The Lifetime Prevention Schedule

Establishing Priorities among Effective Clinical Prevention Services in British Columbia

Summary and Technical Report
March 2016 Update

Screening for and Management of Obesity in Children and Youth, Screening for Lung Cancer, Screening for Depression in Adults, Screening for Depression in Pregnant and Postpartum Women and HPV-Based Screening for Cervical Cancer

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The Lifetime Prevention Schedule 2016 update was supported by Child Health BC, the Doctors of BC and the Ministry of Health.

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Update completed by H. Krueger & Associates Inc.

Acknowledgments

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Establishing Priorities among Effective Clinical Prevention Services in British Columbia: *2016 Update*

Executive Summary

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 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) 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.

In 2013/14, a Lifetime Prevention Schedule Expert Advisory Committee was formed by the Ministry of Health and tasked with updating and potentially expanding the number of clinical prevention services included on the LPS. That process involved calculating the clinically preventable burden (CPB) and cost-effectiveness (CE) associated with the clinical prevention service. CPB is defined as "the total quality-adjusted life years (QALYs) 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 updated list reviewed in 2013/14 included the 10 maneuvers on the original 2009 LPS together with 9 additional maneuvers (highlighted in *italics* below) to be considered for inclusion on the updated LPS:

[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 August 2013.

Screening for Asymptomatic Disease or Risk Factors – Children/Youth

- Newborn screening for hearing
- Vision (amblyopia) screening

Behavioural Counseling Interventions – Children/Youth

- *Preventing tobacco use*

Preventive Medication – Children/Youth

- Fluoride varnish and sealants to prevent dental caries

Screening for Asymptomatic Disease or Risk Factors – Adults

- Breast cancer screening - women 50-74
- Cervical cancer screening - women 25-69
- Colorectal cancer screening - adults 50-74
- Hypertension screening and treatment - adults 18+
- Cholesterol screening and treatment - men 35+, women 45+
- *Screening for hepatitis C virus - adults born between 1945 and 1965*

Routine Offer of Screening for STIs in Sexually Active Young Adults

- *Screening for human immunodeficiency virus (HIV) – adolescents/adults 15-65*
- *Screening for gonorrhea - females 15-29*
- *Screening for chlamydia - females 15-29*
- *Screening for syphilis*

Behavioural Counseling Interventions – Adults

- Smoking cessation advice and help to quit
- *Alcohol screening and brief counseling*
- *Prevention of fetal alcohol spectrum disorder (FASD)*

Preventive Medication – Adults

- Discuss daily aspirin use - men 45-79, women 55-79
- *Preventing falls in community–dwelling elderly - adults 65+*

In 2015, the Lifetime Prevention Schedule Expert Advisory Committee requested an assessment of the estimated CPB and CE associated with the following four additional clinical prevention services:

Behavioural Counseling Interventions – Children/Youth

- Promotion of breastfeeding

Screening for Asymptomatic Disease or Risk Factors - Adults

- Screening for type 2 diabetes mellitus

Behavioural Counseling Interventions – Adults

- Prevention of sexually transmitted infections
- Screening for and management of obesity

The Lifetime Prevention Schedule Expert Advisory Committee is currently seeking an assessment of the estimated CPB and CE associated with the following five additional clinical prevention services (highlighted in yellow on Table ES-1):

Behavioural Counseling Interventions – Children/Youth

- Screening for and management of obesity in children/youth ages 2-17

Screening for Asymptomatic Disease or Risk Factors - Adults

- Screening for lung cancer in adults ages 55 - 79 who have a 30 pack-year smoking history
- Screening for depression in nonpregnant adults ages 18+
- Screening for depression in pregnant and postpartum women
- The addition of HPV-based screening for cervical cancer in women ages 30-69

This document provides the details supporting the estimated CPB and CE associated with these five maneuvers.

In order to avoid duplicating evidence reviews, the Lifetime Prevention Schedule Expert Advisory Committee decided to refer any recommendations regarding immunizations to the BC Immunization Schedule and any recommendations regarding prenatal care, intrapartum care and immediate postpartum care to Perinatal Services BC (PSBC) or to other relevant Provincial Health Services Authority (PHSA) guidelines.

This executive summary includes the summary tables and figures from the analysis of the 19 clinical prevention services considered for inclusion on the LPS in 2013/14, the four maneuvers considered for inclusion in 2015 and the five maneuvers currently being considered for inclusion.

Three of the original 19 services were excluded from the previous review. *Screening for hearing in newborns* was considered to be part of immediate postpartum care, *screening for syphilis* was excluded as the Lifetime Prevention Schedule Expert Advisory Committee determined that the targeted population was too specific to meet the definition of a clinical prevention service, and *discuss daily aspirin use* was excluded as current evidence calls into question the effectiveness of this maneuver.

Screening for chlamydia and *screening for gonorrhea* were combined as there is a strong overlap in at-risk populations and both STIs are often being seen in the same individual.

Finally, *fluoride varnish and sealants to prevent dental caries* was divided into two separate models; 1) *fluoride varnish for the prevention of dental caries in primary teeth* and 2) *sealants for the prevention of caries in permanent teeth*.

Table ES-1 provides an overview of the results for all 25 maneuvers. The *estimated coverage* columns include information on current coverage in BC for a specific maneuver as well as information indicating the best coverage in the world (BiW). For example, 37% of adults ages 50-74 in BC are currently being screened for colorectal cancer. Evidence from other jurisdictions suggests that this coverage could be increased to 73%.

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 BiW coverage is achieved. For example, if coverage for colorectal cancer screening were as high as the BiW (73%), we would expect a CPB of 10,384 QALYs. Since BC's coverage is at 37%, a CPB of 5,263 QALYs is being achieved. This is 5,121 QALYs short of the potential 10,384 QALYs achievable based on BiW coverage, as identified in the *Gap* column.

The *CE* columns identify the cost-effectiveness ratio associated with a maneuver stated in terms of the cost per QALY. The ratio is given based on the use of a 3% and a 0% discount rate. For example, the cost/QALY associated with colorectal cancer screening in BC is estimated at $2,804, based on a discount rate of 3%. If a 0% discount rate is used, then the cost/QALY would be reduced to $2,777.

Table ES-1: Effective Clinical Prevention Services in B.C.

Summary *(Not including Immunizations or Perinatal Care)*

Clinical Prevention Services	Estimated Coverage B.C.	Estimated Coverage 'BiW'(1)	CPB(2) (0% Discount) QALYs B.C.	CPB(2) (0% Discount) QALYs 'BiW'(1)	CPB(2) (0% Discount) QALYs Gap	CE(3) (% Discount) Cost/QALY 3%	CE(3) (% Discount) Cost/QALY 0%
Screening for Asymptomatic Disease or Risk Factors - Children							
Screening for hearing - newborn	*Part of immediate postpartum care*						
Vision screening for amblyopia - children, 3-5	93%	93%	25	25	-	$879,199	$179,901
Behavioural Counseling Interventions - Children/Youth							
Preventing tobacco use - children/youth	Unknown, assume 0%	65%	-	1,299	1,299	($7,262)	($16,750)
Promotion of breastfeeding	41%	60%	7,031	10,370	3,339	$397	($4,586)
Screening for and management of obesity - children/youth ages 2-17	Unknown, assume 15%	30%	159	318	159	$41,106	$14,971
Preventive Medication - Children							
Fluoride varnish - children	92%	92%	407	407	-	$19,292	$19,292
Dental sealants - children/youth	30%	70%	239	558	319	($15,140)	($18,917)
Screening for Asymptomatic Disease or Risk Factors - Adults							
Breast cancer screening - women 50-74	53%	70%	871	1,150	279	$25,412	$22,125
Cytology-based cervical cancer screening for women ages 25-69	67%	80%	1,243	1,477	234	$18,217	$16,781
Addition of HPV-based cervical cancer screening for women ages 30-69	0%	70%	-	355	355	($5,181)	($6,877)
Colorectal cancer screening - adults 50-74	37%	73%	5,263	10,384	5,121	$2,804	$2,777
Hypertension screening and treatment - adults 18+	85%	85%	8,791	8,791	-	$15,131	$5,573
Cholesterol screening and treatment - men 35+, women 45+	75%	75%	3,150	3,150	-	$23,204	$18,655
Screening for Type 2 Diabetes Mellitus	Unknown, assume 0%	70%	-	3,693	3,693	($3,777)	($4,045)
Screening for lung cancer - adults 55 - 74 who have a 30 pack-year smoking history	Unknown, assume 0%	80%	-	2,736	2,736	$1,556	$1,553
Screening for depression - nonpregnant adults ages 18+	Unknown, assume 0%	5%	-	50	50	$67,322	$67,322
Screening for depression - pregnant and postpartum women	Unknown, assume 0%	40%	-	102	102	$26,670	$19,181
Routine Offer of Screening for Sexually Transmitted Infections - Adults							
Screening for Human Immunodeficiency Virus - adults 15-65	20%	70%	111	387	276	$43,846	$43,846
Screening for Chlamydia/Gonorrhea - women 15-29	29%	50%	647	1,115	468	$9,900	$7,980
Screening for Syphilis	*Not for general population*						
Screening for Hepatitis C Virus - adults born between 1945 and 1965	33%	90%	2,895	7,895	5,000	$4,751	$3,321
Behavioural Counseling Interventions - Adults							
Smoking cessation advice and help to quit - adults	50%	75%	10,743	16,034	5,291	$7,277	$1,749
Alcohol screening and brief counseling - adults	Unknown, assume 0%	35%	-	1,136	1,136	$1,175	($12,636)
LARC(4) and screening/counseling to reduce Fetal Alcohol Spectrum Disorder (FASD)	Unknown, assume 0%	70%	-	3,752	3,752	($2,829)	($4,980)
Prevention of sexually transmitted infections - adults 15-59	Unknown, assume 0%	30%	-	3,543	3,543	$7,142	$7,142
Screening for and management of obesity	Unknown, assume 0%	30%	-	3,233	3,233	$10,346	$8,005
Preventive Medication - Adults							
Discuss daily aspirin use - men 45-79, women 55-79	*No longer clinically effective*						
Preventing falls in community–dwelling elderly - adults 65+	Unknown, assume 0%	30%	-	2,394	2,394	$5,615	$5,615

