1244]

> *The USPSTF recommends initiating low dose aspirin use for the primary prevention of CVD and 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.*

Modelling the Clinically Preventable Burden

In this section, we will calculate the CPB associated with initiating low dose aspirin use for the primary prevention of CVD and CRC in adults between the ages of 50 and 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.

In estimating CPB, we made the following assumptions:

- Based on BC life tables for 2010 to 2012, there are a total of 380,576 life years lived between the ages of 50 and 59 in a BC birth cohort of 40,000 (see Table 1).
- Based on BC life tables for 2010 to 2012, a total of 1,072 deaths would be expected between the ages of 50-59, a further 2,460 deaths between the ages of 60-69 and 5,808 deaths between the ages of 70-79 in a BC birth cohort of 40,000 (see Table 1).
- Based on BC vital statistics data, 601 of 5,076 (11.8%) deaths in 45-64 year olds in 2011 were due to cardiovascular disease (ICD-10 codes I00-I51) and 191 of 5,076 (3.8%) deaths were due to cerebrovascular disease (ICD-10 codes I60-I69).[1245] This data was used to estimate that approximately 190 of the 1,611 (11.8%) deaths between the ages of 55-64 in the birth cohort would be due to cardiovascular disease and 61 (3.8%) due to cerebrovascular disease (see Table 1).

[1244] 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.

[1245] British Columbia Vital Statistics Agency. *Selected Vital Statistics and Health Status Indicators: One Hundred and Fortieth Annual Report*. 2011. British Colubmia Ministry of Health. Available at http://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2011/pdf/ann2011.pdf. Accessed January 2017.

- Based on BC Cancer Agency data, there were 3,021[1246] new cases of colorectal cancers (CRC) in BC in 2012 and 1,099[1247] deaths due to CRC that same year. An estimated 19.9%[1248] of deaths (or 219 in BC in 2012) from CRC are in individuals between the ages of 60-69. Since the effectiveness of aspirin on reducing the incidence of CRC only appears after approximately ten years, the age range of 65-74 is being used in the modelling when considering CRC ***incidence***. Similarly, the age range of 75-84 is being used in the modelling when considering CRC ***mortality*** due to the 20-year lag time observed for this outcome in the research.[1249] An estimated 26.9%[1250] of deaths (or 296 in BC in 2012) from CRC are in individuals between the ages of 70-79.
- Based on BC vital statistics data, there were 31,776 deaths in BC in 2011.[1251] An estimated 12.5% of these deaths (or 3,972) are in individuals between the ages of 60-69 and 22.2% (or 7,065) in individuals between the ages of 70-79.[1252] The 219 deaths from CRC between the ages of 60-69 therefore represents approximately 5.3% of all deaths in this age cohort. In the birth cohort of 40,000, 5.3% of deaths between the ages of 60-69 represents 130 deaths due to CRC (see Table 1). The 296 deaths from CRC represents approximately 4.2% of all deaths in this age cohort. In the birth cohort of 40,000, 4.2% of deaths between the ages of 70-79 represents 244 deaths due to CRC (see Table 1).

Table 1: Deaths and Selected Causes of Death Between the Ages of 50 and 84
in a British Columbia Birth Cohort of 40,000

Age Group	*Mean Survival Rate*		*Individuals in Birth Cohort*			*Life Years Lived*	*Deaths in Birth Cohort*		Cardiovascular Disease		*Deaths due to* Cerebrovascular Disease		Colorectal Cancer	
	Males	Females	Males	Females	Total		%	#	%	#	%	#	%	#
45-49	0.963	0.977	19,263	19,546	38,809									
50-54	0.950	0.969	19,003	19,375	38,378	191,890	1.1%	431						
55-59	0.931	0.956	18,619	19,118	37,737	188,686	1.7%	641	11.8%	76	3.8%	24		
60-64	0.902	0.936	18,041	18,726	36,767	183,834	2.6%	970	11.8%	115	3.8%	37	5.3%	51
65-69	0.858	0.906	17,164	18,113	35,277	176,387	4.2%	1,489					5.3%	79
70-74	0.792	0.857	15,837	17,144	32,981	164,903	7.0%	2,297					4.2%	96
75-79	0.693	0.780	13,861	15,608	29,469	147,346	11.9%	3,511					4.2%	147
80-84	0.553	0.661	11,053	13,228	24,281	121,405	21.4%	5,188					4.2%	218

1246 BC Cancer Agency. *New Cancer Diagnoses for 2012 by Cancer Type, Age at Diagnosis and Gender*. 2012. Provincial Health Services Authority,. Available at http://www.bccancer.bc.ca/statistics-and-reports-site/Documents/Cancer_Incidence_Counts_2012.pdf. Accessed February 2017.
1247 BC Cancer Agency. *Cancer Deaths in British Columbia, 2012 by Cancer Type, Age at Death and Gender*. 2012. Provincial Health Services Authority,. Available at http://www.bccancer.bc.ca/statistics-and-reports-site/Documents/Cancer_Mortality_Counts_2013.pdf. Accessed February 2017.
1248 Canadian Cancer Society's Advisory Committee on Cancer Statistics. *Canadian Cancer Statistics 2016, Special Topic: HPV-Associated Cancers*. 2016. Canadian Cancer Society. Available at http://www.colorectal-cancer.ca/IMG/pdf/Canadian-Cancer-Statistics-2016-EN.pdf. Accessed February 2017.
1249 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.
1250 Canadian Cancer Society's Advisory Committee on Cancer Statistics. *Canadian Cancer Statistics 2016, Special Topic: HPV-Associated Cancers*. 2016. Canadian Cancer Society. Available at http://www.colorectal-cancer.ca/IMG/pdf/Canadian-Cancer-Statistics-2016-EN.pdf. Accessed February 2017.
1251 British Columbia Vital Statistics Agency. *Selected Vital Statistics and Health Status Indicators: One Hundred and Fortieth Annual Report*. 2011. British Colubmia Ministry of Health. Available at http://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/statistics-reports/annual-reports/2011/pdf/ann2011.pdf. Accessed January 2017.
1252 Jayaraman J and Joseph K. Determinants of place of death: a population-based retrospective cohort study. *BioMed Central Palliative Care*. 2013; 12(19): 1-9.

- We are not aware of any information which indicates the proportion of adults aged 50 to 59 years in BC who have had a cardiovascular or bleeding risk assessment. Nor are we aware of BC-specific data on the proportion of adults at intermediate or higher risk of CVD and low bleeding risk who are taking aspirin over the longer term for primary prevention purposes. Research suggests that 73.3% of Canadians between the ages of 40 and 59 are at low risk (defined as a mean 10-year risk of a CVD event of less than 10%), 10.3% are at intermediate risk (mean 10-year risk of a CVD event of 10%-19%) and 16.4% are at high risk (mean 10-year risk of a CVD event of ≥20%)[1253] (see Table 2).

Table 2: Estimated Number of Canadian Adults Ages 20-79 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%**

- We assumed that the average age at which a cardiovascular or cerebrovascular event was prevented due to the use of aspirin would be 60 (Table 3, rows *q* & *x*). For the prevention of a CRC event, this would be 70.4 (Table 3, row *ae*). For the prevention of a death due to CRC, this would be 80 (Table 3, row *aj*). Based on BC life tables for 2010 to 2012, the average life expectancy of a 60 year old is 25.1 years (Table 3, rows *y* & *z*), that of a 70.4 year old is 16.5 years (Table 3, rows *af* & *ag*) and that of an 80 year old is 9.9 years (Table 3, row *ak*).[1254]

- Very-low dose aspirin use (≤100mg daily) for primary prevention reduces the risk of nonfatal myocardial infarction by 17% (RR of 0.83, 95% CI of 0.74 – 0.94) (Table 3, row *ao*) and nonfatal stroke by 14% (RR of 0.86, 95% CI of 0.76 – 0.98) (Table 3, row *aq*), but does not reduce all-cause or cardiovascular mortality.[1255]

- Use of aspirin (in dosages ranging from 50 to 500mg daily) for primary prevention reduces the incidence of colorectal cancer by 40% (RR of 0.60, 95% CI of 0.47 – 0.76) (Table 3, row *as*) but only in secondary studies which followed individuals for at least 10 years.[1256]

- The use of aspirin for approximately 5 years reduces the risk of death from CRC about 20 years later by 33% (RR of 0.67, 95% CI of 0.52 – 0.86) (Table 3, row *au*).[1257]

- The rate of a major bleeding event in a 50-69 year old not taking aspirin is 1.99 per 1,000 person-years (95% CI 1.82 to 2.18) (Table 3, row *az*). The rate of a major bleeding event in a 50-69 year old who is taking aspirin increases to 3.21 per 1,000

[1253] Hennessy D, Tanuseputro P, Tuna M et al. Population health impact of statin treatment in Canada. *Health Reports*. 2016; 27(1): 20-8.
[1254] See http://www.statcan.gc.ca/pub/84-537-x/2013005/tbl-eng.htm. Accessed January 2017.
[1255] 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.
[1256] 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.
[1257] Ibid.

person-years (95% CI 2.93 to 3.53) (Table 3, row *ba*). Sixty-five percent of bleeding events are episodes of gastrointestinal bleeding (Table 3, row *bc*) while 35% are episodes of intracranial hemorrhage (Table 3, row *bd*).[1258]

- In a study of 936 patients with acute upper gastrointestinal bleeding (AUGIB) in the UK, 42 (4.5%) had died by day 28 following the bleeding episode (Table 3, row *bg*). The mean QoL score at 28 days for surviving patients was 0.735 compared to 0.86 for the general UK population, a disutility of 14.5% (Table 3, row *bo*). We have assumed that this disutility lasts for a one-year period.[1259]
- An estimated 40% of patients die within 28 days after a haemorrhagic stroke (Table 3, row *bh*).[1260]
- 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 initiating use of low-dose aspirin for the primary prevention of CVD and 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 is 1,098 QALYs (Table 3, row *bs*). This is based on the assumption of moving from no aspirin use in this intermediate to high risk cohort to 24% of this cohort initiating and sustaining aspirin use.

[1258] De Berardis G, Lucisano G, D'ettorre A et al. Association of aspirin use with major bleeding in patients with and without diabetes. *Journal of American Medical Association*. 2012; 307(21): 2286-94.
[1259] Campbell H, Stokes E, Bargo D et al. Costs and quality of life associated with acute upper gastrointestinal bleeding in the UK: cohort analysis of patients in a cluster randomised trial. *British Medical Journal Open*. 2015; 5(4): e007230.
[1260] Krueger H, Lindsay P, Cote R et al. Cost avoidance associated with optimal stroke care in Canada. *Stroke*. 2012; 43(8): 2198-206.