(1) 'BiW' = best in world; (2) CPB = clinically preventable burden; (3) CE = cost-effectiveness; (4) LARC = Long-Acting Reversible Contraception;

Figure ES-1 provides a summary of the CPB associated with each service. Results are displayed based on a 0% discount rate and results based on a 3% discount rate are available in the body of the text. Using a 3% discount rate tends to reduce the CPB. The results are organized from left to right based on the maneuvers with the highest to lowest potential CPB. For example, full implementation of the maneuver *smoking cessation advice and help to quit – adults* (Tobacco-A) (i.e., achieving levels that are comparable to the best in the world) would result in a CPB of 16,034 QALYs, the highest of any maneuver reviewed. Our best estimates suggest that approximately 50% of adults in BC are receiving the maneuver, resulting in a CPB of 10,743 QALYs. This would leave a gap of 5,291 QALYs between current services in BC and the potential full implementation of this maneuver in the province.

The black error bars / whiskers associated with each maneuver 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 model results. Simultaneously varying more than one assumption would increase the potential range. A larger range suggests a higher sensitivity in the model to the assumptions used.

Figure ES-1: ***Clinically Preventable Burden*** Based on Providing Clinically Effective Maneuvers to a B.C. Birth Cohort of 40,000

0% Discount Rate

(Not including Immunizations or Perinatal Care)

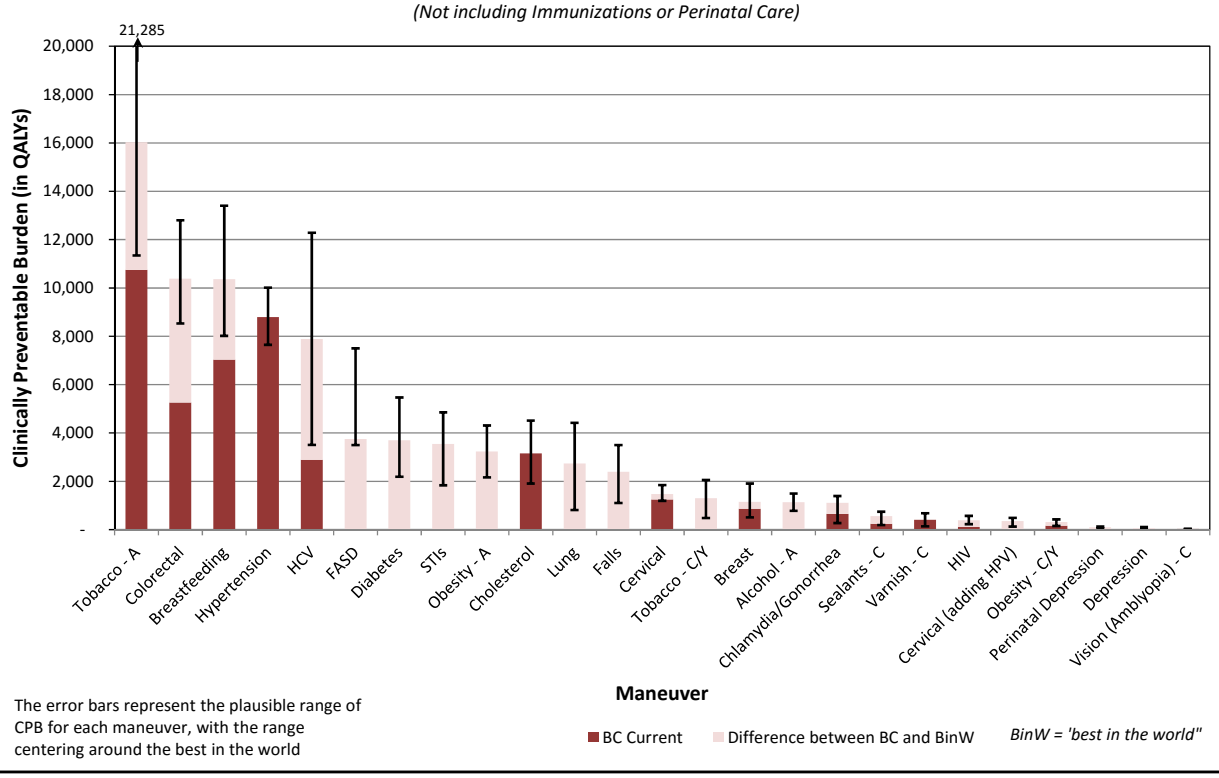


Figure ES-2 provides a summary of the CE associated with each service. Results are displayed based on a 3% discount rate. Results based on a 0% discount rate are available in the body of the text. Using a 0% discount rate tends to improve the CE. Furthermore, the results are organized from left to right based on the maneuvers with the best to worst potential CE, including a plausible range for each maneuver based on sensitivity analysis. The use of *dental sealants for the prevention of caries in permanent teeth* has the best CE result of any maneuver reviewed. That is, this maneuver is considered to be cost-saving, with a cost per QALY of -$15,140 (with a potential range from -$45,421 to -$4,706).

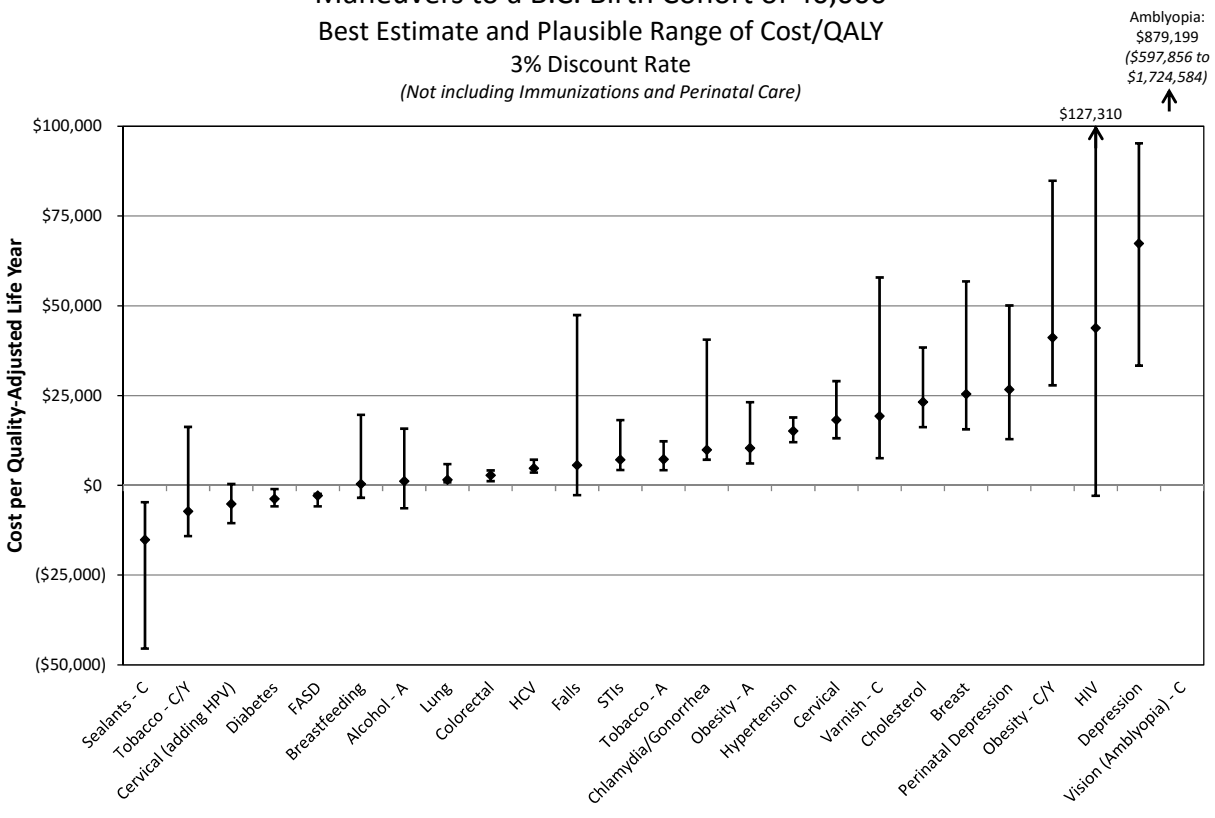
The black error bars / whiskers associated with each maneuver represent a potential range in CE based on one-way sensitivity analysis. That is, the range is based on varying (over a plausible range) the one assumption that has the largest effect on the model results. Simultaneously varying more than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