Table 3: CPB of Screening for and Initiating Use of Aspirin in Adults Between the Ages of 50 and 59 Years with an Intermediate or Higher 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 55-64 in birth cohort	372,520	Table 1
b	% of life years at low risk of CVD	73.3%	Table 2
c	% of life years at intermediate risk of CVD	10.3%	Table 2
d	% of life years at high risk of CVD	16.4%	Table 2
e	# of life years at low risk	273,119	= (a * b)
f	# of life years at intermediate risk	38,312	= (a * c)
g	# of life years at high risk	61,089	= (a * d)
h	Total deaths in birth cohort between the ages of 55-64	1,611	Table 1
i	Cardiovascular deaths in birth cohort between the ages of 55-64	190	Table 1
j	Cerebrovascular deaths in birth cohort between the ages of 55-64	61	Table 1
k	Total deaths in birth cohort between the ages of 65-74	3,786	Table 1
l	Colorectal cancer deaths in birth cohort between the ages of 65-74	175	Table 1
m	Total deaths in birth cohort between the ages of 75-84	8,700	Table 1
n	Colorectal cancer deaths in birth cohort between the ages of 75-84	365	Table 1
o	# of nonfatal ***cardiovascular*** events per fatal event	5.09	See Ref Doc
p	# of nonfatal cardiovascular events	968	= (i * o)
q	Average age of individual with a cardiovascular event	60	√
r	Life years lived with a nonfatal cardiovascular event	18.8	√
s	Life years lost due to a nonfatal cardiovascular event	6.3	See Ref Doc
t	QoL reduction living with a nonfatal cardiovascular event (for 1 month)	0.125	See Ref Doc
u	**QALYs lost due to nonfatal cardiovascular events**	**6,286**	= (p * s) + (p * r * t)/12
v	Ratio of nonfatal ***cerebrovascular*** events per fatal event	4.58	See Ref Doc
w	# of nonfatal cerebrovascular events	280	= (j * u)
x	Average age of individual with a cerebrovascular event	60	√
y	Life years lived with a nonfatal cerebrovascular event	19.7	√
z	Life years lost due to a nonfatal cerebrovascular event	5.5	See Ref Doc
aa	QoL reduction living with a nonfatal cerebrovascular event	0.264	See Ref Doc
ab	**QALYs lost due to nonfatal cerebrovascular events**	**3,001**	= (w * z) + (w * y * aa)
ac	Ratio of nonfatal ***colorectal cancer*** events per fatal event	4.32	See Ref Doc
ad	# of nonfatal colorectal cancer events, ages 65-74	758	= (l * aa)
ae	Average age of individual with colorectal cancer	70.4	See Ref Doc
af	Life years lived with colorectal cancer	6.6	See Ref Doc
ag	Life years lost due to nonfatal colorectal cancer	9.9	See Ref Doc
ah	QoL reduction living with a nonfatal colorectal cancer event	0.065	See Ref Doc
ai	**QALYs lost due to nonfatal colorectal cancer events**	**7,825**	= (ad * ag) + (ad * af * ah)
aj	Average age of individual dying from colorectal cancer	80	√
ak	Life expectancy of a 80 year old in BC	9.9	√
al	**QALYs lost due to deaths from colorectal cancer**	**3,617**	= (n * ak)

Table 3 (continued): CPB of Screening for and Initiating Use of Aspirin in Adults Between the Ages of 50 and 59 Years with an Intermediate or Higher Risk of CVD in a Birth Cohort of 40,000			
Label	**Variable**	**Base Case**	**Data Source**
	Benefits if 24% of intermediate & high risk individuals were on aspirin		
am	% of life years at intermediate or high risk on aspirin	24%	See Ref Doc
an	# of life years at intermediate or high risk on aspirin	23,856	= (f + g) * am
ao	% reduction in risk of cardiovascular disease associated with aspirin use	17%	√
ap	**QALYs gained due to cardiovascular disease events avoided with 24% aspirin usage**	**256**	= (u * am * ao)
aq	% reduction in cerebrovascular events associated with aspirin use	14%	√
ar	**QALYs gained due to cerebrovascular disease events avoided with 24% aspirin usage**	**101**	= (ab * am * aq)
as	% reduction in colorectal cancer events associated with aspirin use, ages 60-69	40%	√
at	**QALYs gained due to a reduction in nonfatal colorectal cancer events associated with 24% aspirin use**	**751**	= (ai * am * as)
au	% reduction in colorectal cancer deaths associated with aspirin use, ages 70-79	33%	√
av	**QALYs gained due to a reduction in colorectal cancer deaths associated with 24% aspirin use**	**286**	= (al * am * au)
aw	***Total QALYs gained*** if 24% of intermediate & high risk individuals were on aspirin	**1,395**	= (an + aq + at + av)
	Harms if 24% of intermediate & high risk individuals were on aspirin		
ax	Disutility per year associated with taking pills for cardiovascular prevention	-0.0032	See Ref Doc
ay	Disutility associated with taking pills for cardiovascular prevention	-76	= (an * ax)
az	Risk of major bleeding event in age group 50-69 per 1,000 person-years, no aspirin	1.99	√
ba	Risk of major bleeding event in age group 50-69 per 1,000 person-years, with aspirin	3.21	√
bb	Major bleeding events in cohort due to aspirin	29	=((ak/1000)*ba)-((ak/1000)*az)
bc	Proportion of major bleeding events - gastrointestinal bleeding	0.65	√
bd	Proportion of major bleeding events - haemorrhagic stroke	0.35	√
be	Gastrointestinal bleeding events attributable to aspirin use	19	= (bb * bc)
bf	Haemorrhagic strokes attributable to aspirin use	10	= (bb * bd)
bg	Death rate following a gastrointestinal bleeding event	0.045	√
bh	Death rate following a haemorrhagic stroke	0.40	√
bi	Deaths due to a gastrointestinal bleeding event	0.9	= (be * bg)
bj	Deaths due to a haemorrhagic stroke	4.1	= (bf * bh)
bk	Average age of individual with a major bleeding event	60	√
bl	Life years lived following a non-fatal gastrointestinal bleeding event	29.6	√
bm	Life years lived following a non-fatal haemorrhagic stroke	24.1	= (bl - bn)
bn	Life years lost following a non-fatal haemorrhagic stroke	5.5	See Ref Doc
bo	QoL reduction living with a gastrointestinal bleed (1 year only)	-0.145	√
bp	QALYs lost due to gastrointestinal bleeding	-28	=(-bi*bl)+((be-bi)*bo)
bq	QALYs lost due to haemorrhagic stroke	-193	=(-bj*bl)-((bf-bj)*bn)-((bf-bj)*bm*aa)
br	***Total QALYs lost*** if 100% of intermediate & high risk individuals were on aspirin	**-297**	= ay + bp + bq
bs	**Net QALYs gained, Screening & Intervention from 0% to 24%**	**1,098**	= (aw + br)