Figure ES-2: ***Cost Effectiveness*** Based on Providing Clinically Effective Maneuvers to a B.C. Birth Cohort of 40,000

Best Estimate and Plausible Range of Cost/QALY

3% Discount Rate

(Not including Immunizations and Perinatal Care)



The base models include an estimate of costs associated with a person's time used in accessing the preventive maneuvers. The most significant effect of these inclusions/exclusions is seen in maneuvers that require frequent contact with health care providers. For example, the cost/QALY associated with screening for breast cancer is reduced from $25,412 to $13,859 if patient time costs are excluded. The cost/QALY associated with cytology-based screening for cervical cancer is reduced from $18,217 to $8,239, the cost/QALY associated with screening for HIV is reduced from $43,846 to $9,955, the cost/QALY associated with screening for hypertension is reduced from $15,131 to $8,400, the cost/QALY associated with screening and counselling to reduce alcohol misuse is reduced

from $1,175 to -$19,238 and the cost/QALY associated with applying fluoride varnish to primary teeth is reduced from $19,292 to $3,482.

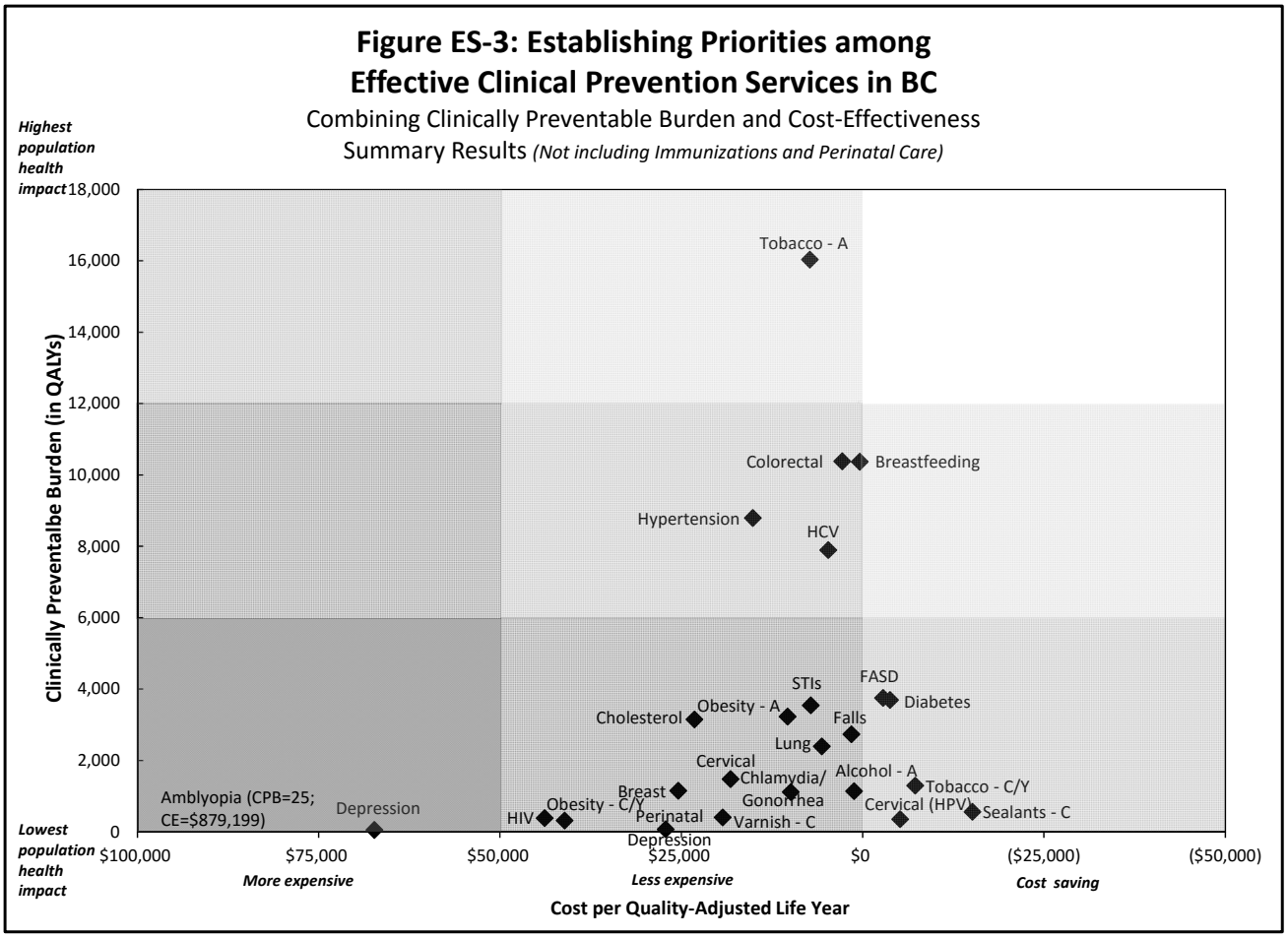
The results for CPB and CE are combined in Figure ES-3. CPB is on the vertical axis, ranging from 0 to 18,000 QALYs. CE is on the horizontal axis, ranging from $100,000/QALY at the intersection of the x- and y-axis to -$50,000 at the far right of the x-axis. By arranging CPB and CE in this manner, the 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 6,000 QALYs, 6,001 to 12,000 QALYs and 12,001 to 18,000 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. Maneuvers in the upper right segment have the most favourable combination of CPB and CE while maneuvers in the lower left segment have the least favourable combination of CPB and CE.

Figure ES-3: Establishing Priorities among Effective Clinical Prevention Services in BC

Combining Clinically Preventable Burden and Cost-Effectiveness

Summary Results *(Not including Immunizations and Perinatal Care)*



In Figures ES-4 to ES-6, we have incorporated visual information on plausible ranges (based on one-way sensitivity analysis) with the point estimates for each maneuver. To avoid overcrowding the above figure (ES-3), we have separated the maneuvers into three figures. Figure ES-4 includes maneuvers specific to children and youth, Figure ES-5 includes screening maneuvers and Figure ES-6 includes behavioural counselling, etc. maneuvers.

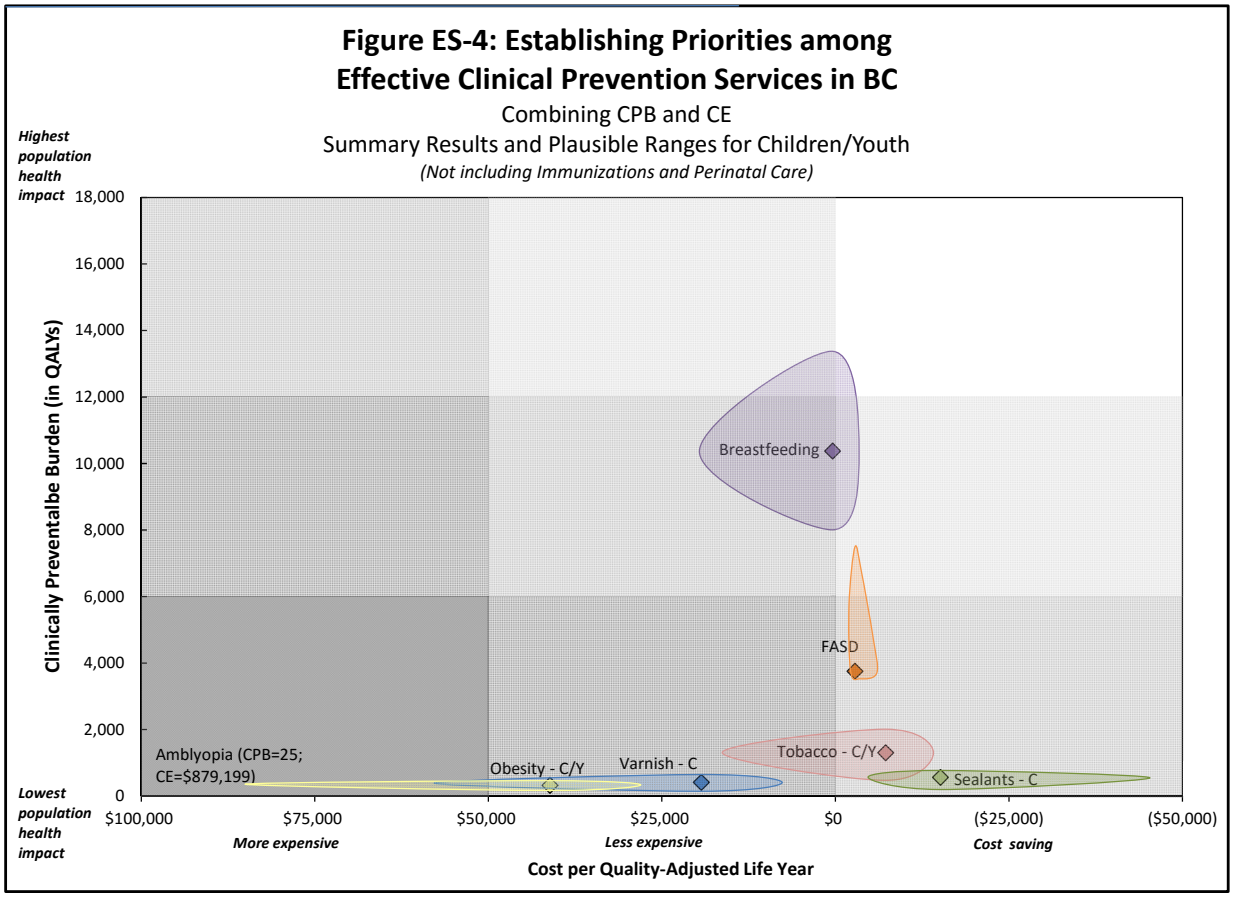


Figure ES-5: Establishing Priorities among Effective Clinical Prevention Services in BC

Combining CPB and CE

Summary Results and Plausible Ranges for Screening Maneuvers

(Not including Immunizations and Perinatal Care)

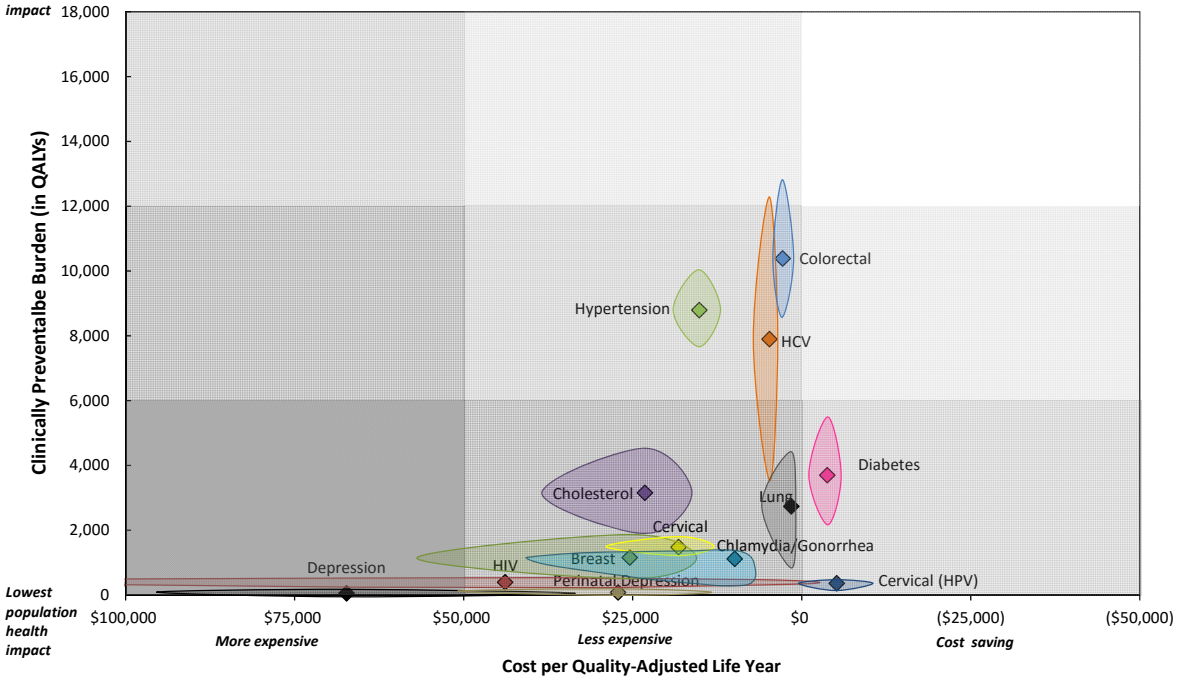
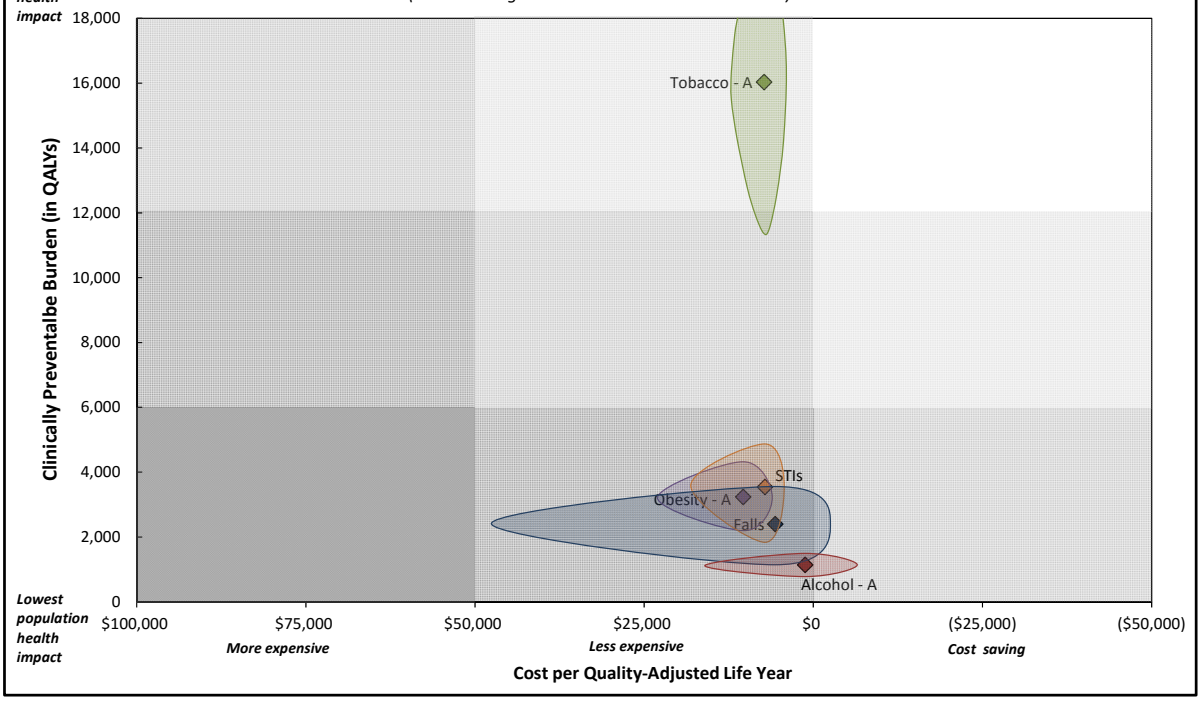


Figure ES-6: Establishing Priorities among Effective Clinical Prevention Services in BC

Combining CPB and CE

Summary Results and Plausible Ranges for Behavioural Counselling, etc. Maneuvers

(Not including Immunizations and Perinatal Care)



Key Assumptions

The following key assumptions have been made throughout this project.

Duplication of Effort

In order not to duplicate evidence reviews, the Lifetime Prevention Schedule Expert Advisory Committee decided to refer any recommendations regarding immunizations to the BC Immunization Schedule and any recommendations regarding prenatal care, intrapartum care and immediate postpartum care to the Perinatal Services BC (PSBC) guidelines or to other agencies responsible for specific recommendations. Many of these guidelines have not gone through the same rigor or economic modelling as the maneuvers being considered for the Lifetime Prevention Schedule.

Delivery Mechanism(s)

The definition of clinical prevention is independent of delivery mechanism(s). In estimating cost-effectiveness, however, we had to make assumptions about delivery mechanisms in order to estimate the costs of providing the service. For purposes of consistency and comparability between the various preventive services, we chose to use a general physician's office as the delivery mechanism whenever appropriate. That is, if an established delivery mechanism is not in place, then we assumed, for costing purposes, that it would take place in a general physician's office. For example, no program currently exists in BC for screening and interventions to reduce falls in community-dwelling elderly so we assumed this would take place in a general physician's office. Determining which delivery mechanism would be most suitable for each service will be assessed in a subsequent phase of this project.

Patient Costs

Clinical prevention services are offered to the asymptomatic general population. As such, people are being asked to give up some of their time for a service which has a (relatively small) chance of detecting a clinically relevant issue. Or, they may be asked to give up some of their time for a behavioural counselling intervention that has a modest potential for success. As such, it is important to value this time in an assessment of the cost-effectiveness of the intervention. For the purposes of consistency and comparability, we have assessed this time by including travel time to and from the intervention as well as time during the intervention and then valued this total time based on average wage rates for the BC population. We have also identified the proportion of costs attributable to patient costs for each maneuver.