√ = 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 cardiovascular disease events associated with aspirin use is reduced from 17% to 6% (Table 3, row *ao*), the decreased risk of cerebrovascular disease events is reduced from 14% to 2% (Table 3, row *aq*), the decreased risk of incident CRC is reduced from 40% to 24% (Table 3, row *as*) and the decreased risk of mortality due to CRC is reduced from 33% to 14% (Table 3, row *au*): CPB = 380.
- Assume that decreased risk of cardiovascular disease events associated with aspirin use is increased 17% to 26% (Table 3, row *ao*), the decreased risk of cerebrovascular disease events is increased from 14% to 24% (Table 3, row *aq*), the decreased risk of

incident CRC is increased from 40% to 53% (Table 3, row *as*) and the decreased risk of mortality due to CRC is increased from 33% to 48% (Table 3, row *au*): CPB = 1,680.

- Assume that the disutility per year associated with taking pills for cardiovascular prevention is reduced from -0.0033 to 0.000 (Table 3, row *ax*): CPB = 1,174.
- Assume that the disutility per year associated with taking pills for cardiovascular prevention is increased from -0.0033 to -0.0044 (Table 3, row *ax*): CPB = 1,069.
- Assume that the rate of a major bleeding event in a 50-69 year old not taking aspirin is reduced from 1.99 to 1.82 per 1,000 person-years (Table 3, row *az*) while the rate of a major bleeding event in a 50-69 year old who is taking aspirin is reduced from 3.21 to 2.93 per 1,000 person-years (Table 3, row *ba*): CPB = 1,118.
- Assume that the rate of a major bleeding event in a 50-69 year old not taking aspirin is increased from 1.99 to 2.18 per 1,000 person-years (Table 3, row *az*) while the rate of a major bleeding event in a 50-69 year old who is taking aspirin is increased from 3.21 to 3.53 per 1,000 person-years (Table 3, row *ba*): CPB = 1,074.

Modelling Cost-Effectiveness

In this section, we will calculate the CE associated with initiating low dose aspirin use for the primary prevention of CVD and CRC in adults between the ages of 50 and 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.

In estimating CE, we made the following assumptions:

- **Screening for CVD risk -** The USPSTF notes that it used the ACC/AHA Pooled Cohort Equations to calculate the 10-year risk of CVD events in their analysis and identified key risk factors for GI bleeding: higher doses and longer duration of aspirin use, GI ulcers or upper GI pain, bleeding disorders, renal failure, severe liver disease, thrombocytopenia, concurrent anticoagulation or nonsteroidal anti-inflammatory drug use, uncontrolled hypertension, male sex and older age. [1261]
- The need to concurrently screen for CVD risk, bleeding risk and willingness to take low-dose aspirin daily for at least 10 years has recently led to the development of a clinical decision support tool called the Aspirin Guide.[1262,1263]
- We have assumed that the CVD screening and bleeding risk assessment would take place three times between the ages of 50 and 59 (beginning, mid-point and end of this age range). This would involve screening individuals to determine their risk status and whether or not aspirin would be recommended as well as for follow-up purposes for individuals taking aspirin for primary prevention purposes (Table 3, row *e*).
- Completion of a CVD risk assessment includes a physician 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

[1261] 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.
[1262] Mora S and Manson J. Aspirin for primary prevention of atherosclerotic cardiovascular disease: advances in diagnosis and treatment. *Journal of the American Medical Association Internal Medicine*. 2016; 176(8): 1195-204.
[1263] Mora S, Ames J and Manson J. Low-dose aspirin in the primary prevention of cardiovascular disease: shared decision making in clinical practice. *Journal of the American Medical Association*. 2016; 316(7): 709-10.

full lipid profile costs $21.31 (Table 3, row *l*).[1264] Note that a CVD risk assessment is required when considering both statins (see previous modelling section) and aspirin for the primary prevention of CVD.

- 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 follow-up visit would be required to discuss the results and the possibility of taking aspirin.
- **Cost of aspirin therapy –** The cost of 100 – 81mg aspirin tablets at London Drugs is $14.99.[1265] We assumed an annual cost of $54.70 (Table 3, row *t*).
- We assumed an annual follow-up visit with a clinician for patients taking aspirin for preventative purposes (Table 3, row *v*).
- 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 screening for and initiating use of low-dose aspirin for the primary prevention of CVD and CRC in adults between the ages of 50 and 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 is $2,302 / QALY (Table 3, row *bi*).

[1264] 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.
[1265] See http://www.londondrugs.com/. Accessed February 2017.