Discounting

In the economic appraisal of health programs or interventions, costs and benefits that are spread over time are usually weighted according to when they are experienced. The further in the future, the less heavily they are weighted or the more they are discounted. This can be particularly challenging for interventions in which costs are current and benefits are further in the future (e.g. prevention). The impact of discounting is most noticeable for preventive

services in children and youth, given that costs are generally current while benefits and potential costs avoided may stretch over the lifetime of the individual.[2,3,4,5]

From a health economics perspective, the usual approach is to discount both costs and benefits when calculating cost-effectiveness. However, discounting may fail to reflect a value we as a society might hold for the future of our children. It would thus be important to explicitly understand the impact of discounting in the current project. To do so, we will use both a 3% discount rate as well as a 0% discount rate. A 0% discount rate is equivalent to not discounting.

Incorporating Information on Current Coverage

A number of the preventive services assessed in this project have an established history in the province while others may only be provided in a limited, fairly random approach (as 'random acts of kind prevention'). With this in mind, we set out to assess CPB and CE from two perspectives. First, assuming that the service had no current coverage in the province (i.e. that the service had not yet been established in the province). Second, assessing the gap between current coverage in the province and what arguably could be considered the best possible coverage (based on information on 'best in the world' coverage for the service).

Incorporating Key Recent Evidence

The USPSTF is attempting to update their evidence review and recommendations every five years. It is possible that a landmark study (or studies) have been published during the interval between updates and that these studies may alter recommendations. To take this into account, we reviewed evidence reviews from other organizations (e.g. the Cochrane Collaboration and the National Institute for Health and Clinical Excellence [NICE] in the UK) for any USPSTF or CTFPHC recommendations published more than four years ago.

Focus on the Best Available Evidence

An important assumption of this project is to focus on the highest level of available evidence. Given the limited capacity in the health care system, it is better to focus on a limited number of preventive interventions that are clearly proven to be effective, will have an important impact on the health of the entire population of BC and are likely to be cost-effective. The focus should be on achieving potential coverage and an effective dose for a limited number of preventive services rather than incomplete coverage of a larger number of preventive services.

[2] Parsonage M and Neuburger H. Discounting and health benefits. *Health Economics*. 1992; 1(1): 71-6.
[3] Brouwer WB, Niessen LW, Postma MJ et al. Need for differential discounting of costs and health effects in cost effectiveness analyses. *British Medical Journal*. 2005; 331(7514): 446-8.
[4] Claxton K, Sculpher M, Culyer A et al. Discounting and cost-effectiveness in NICE - stepping back to sort out a confusion. *Health Economics*. 2006; 15(1): 1-4.
[5] Gravelle H, Brouwer W, Niessen L et al. Discounting in economic evaluations: stepping forward towards optimal decision rules. *Health Economics*. 2007; 16(3): 307-17.

List of Abbreviations

ADM – Anti-depressant medication

BC - British Columbia

BiW – Best in the world

BMI - Body mass index

CBT – Cognitive behavioural therapy

CCHS - Canadian Community Health Survey

CE - Cost-effectiveness

CI - Confidence interval

CIN – Cervical intraepithelial neoplasia

CPB - Clinically preventable burden

CPI – Consumer price index

CPPRC - Clinical Prevention Policy Review Committee

CPS - Clinical prevention service

CT - Computed tomography

CTFPHC - Canadian Task Force on Preventive Health Care

EPDS – Edinburgh Postnatal Depression Scale

ES - Executive summary

GPO – General practitioner

HDRS – Hamilton Depression Rating Scale

HIV - Human immunodeficiency virus

HPV - Human papillomavirus

LDCT - Low-dose computed tomography

LEEP – Loop electrosurgical excision procedure

LPS - Lifetime Prevention Schedule

MDE - Major depressive episode

MEND - Mind, Exercise, Nutrition, Do It!

NLST - National Lung Cancer Screening Trial

OR – Odds ratio

PAN-CAN - Pan-Canadian Early Detection of Lung Cancer Study

PET - Positron emission tomography

PHSA - Provincial Health Services Authority

PPD – Post-partum depression

PSBC - Perinatal Services British Columbia

QALY - Quality-adjusted life-year

QoL - Quality of life

RCT - Randomized controlled trial

RR - Relative risk

SIDS – Sudden Infant Death Syndrome

STI - Sexually transmitted infection

USPSTF - United States Preventive Services Task Force Recommendations

WHO - World Health Organization

Behavioural Counseling Interventions

Prevention and Management of Obesity in Children and Youth

Canadian Task Force on Preventive Health Care (CTFPHC; 2015)[6]

> *We recommend growth monitoring[7] at all appropriate[8] 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.

> *We recommend that primary care practitioners not routinely offer structured interventions[9] aimed at preventing overweight and obesity in healthy weight children and youth. (Weak recommendation; very low quality evidence)*

This prevention recommendation applies to all children and youth 0–17 years of age who have a healthy weight. They do not apply to children and youth with eating disorders, or who are underweight, overweight, or obese.

> *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 aimed at healthy weight management. (Weak recommendation; moderate quality evidence)*

> *For children and youth aged 2 to 11 years who are overweight or obese, we recommend that primary care practitioners not offer Orlistat[10] aimed at healthy weight management. (Strong recommendation; very low quality evidence)*

> *For children and youth aged 12 to 17 years who are overweight or obese, we recommend that primary care practitioners not routinely offer Orlistat aimed at healthy weight management. (Weak recommendation; moderate quality evidence)*

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[6] 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.

[7] **Growth monitoring** consists of measurement of height or length, weight and BMI calculation or weight for length according to age.

[8] **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).

[9] **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.

[10] **Orlistat** is a prescription drug designed as an aid for weight loss.

For children and youth aged 2 to 17 years who are overweight or obese, we recommend that primary care practitioners not routinely refer for surgical interventions. (Strong recommendation; very low 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 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."[11]

United States Preventive Services Task Force Recommendations (USPSTF; 2010)[12]

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

Utilization of This Clinical Preventive Service

Currently in British Columbia

Shapedown is a family-based obesity reduction initiative for children and adolescents originally developed in the early 1980s at the University of California.[13, 14] The 10-week program aims to normalize participant weight through group and individualized counselling sessions, which involve the use of workbooks and guides for both parents and children and the application of knowledge learned through active participation.

The original Shapedown program was evaluated in 1987 by Mellin et al. with a randomized control trial (N=66) comparing obese adolescents receiving the Shapedown intervention (n=37) to controls receiving no intervention (n=29).[15] The study spanned 15 months and assessed variables including relative weight (actual weight / expected weight based on age, sex, and height), weight-related behaviour (measured by the Shapedown Habit Inventory), self-esteem (measured by Rosenberg's Self-Esteem Scale), depression (measured by Rosenberg's Depressive Affect Scale), and weight management knowledge (measured by the Shapedown Knowledge Test). Results showed significant improvements in relative weight, weight-related behaviour, self-esteem, depression score, and weight management knowledge for those participating in the Shapedown program, while controls only experienced significant improvements in self-esteem. At the conclusion of the study period (15 months), adolescents receiving the Shapedown intervention had a mean absolute weight loss of 5.15 kg compared to controls.

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[11] 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.

[12] US Preventive Services Task Force. Screening for obesity in children and adolescents: US Preventive Services Task Force recommendation statement. *Pediatrics*. 2010; 125(2): 361-7.

[13] Mellin LM. Managing child and adolescent obesity: The SHAPEDOWN program. *Topics in Clinical Nutrition*. 1991; 6(4): 70-6.

[14] Mellin LM and Frost L. Child and adolescent obesity: the nurse practitioner's use of the SHAPEDOWN method. *Journal of Pediatric Health Care*. 1992; 6(4): 187-93.

[15] Mellin L, Slinkard L and Irwin Jr C. Adolescent obesity intervention: validation of the SHAPEDOWN program. *Journal of the American Dietetic Association*. 1987; 87(3): 333-8.

Shapedown BC was established in 2006 at the BC Children's Hospital in Vancouver and continues to expand across the province with current locations in Vancouver, Richmond (also available in Chinese), Langley, Nanaimo, and Kamloops. Between 2006 and 2013, approximately 1,000 families were referred to Shapedown BC in Vancouver and 700 completed the program. The Vancouver location can accommodate up to 200 families per year. [16,17,18,19,20]

Criteria for program entry to Shapedown BC includes (a) physician referral, (b) age 6-17 years, (c) BMI > 97th percentile for age (according to growth chart) or BMI >85th percentile and co-morbidities or other complex medical or psychosocial profiles, and (d) parent or caregiver participation.[21]

Shapedown BC group sessions occur once per week for 10 weeks with a duration of 2 hours. Sessions are assembled according to child age and consist of 6-10 families. Each session includes 30 minutes of physical activity for the child which is led by a fitness instructor, separate child and parent lessons led by a dietitian or psychologist, and joint family activities related to nutrition or goal-setting/problem-solving led by a dietitian or psychologist. Follow-up sessions are offered on an ongoing basis for families who have completed the program.

A review of Shapedown BC followed a cohort of 119 children and youth before and during the 10 weeks of the intervention.[22] Participants experienced an average 0.89% monthly increase in weight before program entry, compared to a 0.37% monthly decline afterwards, a statistically significant drop of 1.26%. Significant improvements were also seen in physical activity, self-concept and anxiety.

MEND (Mind, Exercise, Nutrition, Do It!) was developed in 2000 in the UK as an early intervention weight management program for families with children who are above a healthy weight and in good health. Evaluations of the program in 2010 showed that children participating in the MEND program had a significant decrease in BMI (at 6 months), waist circumference, systolic blood pressure, and recovery heartrate compared to controls as well as

[16] BC Children's Hospital. *Shapedown BC*. Available at http://www.bcchildrens.ca/our-services/clinics/shapedown-bc. Accessed January 2016.
[17] Ministry of Tourism Sport and the Arts. *News Release - New BC Centre to Help Kids Tackle Obesity*. 2006. BC Legislative Assembly. Available at http://www2.news.gov.bc.ca/news_releases_2005-2009/2006TSA0047-001194.pdf. Accessed January 2016.
[18] 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.
[19] Ministry of Tourism Sport and the Arts. *News Release - New BC Centre to Help Kids Tackle Obesity*. 2006. BC Legislative Assembly. Available at http://www2.news.gov.bc.ca/news_releases_2005-2009/2006TSA0047-001194.pdf. Accessed January 2016.
[20] Ministry of Health. *News Release - More Support Available to Help BC Children Achieve a Healthy Weight*. 2013. Available at http://www2.news.gov.bc.ca/news_releases_2009-2013/2013HLTH0068-000688.htm. Accessed January 2016.
[21] 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.
[22] 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.

significantly higher self-esteem and time spent in physical activity compared to controls at both 6 and 12 months.[23] In addition, the program was found to be highly cost-effective.[24]

Between April 2013 and June 2015, 625 children participated in MEND BC with 12 active sites across the province. Criteria for program entry include (a) age 5-13 years, (b) BMI > 85th percentile for age and no contraindications for participating in physical activity, and (c) parent or caregiver participation. Physicians may recommend MEND, but a referral is not required for program entry.

The intervention spans 10 weeks with 20 group sessions for children ages 7-13 years and 10 group sessions for children ages 5-7 years, which accommodate 15 children per session. Sessions are delivered by trained recreation and/or health leaders and target behaviour change, active living and healthy eating.

In February of 2015, the province launched HealthLink BC's Eating and Activity Program for Kids (HEAPK).[25] This telehealth service is intended to reach children and youth in remote communities where it is not feasible to offer either Shapedown or MEND programs. The program will be evaluated during the coming year.

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 had documented treatment recommendations, usually consisting of general advice regarding diet and exercise.[26]

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."[27]

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.[28]

[23] Sacher PM, Kolotourou M, Chadwick PM et al. Randomized controlled trial of the MEND program: a family-based community intervention for childhood obesity. *Obesity*. 2010; 18(S1): S62-S8.
[24] New Economics Foundation Consulting. *The Social and Economic Value of the MEND 7-13 Programme*. 2010. York Health Economics Consortium. Available at http://www.physicalactivityandnutritionwales.org.uk/documents/740/Final%20report%20nef_YHEC_JULY%202010.pdf. Accessed January 2016.
[25] HealthLink BC. *HealthLink BC Eating and Activity Program for Kids*. 2015. Available at http://www.healthlinkbc.ca/healthyeating/eating-activity-program.html. Accessed February 2016.
[26] 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.
[27] 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.
[28] 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.

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.[29]

Relevant British Columbia Population in 2013

There were 839,395 children and youth ages 0-17 living in BC in 2013. The majority of these children and youth would be eligible for growth monitoring. Based on *measured height and weight* as calculated for the 2004 Canadian Community Health Survey (CCHS), 26.5% of BC children and youth ages 1-17 are either overweight or obese.[30] An estimated 19.9% are overweight (or 167,459 individuals) while a further 6.6% are obese (or 55,064 individuals) (see Table 1-1). The 55,064 children and youth with obesity are most likely to be offered structured behavioural interventions aimed at healthy weight management.

Table 1-1: Estimated Number of Overweight and Obese Children and Youth In British Columbia
By Sex and Age, 2013
Prevalence Based on 2004 CCHS Data

	Male		Female		Total	
Population						
<1	22,604		21,365		43,969	
1 to 3	68,243		64,089		132,332	
4 to 8	116,492		108,765		225,257	
9 to 13	117,441		110,315		227,756	
14 to 17	108,734		101,347		210,081	
Total	**433,514**		**405,881**		**839,395**	
	Overweight	**Obese**	**Overweight**	**Obese**	**Overweight**	**Obese**
Prevalence						
<1	-	-	-	-	-	-
1 to 3	11.5%	8.5%	13.9%	2.1%	12.9%	4.7%
4 to 8	17.3%	2.2%	11.4%	13.6%	14.2%	8.2%
9 to 13	32.8%	6.1%	22.2%	4.7%	27.6%	5.4%
14 to 17	20.0%	10.1%	18.5%	3.8%	19.2%	6.8%
Total	23.1%	6.3%	17.1%	6.8%	19.9%	6.6%
	Overweight	**Obese**	**Overweight**	**Obese**	**Overweight**	**Obese**
# of Individuals						
<1	-	-	-	-	-	-
1 to 3	7,822	5,780	8,938	1,375	17,129	6,215
4 to 8	20,210	2,600	12,386	14,812	31,997	18,555
9 to 13	38,504	7,219	24,532	5,136	62,841	12,327
14 to 17	21,721	10,994	18,759	3,875	40,341	14,272
Total	**99,965**	**27,448**	**69,434**	**27,474**	**167,459**	**55,064**

Modelling CPB and CE

In this section, we will calculate the CPB and 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 aged 2 to 17 years who are overweight or obese.

[29] 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.
[30] Statistics Canada. Canadian Community Health Survey (CCHS) - Nutrition, 2004 Public Use Microdata file (Catalogue number 82M0024GPE). 2004: All computations, use and interpretation of these data are entirely that of H. Krueger & Associates Inc.

In estimating CPB, we made the following assumptions:

- Data on the proportion of each sex within the population that is expected to survive to a given age group within a BC birth cohort of 40,000 is based on life tables for 2009 to 2011 for BC.[31] A birth cohort of 40,000 would generate 3.1 million years of life, 1.5 million in males and 1.6 million in females (see Table 1-2).
- We assumed that, without any intervention, the 20.0% of 14-17 year old males and 18.5% of 14-17 year old females who are overweight would remain so for the rest of their lives (see Table 1-1). A similar assumption was made for the 10.1% of 14-17 year old males and 3.8% of 14-17 year old females who are obese. This is based on evidence that excess weight in children/youth often persists into adulthood.[32,33,34] Based on this assumption, of the total 1.5 million life years in the male birth cohort (see Table 1-5, row a), 310,130 would be lived as overweight (see Table 1-5, row b) and 142,722 as obese (see Table 1-5, row c). Similarly, of the total 1.6 million life years in the female birth cohort (see Table 1-5, row d), 287,472 would be lived as overweight (see Table 1-5, row e and 69,928 as obese (see Table 1-5, row f).

Table 1-2: Years of Life as Overweight or Obese in a Birth Cohort of 40,000

Age Group	Mean Survival Rate		Individuals in Birth Cohort		Years of Life in Birth Cohort		% Overweight		Years of Life Overweight		% Obese		Years of Life Obese	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
0-4	99.6%	99.6%	19,921	19,925	99,603	99,627	11.5%	13.9%	11,417	13,894	8.5%	2.1%	8,436	2,138
5-9	99.5%	99.6%	19,908	19,915	99,541	99,574	17.3%	11.4%	17,269	11,339	2.2%	13.6%	2,222	13,561
10-14	99.5%	99.5%	19,899	19,909	99,496	99,547	32.8%	22.2%	32,621	22,138	6.1%	4.7%	6,116	4,635
15-19	99.4%	99.5%	19,876	19,897	99,378	99,485	20.0%	18.5%	19,852	18,415	10.1%	3.8%	10,048	3,804
20-24	99.1%	99.3%	19,814	19,869	99,072	99,345	20.0%	18.5%	19,791	18,389	10.1%	3.8%	10,017	3,798
25-29	98.7%	99.2%	19,736	19,836	98,679	99,180	20.0%	18.5%	19,712	18,358	10.1%	3.8%	9,978	3,792
30-34	98.3%	99.0%	19,652	19,798	98,262	98,992	20.0%	18.5%	19,629	18,323	10.1%	3.8%	9,936	3,785
35-39	97.7%	98.7%	19,548	19,744	97,742	98,721	20.0%	18.5%	19,525	18,273	10.1%	3.8%	9,883	3,774
40-44	97.1%	98.3%	19,410	19,665	97,052	98,324	20.0%	18.5%	19,387	18,200	10.1%	3.8%	9,813	3,759
45-49	96.1%	97.7%	19,218	19,547	96,090	97,736	20.0%	18.5%	19,195	18,091	10.1%	3.8%	9,716	3,737
50-54	94.7%	96.9%	18,938	19,372	94,690	96,861	20.0%	18.5%	18,915	17,929	10.1%	3.8%	9,574	3,703
55-59	92.6%	95.5%	18,519	19,108	92,594	95,542	20.0%	18.5%	18,497	17,685	10.1%	3.8%	9,362	3,653
60-64	89.4%	93.5%	17,887	18,704	89,435	93,520	20.0%	18.5%	17,865	17,311	10.1%	3.8%	9,043	3,576
65-69	84.7%	90.4%	16,935	18,074	84,673	90,371	20.0%	18.5%	16,914	16,728	10.1%	3.8%	8,562	3,455
70-74	77.6%	85.4%	15,514	17,086	77,572	85,428	20.0%	18.5%	15,496	15,813	10.1%	3.8%	7,844	3,266
75-79	67.3%	77.7%	13,453	15,540	67,263	77,698	20.0%	18.5%	13,436	14,382	10.1%	3.8%	6,801	2,971
80+	53.1%	65.9%	10,623	13,187	53,114	65,933	20.0%	18.5%	10,610	12,204	10.1%	3.8%	5,370	2,521
Total					**1,544,255**	**1,595,884**	**20.1%**	**18.0%**	**310,130**	**287,472**	**9.2%**	**4.4%**	**142,722**	**69,928**