Table 4: CE of Screening for and Initiating Use of Aspirin in Adults Between the Ages of 50 and 59 Years with an Intermediate or Higher Risk of CVD in a Birth Cohort of 40,000			
Row Label	**Variable**	**Base Case**	**Data Source**
a	# of individuals alive at age 59 in birth cohort	37,737	Table 1
b	# of life years lived between the ages of 55-64 in birth cohort	372,520	Table 3
c	% of life years at intermediate or high risk	26.7%	Table 3
d	# of life years at intermediate or high risk	99,401	= (b * c)
e	Lifetime number of screens	3.0	Assumed
f	Adherence with offers to receive screening	33%	See Ref Doc
g	Total # of screens in birth cohort	37,360	= (a * e * f)
	Estimated cost of screening		
h	Number of office visits associated with screening - low risk	1	Expert Opinion
i	Number of office visits associated with screening - medium or high risk	2	Expert Opinion
j	Cost of 10-minute office visit	$34.85	√
k	Cost of a follow-up phone call	$15.00	√
l	Cost to measure cholesterol	$21.31	√
m	Health care costs of screening - low risk	$1,949,142	= (1 - c) * g * h * (j + k + l)
n	Health care costs of screening - medium and high risk	$907,264	= ((c * g) * i) * (j + l * 0.5)
o	Patient time required / office visit (hours)	2	√
p	Value of patient time (per hour)	$29.69	√
q	Value of patient time and travel for screening	$2,810,376	=(((c * g * i) + ((1 - c) * g * h))) * o * p
	Estimated cost of intervention		
r	Adherence with long-term aspirin therapy in intermediate & high risk cohort	24.0%	See Ref Doc
s	Years on aspirin therapy	23,856	= (d * r)
t	Cost of aspirin therapy / year	$54.70	√
u	Cost of aspirin therapy	$1,304,933	= (s * t)
v	Follow-up office visits / year on aspirin therapy	1.0	Expert Opinion
w	Health care costs of intervention	$831,388	= s * v * j
x	Value of patient time and travel for intervention	$1,416,579	= s * v * o * p
	Estimated costs avoided due to intervention		
y	# of nonfatal cardiovascular events avoided	39.5	= Table 3, row p * Table 3, row ao * r
z	# of nonfatal cerebrovascular events avoided	9.4	= Table 3, row w * Table 3, row aq * r
aa	# of nonfatal colorectal cancer events avoided	72.7	= Table 3, row ad * Table 3, row as * r
ab	# of fatal colorectal cancer events avoided	28.9	= Table 3, row n * Table 3, row au * r
ac	First year costs avoided per nonfatal cardiovascular event avoided	$33,934	See Ref Doc
ad	First year costs avoided per nonfatal cerebrovascular event avoided	$21,139	See Ref Doc
ae	First year costs avoided per nonfatal colorectal cancer event avoided	$40,080	See Ref Doc
af	Costs avoided per fatal colorectal cancer event avoided	$49,197	See Ref Doc
ag	First year costs avoided	$5,878,221	=(y*ac)+(z*ad)+(aa*ae)+(ab*af)
ah	Post-first-year annual costs avoided for nonfatal cardiovascular events avoided	$2,278	See Ref Doc
ai	Duration of post-first year annual costs	12.1	See Ref Doc
aj	Post-first-year annual costs avoided for nonfatal cerebrovascular events avoided	$6,246	See Ref Doc
ak	Duration of post-first year annual costs	9.3	See Ref Doc
al	Post-first-year annual costs avoided for nonfatal colorectal cancer events avoided	$3,687	See Ref Doc
am	Duration of post-first year annual costs	6.6	See Ref Doc
an	Post-first-year costs avoided for nonfatal cardiovascular events avoided	$1,088,300	= (y * ah * ai)
ao	Post-first-year costs avoided for nonfatal cerebrovascular events avoided	$547,297	= (z * aj * ak)
ap	Post-first-year costs avoided for nonfatal colorectal cancer events avoided	$1,770,154	= (aa * al * am)
aq	Costs avoided due to intervention	$9,283,971	= ag + an + ao + ap
	Estimated costs incurred due to intervention		
ar	# of gastrointestinal bleeds incurred	18.9	= Table 3, row be
as	# of nonfatal haemorrhagic strokes incurred	6.1	= Table 3, row bf - Table 3, row bj
at	# of fatal haemorrhagic strokes incurred	4.1	= Table 3, row bj
au	Costs per nonfatal gastrointestinal bleed	$6,425	See Ref Doc
av	Cost per fatal haemorrhagic stroke	$9,583	See Ref Doc
aw	First year costs per nonfatal cerebrovascular event	$21,139	See Ref Doc
ax	Post-first-year costs for nonfatal cerebrovascular events	$6,246	See Ref Doc
ay	Duration of post-first year annual costs	9.3	See Ref Doc
az	Costs incurred due to intervention	$515,625	= (ar * au) + (at * av) + (as * ay * ax)
	CE Calculation		
ba	Cost of intervention over lifetime of birth cohort	$9,219,683	= m + n + q + u + w + x
bb	Costs avoided due to intervention over lifetime of birth cohort	$9,283,971	= aq
bc	Costs incurred due to intervention over lifetime of birth cohort	$515,625	= az
bd	Net QALYs saved	1,098	Table 3, row bs
be	Cost of intervention over lifetime of birth cohort (1.5% discount)	$8,045,187	Calculated
bf	Costs avoided due to intervention over lifetime of birth cohort (1.5% discount)	$6,864,254	Calculated
bg	Costs incurred due to intervention over lifetime of birth cohort (1.5% discount)	$449,939	Calculated
bh	Net QALYs saved (1.5% discount)	708	Calculated
bi	**CE ($/QALY saved)**	**$2,302**	= (be + bg - bf) / bh