- Excess weight has a negative effect on an individual's QoL with reductions of 2.3% associated with being overweight and 6.8% for obesity.[35] 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.[36]

[31] See http://www.statcan.gc.ca/pub/84-537-x/2013005/tbl-eng.htm. Accessed January 2016.
[32] Whitaker RC, Wright JA, Pepe MS et al. Predicting obesity in young adulthood from childhood and parental obesity. *New England Journal of Medicine*. 1997; 337(13): 869-73.
[33] Freedman DS, Khan LK, Serdula M et al. The relation of childhood BMI to adult adiposity: the Bogalusa Heart Study. *Pediatrics*. 2005; 115(1): 22-7.
[34] Herman KM, Craig CL, Gauvin L et al. Tracking of obesity and physical activity from childhood to adulthood: the Physical Activity Longitudinal Study. *International Journal of Pediatric Obesity*. 2009; 4(4): 281-8.
[35] 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.
[36] Williams J, Wake M, Hesketh K et al. Health-related quality of life of overweight and obese children. *JAMA*. 2005; 293(1): 70-6.

For modelling purposes we assumed a disutility of 2.3% (ranging from 1.5% to 3.7%) with overweight (Table 1-5, row g) and 6.8% (ranging from 5.5% to 8.1%) with obesity (Table 1-5, row h).

- Excess weight also reduces an individual's longevity.[37,38] Research by Fontaine and colleagues[39] suggests that the number of life years lost increases with increasing levels of excess weight (see Table 1-3).

Table 1-3: Years of Life Lost Due to Overweight and Obesity for an 18 Year-old
Relative to BMI = 24

	Overweight	Obese Class I	Obese Class II	Obese Class III
White Males	0.8	2.2	4.2	7.8
White Females	0.4	1.6	3.4	5.7

Source: Fontaine et al., JAMA, 2003

For modelling purposes, we assumed a decrease in longevity of 0.6 years (the mean for males and females) associated with being overweight (Table 1-5, row q) and a decrease in longevity of 2.9 years (the midpoint of the mean for males and females for obese class I and II) associated with being obese (Table 1-5, row r). We varied this from 0.4 to 0.8 for overweight and 1.9 and 3.8 for obesity in the sensitivity analysis.

- Between January 2013 and June 2015, 1,071 children and their parent(s) were referred to Shapedown BC (see Table 1-4).[40] After a comprehensive screening process, 594 of the 1,071 (55%) had care plans completed. Of the 594, 75% (446) completed a feedback session and indicated a desire to participate in the intervention. Most but not all of these 446 (395 or 89%) attended the first of the 10 Shapedown BC sessions. Finally, of the 395 who commenced the program, 292 (74%) completed at least 70% of the sessions (see Table 1-4). The gap between referral and program completion has closed significantly since the initiation of Shapedown BC. In 2013, just 13% of those referred to the program ultimately completed it. This increased to 31% in 2014 and 39% in 2015 (see Table 1-4).

[37] 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.
[38] 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.
[39] Fontaine KR, Redden DT, Wang C et al. Years of life lost due to obesity. *JAMA*. 2003; 289(2): 187-93.
[40] HealthyFamiliesBC. *Provincial Management and Evaluation Report Cycles I-VII: January 2013 – June 2015*. September 2015.

Table 1-4: Utilization of Shapedown BC

January 2013 to June 2015

	Calendar Year			
	2013	2014	2015 (to June)	Total
Total Referrals	344	470	257	**1,071**
Intake Assessment and Care Plans Completed	177	277	140	**594**
% Referral to Intake	51%	59%	54%	**55%**
Assigned to Intervention	75	214	157	**446**
% Intake to Assignment	42%	77%	112%	**75%**
Commenced Intervention	67	192	136	**395**
% Assignment to Commencement	89%	90%	87%	**89%**
Completed Intervention	45	148	99	**292**
% Commencement to Completion	67%	77%	73%	**74%**
Proportion of Total Referrals who Completed Intervention	***13%***	***31%***	***39%***	***27%***

- A current evaluation of Shapedown BC, based on a simple pre- and post-intervention design, found that the successful completion of the program led to a statistically significant improvement in participant's QoL, confidence, BMI, physical activity, physical appearance and selected nutrition indicators. No data is provided, however, on the proportion of children / youth who benefited and how long the benefit lasted.[41]
- As noted above, a previous review of Shapedown BC followed a cohort of 119 children and youth during the 10 weeks of the intervention. Participants experienced an average 0.89% monthly increase in weight before program entry, compared to a 0.37% monthly decline afterwards, a statistically significant drop of 1.26%. Significant improvements were also seen in physical activity, self-concept and anxiety. The authors of the review note "the need for ongoing evaluation to assess the long-term implications of this unique program and ultimately optimize utilization of governmental resources."[42]
- The systematic review and meta-analysis for the CTFPHC found that the overall effectiveness of interventions resulted in a -0.53 drop in BMI (95% CI from -0.69 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 QoL.[43]
- Interventions reduced the prevalence of overweight from 40% to 35% and obesity from 33% to 31% over a duration of up to 36 months.[44]

[41] Childhood Obesity Foundation. *Childhood Healthy Weights Intervention Initiative: Shifting the Destination by Shifting the Trajectory - Evaluation Report*. 2015. Available at http://childhoodobesityfoundation.ca/wp-content/uploads/2015/02/CHWII-Healthy-Weights-Evaluation-Report-Exec-Summary.pdf. Accessed March 2016.
[42] 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.
[43] 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.
[44] 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.

- Improvements in QoL appear to be positively correlated with weight loss.[45] One small study found a clinically important improvement in 22% (4 of 18) of the children/youth who successfully completed a multidisciplinary lifestyle program.[46]
- For modelling purposes we assumed that a weight management program would reduce overweight by 12.5% (Table 1-5, row ak) and obesity by 6.1% (Table 1-5, row al) (based on the reduction in the prevalence of overweight from 40% to 35% and obesity from 33% to 31% noted above[47]). We also assumed the increase in QoL associated with the successful completion of a weight management program would be maintained long-term for 22% of participants (Table 1-5, row an and ao). This assumption was varied in the sensitivity analysis from 12.5% for overweight and 6.1% for obese to 30% for both overweight and obese.
- The children in families that do not have a regular PCP are unlikely to enter into a weight monitoring/management process. Based on 2012 CCHS data, 89% of families in BC have a regular PCP (Table 1-5, row ad).[48]
- We noted earlier that the regular assessment of BMI by primary care providers (PCPs) is relatively poor. For modelling purposes we assumed that 30% of PCPs would regularly monitor BMI (Table 1-5, row ae with a range from 20% to 40%) and that 70% of these PCPs would refer overweight and obese children youth to a weight management program (Table 1-5, row af with a range from 60% to 80%). Furthermore, we assumed that 39% of families referred to a weight management program would successfully complete the program (Table 1-5, row ag with a range from 29% to 49%).
- The USPSTF review grouped interventions by intensity as follows: very low (<10 hours), low (10-25 hours), moderate (26-75 hours) or high (>75 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. Only comprehensive interventions of moderate to high intensity were effective (a reduction of between 1.9 to 3.3kg/m^2 at 12 months).[49,50]

Based on these assumptions, the 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 is 318 QALYs (see Table 1-5, row ar). The CPB of 318 represents the gap between no coverage and the 'best in the world' growth monitoring coverage, which was estimated at 30%. While we are unable to determine the level of growth monitoring currently occurring in BC, it is clearly greater than 0%, given the existing referrals to weight management programs

[45] Dreimane D, Safani D, MacKenzie M et al. Feasibility of a hospital-based, family-centered intervention to reduce weight gain in overweight children and adolescents. *Diabetes Research and Clinical Practice*. 2007; 75(2): 159-68.

[46] Vignolo M, Rossi F, Bardazza G et al. Five-year follow-up of a cognitive-behavioural lifestyle multidisciplinary programme for childhood obesity outpatient treatment. *European Journal of Clinical Nutrition*. 2008; 62(9): 1047-57.