√ = 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 cardiovascular disease events associated with aspirin use is reduced from 17% to 6% (Table 3, row *ao*), the decreased risk of cerebrovascular disease events is reduced from 14% to 2% (Table 3, row *aq*), the decreased risk of incident CRC is reduced from 40% to 24% (Table 3, row *as*) and the decreased risk of mortality due to CRC is reduced from 33% to 14% (Table 3, row *au*): CE = $24,255.
- Assume that decreased risk of cardiovascular disease events associated with aspirin use is increased 17% to 26% (Table 3, row *ao*), the decreased risk of cerebrovascular disease events is increased from 14% to 24% (Table 3, row *aq*), the decreased risk of incident CRC is increased from 40% to 53% (Table 3, row *as*) and the decreased risk of mortality due to CRC is increased from 33% to 48% (Table 3, row *au*): CE = -$1,189.
- Assume that the disutility per year associated with taking pills for cardiovascular prevention is reduced from -0.0033 to 0.000 (Table 3, row *ax*): CE = $2,105.
- Assume that the disutility per year associated with taking pills for cardiovascular prevention is increased from -0.0033 to -0.0044 (Table 3, row *ax*): CE = $2,387.
- Assume that the rate of a major bleeding event in a 50-69 year old not taking aspirin is reduced from 1.99 to 1.82 per 1,000 person-years (Table 3, row *az*) while the rate of a major bleeding event in a 50-69 year old who is taking aspirin is reduced from 3.21 to 2.93 per 1,000 person-years (Table 3, row *ba*): CE = $2.191.
- Assume that the rate of a major bleeding event in a 50-69 year old not taking aspirin is increased from 1.99 to 2.18 per 1,000 person-years (Table 3, row *az*) while the rate of a major bleeding event in a 50-69 year old who is taking aspirin is increased from 3.21 to 3.53 per 1,000 person-years (Table 3, row *ba*): CE = $2,441.

Summary

Applying a 1.5% discount rate, the clinically preventable burden (CPB) associated with screening for and initiating use of low-dose aspirin for the primary prevention of CVD and CRC in adults between the ages of 50 and 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 is estimated to be 708 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to result in cost savings of $2,302 per QALY (see Table 5).

Table 5: Screening for and Initiating Use of Aspirin in Adults Aged 50 to 59 Years with an Intermediate or Higher 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' (24%)			
1.5% Discount Rate	708	217	1,108
3% Discount Rate	501	131	802
0% Discount Rate	***1,098***	380	1,680
CE ($/QALY) **including** patient time costs			
1.5% Discount Rate	***$2,302***	-$1,189	$24,255
3% Discount Rate	$4,736	$233	$38,547
0% Discount Rate	$411	-$2,106	$14,098
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	-$2,905	-$4,518	$7,238
3% Discount Rate	-$1,730	-$3,807	$13,873
0% Discount Rate	-$3,439	-$4,622	$2,972

Folic Acid Supplementation in Reproductive-age Women for the Prevention of Neural Tube Defects (NTDs)

United States Preventive Services Task Force Recommendations (2017)[1266]

> *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." [1267]
- 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."[1268]
- 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.[1269]
- 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

[1266] 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.
[1267] 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.
[1268] Copp A, Adzick N, Chitty L et al. Spina bifida. *Nature Reviews Disease Primers*. 2015; 1: 1-45.
[1269] 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.[1270, 1271]

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.[1272] 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).[1273]

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.[1274] 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**

[1270] 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.

[1271] 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.

[1272] The seven provinces include Newfoundland & Labrador, Prince Edward Island, Nova Scotia, Quebec, Manitoba, Alberta and British Columbia.

[1273] 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.

[1274] 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.[1275] Given the results of this trial, RCTs are no longer considered ethically possible because of the clear benefits of folic acid supplementation.[1276]
- Other cohort and case control studies completed between 1976 and 1998 consistently found evidence of a protective effect associated with folic acid supplementation.[1277]
- 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.[1278]

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.[1279]
- 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.[1280, 1281]
- 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.[1282]
- 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).[1283] 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

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[1275] 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.
[1276] 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.
[1277] Ibid.
[1278] Ibid.
[1279] 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.
[1280] 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.
[1281] Ray J. Efficacy of Canadian folic acid food fortification. *Food and Nutrition Bulletin*. 2008; 29(2): S225-30.
[1282] 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.
[1283] 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.[1284] 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).[1285] 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 2010 to 2012, an estimated 19,672 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,[1286] an estimated 28,110 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

[1284] 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.
[1285] 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.
[1286] See http://www.bcstats.gov.bc.ca/StatisticsBySubject/Demography/VitalStatistics.aspx. Accessed February 2017.

births based on Ontario's full fortification rate noted above.[1287] 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.[1288]

- 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 9.6 live births with spina bifida would have occurred in the birth cohort pre-fortification. The estimated post-fortification status would be 6.5 live births with spina bifida with the potential to be further reduced to 5.1 live births with spina bifida if Ontario's rate of 5.8 / 10,000 were achieved (see Table 4). Likewise, an estimated 0.9 live births with anencephaly would occur post-fortification with the potential to reduce this to 0.7 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

					Estimated Prefortification Status					*Estimated Current Status*					*Estimated Potential Status*				
								Live Birth with					*Live Birth with*					*Live Birth with*	
Age Group	*Mean Survival* Females	*Females in Birth Cohort*	*Life Years Lived*	# of Live Births	Est. # of NTDs	Anen-cephaly	Spina Bifida	Anen-cephaly	Spina Bifida	Est. # of NTDs	Anen-cephaly	Spina Bifida	Anen-cephaly	Spina Bifida	Est. # of NTDs	Anen-cephaly	Spina Bifida	Anen-cephaly	Spina Bifida
15-19	0.995	19,900	99,499	759	0.8	0.3	0.5	0.0	0.3	0.6	0.2	0.3	0.0	0.2	0.4	0.2	0.3	0.0	0.1
20-24	0.993	19,868	99,339	3,241	3.6	1.4	2.2	0.2	1.1	2.4	1.0	1.5	0.1	0.8	1.9	0.7	1.1	0.1	0.6
25-29	0.992	19,836	99,179	7,489	8.2	3.2	5.0	0.4	2.6	5.6	2.2	3.4	0.3	1.7	4.3	1.7	2.6	0.2	1.3
30-34	0.990	19,799	98,997	9,894	10.9	4.3	6.6	0.5	3.4	7.4	2.9	4.5	0.3	2.3	5.7	2.3	3.5	0.3	1.8
35-39	0.987	19,748	98,738	5,575	6.1	2.4	3.7	0.3	1.9	4.2	1.6	2.5	0.2	1.3	3.2	1.3	2.0	0.1	1.0
40-44	0.984	19,672	98,358	1,153	1.3	0.5	0.8	0.1	0.4	0.9	0.3	0.5	0.0	0.3	0.7	0.3	0.4	0.0	0.2
Total			**594,110**	**28,110**	**30.9**	**12.1**	**18.8**	**1.4**	**9.6**	**21.1**	**8.3**	**12.8**	**0.9**	**6.5**	**16.3**	**6.4**	**9.9**	**0.7**	**5.1**

- 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.[1289]

- The 2017 USPSTF review found no significant evidence of potential harms associated with folic acid supplementation.[1290]

[1287] 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.
[1288] 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.
[1289] 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.
[1290] 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."[1291]
- 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.[1292, 1293]
- 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 60.6% (or a loss of 39.4% 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 Male	Female	Total	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	0.996	0.996	0.996	39,846	199,230	0.818	32,727	163,636	0.649	25,965	129,825
5-9	0.995	0.996	0.996	39,823	199,115	0.764	30,545	152,727	0.526	21,053	105,263
10-14	0.995	0.995	0.995	39,809	199,043	0.745	29,818	149,091	0.491	19,649	98,246
15-19	0.994	0.995	0.994	39,773	198,864	0.691	27,636	138,182	0.456	18,246	91,228
20-24	0.991	0.993	0.992	39,683	198,417	0.673	26,909	134,545	0.368	14,737	73,684
25-29	0.987	0.992	0.989	39,572	197,859	0.655	26,182	130,909	0.333	13,333	66,667
30-34	0.983	0.990	0.986	39,451	197,253	0.618	24,727	123,636	0.298	11,930	59,649
35-39	0.977	0.987	0.982	39,293	196,463	0.600	24,000	120,000	0.211	8,421	42,105
40-44	0.971	0.983	0.977	39,075	195,375	0.545	21,818	109,091	0.175	7,018	35,088
45-49	0.961	0.977	0.969	38,765	193,826	0.545	21,818	109,091	0.123	4,912	24,561
50-54	0.947	0.969	0.958	38,310	191,551	0.534	21,363	106,816	0.111	4,457	22,286
55-59	0.926	0.955	0.941	37,627	188,136	0.517	20,680	103,401	0.094	3,774	18,872
60-64	0.894	0.935	0.915	36,591	182,955	0.491	19,644	98,220	0.068	2,738	13,690
65-69	0.847	0.904	0.875	35,009	175,045	0.452	18,062	90,310	0.029	1,156	5,780
70-74	0.776	0.854	0.815	32,600	162,999	0.391	15,653	78,265		0	0
75-79	0.673	0.777	0.725	28,992	144,961	0.301	12,045	60,226		0	0
80+	0.531	0.659	0.595	23,809	119,047	0.172	6,862	34,312		0	0
Total					**3,140,140**			**1,902,458**			**786,945**
% Compared to General Population								60.6%			25.1%

[1291] 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.
[1292] 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.
[1293] 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.[1294] 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.[1295] 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.[1296]

- 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.[1297] 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.[1298]

- 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.[1299]

- The life expectancy of an infant born in BC of 82.2 years (Table 6, row *o*) is based on life tables for 2010 to 2012 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).[1300]

1294 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.

1295 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.

1296 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.

1297 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.

1298 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.

1299 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.

1300 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 95 QALYs (see Table 6, row *ac*). The 95 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	19,767	Table 4
b	Life years lived between the ages of 15 and 44	594,110	Table 4
c	Live births between the ages of 15 and 44	28,110	Table 4
d	Estimated live births with spina bifida prefortification	9.6	Table 4
e	Estimated live births with spina bifida currently	6.5	Table 4
f	Estimated potential live births with spina bifida post fortification	5.1	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)	82.2	√
p	Births with sacral lesion spina bifida avoided (9.6 to 5.1)	1.5	= (d - f) * g
q	Births with lumbar lesion spina bifida avoided (9.6 to 5.1)	3.0	= (d - f) - p
r	Life years gained due to sacral lesion spina bifida avoided	49.8	= m * o * p
s	Life years gained due to lumbar lesion spina bifida avoided	184.4	= n * o * q
t	QALYs gained due to sacral lesion spina bifida avoided	26.0	= p * (1 - m) * o * j
u	QALYs gained due to lumbar lesion spina bifida avoided	29.0	= q * (1 -n) * o * (k + l) / 2
v	**Total QALYs gained due to spina bifida avoided (9.6 to 5.1)**	**289**	= r + s + t + u
w	Births with sacral lesion spina bifida avoided (6.5 to 5.1)	0.5	= (e - f) * g
x	Births with lumbar lesion spina bifida avoided (6.5 to 5.1)	1.0	= (e - f) - w
y	Life years gained due to sacral lesion spina bifida avoided	16.3	= m * o * w
z	Life years gained due to lumbar lesion spina bifida avoided	60.3	= n * o * x
aa	QALYs gained due to sacral lesion spina bifida avoided	8.5	= w * (1 - m) * o * j
ab	QALYs gained due to lumbar lesion spina bifida avoided	9.5	= x * (1 -n) * o * (k + l) / 2
ac	**Total QALYs gained due to spina bifida avoided (6.5 to 5.1)**	**95**	= 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 = 83.
- 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 = 106.
- 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 = 105.
- Reduce the incidence of NTDs from 5.8 to 4.0 / 10,000 live births: CPB = 194.

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.[1301]
- 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.[1302]
- 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."[1303]
- 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

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[1301] 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.
[1302] Frey K and Files J. Preconception healthcare: what women know and believe. *Maternal and Child Health Journal*. 2006; 10(1): 73-7.
[1303] 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%).[1304]

- 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 $0.043 per tablet at London Drugs.[1305] We assumed an annual cost of $15.70 (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.[1306]
- 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.[1307]
- 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.[1308] We converted the medical costs to equivalent 2017 Canadian costs; $454,745 in medical costs (Table 7, row *r*), $79,203 in special education and developmental service costs (Table 7, row *s*) and $268,043 in parental time costs (Table 7, row *t*).[1309]
- 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.[1310,1311]

1304 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.
1305 See http://www.londondrugs.com/search/?q=Folic+acid&lang=default. Accessed February 2017.
1306 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.
1307 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.
1308 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.
1309 Campbell and Cochrane Economics Methods Group. *CCEMG – EPPI-Centre Cost Converter*. 2016. Available at https://eppi.ioe.ac.uk/costconversion/. Accessed December 2016.
1310 Wittenberg E and Prosser L. Disutility of illness for caregivers and families: a systematic review of the literature. *Pharmacoeconomics*. 2013; 31(6): 489-500.
1311 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 (Table 7, row *w*).[1312]
- 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.[1313] According to the Canadian Institute for Health Information's *Patient Cost Estimator*, the average cost per day in BC in 2014 for CMG 599 (Neonate 2500+ grams, ages 0-28 days, other major problem) was $2,085.[1314] We therefore calculated an avoided cost of $4,399 (2.11 * $2,085) 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 $195,379 / QALY (Table 7, row *ad*).

[1312] 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.
[1313] 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.
[1314] 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	594,110	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	415,877	= a * b
e	Proportion of women taking folic acid supplementation after receiving advice	76%	√
f	Life years covered by folic acid supplementation	316,067	= d * e
g	Annual cost of folic acid supplementation	$15.70	√
h	Cost of folic acid supplementation	$4,962,244	= f * g
i	Cost of 10-minute office visit	$34.85	√
j	Portion of 10-minute office visit for offering advice	50%	Assumed
k	Costs of office visits	$2,415,552	= (d / c) * i * j
l	Patient time required per office visit (hours)	2	Assumed
m	Value of patient time (per hour)	$29.69	√
n	Value of patient time and travel for intervention	$4,115,796	= (d / c) * l * m * j
o	**Estimated cost of the intervention**	**$11,493,593**	= h + k + n
p	Medical care costs avoided per anencephaly live birth avoided	-$4,399	√
q	Cases of anencephaly live births avoided with intervention	0.21	Table 4
r	Medical care costs avoided per case of spina bifida avoided	-$454,745	√
s	Special education and developmental service costs avoided per case of spina bifida avoided	-$79,203	√
t	Parental time costs avoided per case of spina bifida avoided	$0	√
u	Cases of spina bifida avoided with intervention	1.48	Table 6, row w + x
v	Abortions avoided per spina bifida live birth	2.23	√
w	Costs avoided per abortion avoided	-$609	√
	CE Calculation		
x	Cost of intervention over lifetime of birth cohort	$11,493,593	= o
y	Costs avoided over lifetime of birth cohort	-$793,981	= ((r + s + t) * u)+(u * v * w)+(p * q)
z	QALYs saved	95	Table 6, row ac
aa	Cost of intervention over lifetime of birth cohort (1.5% discount)	$11,493,593	Calculated
ab	Costs avoided over lifetime of birth cohort (1.5% discount)	-$697,164	Calculated
ac	QALYs saved (1.5% discount)	55	Calculated
ad	**CE ($/QALY saved)**	**$195,379**	= (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 = $223,110.
- 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 = $173,945.

- Assume that the reduction in life expectancy with either a sacral and lumbar lesion is increased by 25% (Table 6, rows *m* & *n*): CE = $175,564.
- Reduce the incidence of NTDs from 5.8 to 4.0 / 10,000 live births: CE = $88,410.
- Assume that clinician adherence in offering advice re: folic acid supplementation is reduced from 70% to 60% (Table 7, row *b*): CE = $165,666.
- Assume that clinician adherence in offering advice re: folic acid supplementation is increased from 70% to 80% (Table 7, row *b*): CE = $225,093.
- 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 = $431,720.
- 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 = $148,101.
- Assume the proportion of women taking folic acid supplementation after receiving advice is decreased from 76% to 66% (Table 7, row *e*): CE = $183,563.
- Assume the proportion of women taking folic acid supplementation after receiving advice is increased from 76% to 86% (Table 7, row *e*): CE = $207,195.
- Assume that the portion of 10-minute office visit required for offering advice is reduced from 50% to 33% (Table 7, row *j*): CE = $155,193.
- Assume that the portion of 10-minute office visit required for offering advice is increased from 50% to 66% (Table 7, row *j*): CE = $233,202.
- Include parental time costs avoided per case of spina bifida avoided (Table 7, row *t*): CE = $189,069

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 55 quality-adjusted life years (QALYs) while the cost-effectiveness (CE) is estimated to result in cost savings of $195,379 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	**55**	48	114
3% Discount Rate	35	31	72
0% Discount Rate	95	83	195
CE ($/QALY) **including** patient* time costs			
1.5% Discount Rate	**$195,379**	$88,410	$431,770
3% Discount Rate	$310,525	$141,800	$683,392
0% Discount Rate	$113,155	$50,643	$251,301
CE ($/QALY) **excluding** patient time costs			
1.5% Discount Rate	$120,897	$52,233	$208,324
3% Discount Rate	$193,042	$84,736	$330,943
0% Discount Rate	$69,628	$29,501	$120,720

** 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)." [1315]

[1315] 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.