[47] 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.

[48] 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.

[49] US Preventive Services Task Force. Screening for obesity in children and adolescents: US Preventive Services Task Force recommendation statement. *Pediatrics*. 2010; 125(2): 361-7.

[50] Whitlock EP, O'Connor EA, Williams SB et al. Effectiveness of weight management interventions in children: a targeted systematic review for the USPSTF. *Pediatrics*. 2010; 125(2): e396-e418.

for children/youth such as Shapedown and MEND. If current growth monitoring is at 15%, then the gap between current coverage and 'best in the world' coverage would be 159 QALYs (see Table 1-5, row aq).

Table 1-5: CPB of Screening for and Management of Obesity in Children / Youth in a Birth Cohort of 40,000

Row Label	Variable	Base Case	Data Source
	Current State		
a	Years of life lived in the birth cohort - males	1,544,255	Table 1-2
b	Years of life lived with overweight in the birth cohort - males	310,130	Table 1-2
c	Years of life lived with obesity in the birth cohort - males	142,722	Table 1-2
d	Years of life lived in the birth cohort - females	1,595,884	Table 1-2
e	Years of life lived with overweight in the birth cohort - females	287,472	Table 1-2
f	Years of life lived with obesity in the birth cohort - females	69,928	Table 1-2
g	Disutility associated with overweight	2.3%	√
h	Disutility associated with obesity	6.8%	√
i	QALYs lost due to overweight - males	7,133	= b * g
j	QALYs lost due to obesity - males	9,705	= c * h
k	QALYs lost due to overweight - females	6,612	= e * g
l	QALYs lost due to obesity - females	4,755	= f * h
m	Overweight males at age 18	3,970	Table 1-2
n	Obese males at age 18	2,010	Table 1-2
o	Overweight females at age 18	3,683	Table 1-2
p	Obese females at age 18	761	Table 1-2
q	Life years lost due to overweight per individual	0.6	√
r	Life years lost due to obesity per individual	2.9	√
s	Life years lost due to overweight - males	2,382	= m * q
t	Life years lost due to obesity - males	5,828	= n * r
u	Life years lost due to overweight - females	2,210	= o * q
v	Life years lost due to obesity - females	2,206	= p * r
w	Total QALYs lost due to overweight - males	9,515	= i + s
x	Total QALYs lost due to obesity - males	15,533	= j + t
y	Total QALYs lost due to excess weight in males	25,048	= w + x
z	Total QALYs lost due to overweight - females	8,822	= k + u
aa	Total QALYs lost due to obesity - females	6,961	= l + v
ab	Total QALYs lost due to excess weight in females	15,783	= z + aa
ac	Total QALYs lost due to excess weight in birth cohort	40,831	= y + ab
	Effect of Intervention		
ad	BC families with a regular primary care provider (PCP)	89%	√
ae	Proportion of PCPs who regularly assess BMI	30%	Assumed
af	Proportion of PCPs who regularly assess BMI who would refer children/youth with excess weight to a weight management program	70%	Assumed
ag	Proportion of children/youth who would successfully complete a weight management program	39%	√
ah	Number of overweight individuals who would successfully complete a weight management program	289	= m * ad * ae * af * ag
ai	Number of obese individuals who would successfully complete a weight management program	146	= n * ad * ae * af * ag
aj	Years of life lived by an 8-year old in this subgroup	74	√
ak	Decrease in prevalance of overweight associated with intervention	12.5%	√
al	Decrease in prevalance of obesity associated with intervention	6.1%	√
am	Life-years gained with intervention	48	= (ah * q * ak)+(ai * r * al)
an	Proportion of indidvuals with overweight benefitting from an improvement in QoL	22.0%	√
ao	Proportion of indidvuals with overweight benefitting from an improvement in QoL	22.0%	√
ap	QALYs gained due to intervention	271	= (ah * aj * g * an)+(ai * aj * h *ao)
aq	**Potential QALYs gained, Intervention increasing from 15% to 30%**	**159**	= as / 2
ar	**Potential QALYs gained, Intervention increasing from 0% to 30%**	**318**	= am + ao

√ = Estimates from the literature

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

- Assume the disutility associated with overweight is reduced from 2.3% to 1.5% and the disutility associated with obesity is reduced from 6.8% to 5.5% (Table 1-5, row g & h): CPB = 249.
- Assume the disutility associated with overweight is increased from 2.3% to 3.7% and the disutility associated with obesity is increased from 6.8% to 8.1% (Table 1-5, row g & h): CPB = 415.
- Assume that the life years lost due to overweight per individual is reduced from 0.6 years to 0.4 years and the life years lost due to obesity per individual is reduced from 2.9 years to 1.9 years (Table 1-5, row q & r): CPB = 302.
- Assume that the life years lost due to overweight per individual is increased from 0.6 years to 0.8 years and the life years lost due to obesity per individual is increased from 2.9 years to 3.8 years (Table 1-5, row q & r): CPB = 333.
- Assume that the proportion of PCPs who regularly assess BMI is reduced from 30% to 20% (Table 1-5, row ae): CPB = 212.
- Assume that the proportion of PCPs who regularly assess BMI is increased from 30% to 40% (Table 1-5, row ae): CPB = 424.
- Assume that the proportion who regularly assess BMI who would refer children/youth with excess weight to a weight management program is reduced from 70% to 60% (Table 1-5, row af): CPB = 273.
- Assume that the proportion who regularly assess BMI who would refer children/youth with excess weight to a weight management program is increased from 70% to 80% (Table 1-5, row af): CPB = 364.
- Assume that the proportion of children/youth who successfully complete a weight management program after being referred is reduced from 39% to 29% (Table 1-5, row ag): CPB = 237.
- Assume that the proportion of children/youth who would successfully complete a weight management program after being referred is increased from 39% to 49% (Table 1-5, row ag): CPB = 400.
- Assume that the proportion of children/youth who maintain improvement in QoL after successfully completing a weight management program is reduced from 22% to 12.5% and 6.1% for children / youth who are overweight/obese (Table 1-5, row an & ao): CPB = 154.
- Assume that the proportion of children/youth who maintain improvement in QoL after successfully completing a weight management program is increased from 22% to 30% (Table 1-5, row an & ao): CPB = 417.

In estimating CE, we made the following assumptions:

- **Frequency of screening** – 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)."[51] 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.[52] For modelling purposes, we have assumed that growth monitoring would occur annually between the ages of 0-17 at a well-child visit (Table 1-6, row d).

- **Cost of office visit** - We estimated the average cost of a visit to a General Practitioner to be $34.00 (Table 1-6, row f).[53] We assumed that 30% of a 10-minute office visit would be required for the screening and varied this from 20% to 40% in the sensitivity analysis (Table 1-6, row h).
- **Patient time and travel costs** - For patient time and travel costs, we assumed an hourly wage of $24.39 (the BC average in 2013)[54] plus 18% benefits applied to the estimated two hours of patient time required for a cost per physician visit of $57.56 (Table 1-6, row g). We also estimated patient time costs of participating in the intervention based on 10 2-hour sessions and 1 hour of travel time per session, or 30 hours times $28.78 = $863 (Table 1-6, row o).
- **Program costs** - Holingworth and colleagues estimated a range of program costs between £108 and £662 (in 2009 British pounds) per child based on a review of ten lifestyle interventions to treat overweight and obesity in children.[55] We converted these costs to equivalent Canadian health care costs in 2013 by adjusting for differences between the British pound and Canadian dollars in 2009 (+69.5%)[56] and then adjusting these costs to 2013 Canadian dollars using the health and personal care component of the BC Consumer Price Index (CPI)[57] (+0.0%), for a cost of $183 to $1,122 per child. For modelling purposes we used the mid-point for the base case scenario ($653) and the range in the sensitivity analysis (Table 1-6, row l & m).
- Overweight and obesity are associated with higher annual **medical care costs** than normal weight (e.g., hospitalization, physician, drug, etc. costs). For modelling purposes we have assumed that these costs average $235 per year for overweight (with a range from $165 to $300) (Table 1-6, row r) and $794 for obesity (with a range from $599 to $986) (Table 1-6, row u).[58] Furthermore, the costs would be avoided during the remaining lifetime of the individual after a successful weight management program. We also modified this assumption so that costs would only be avoided for a five year period after a successful weight management program.

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[51] 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.

[52] 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 April 2016.

[53] Medical Services Commission. *Payment Schedule: Section 7 General Practice*. 2013. Available at http://www.health.gov.bc.ca/msp/infoprac/physbilling/payschedule/pdf/7-general-practice.pdf. Accessed December 2013.

[54] Statistics Canada. *Average Hourly Wages of Employees by Selected Characteristics and Occupation, Unadjusted Data, by Province (Monthly) (British Columbia)*. 2013. Available at http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/labr69k-eng.htm. Accessed December 2013.

[55] Hollingworth W, Hawkins J, Lawlor D et al. Economic evaluation of lifestyle interventions to treat overweight or obesity in children. *International Journal of Obesity*. 2012; 36(4): 559-66.

[56] See http://www.exchangerates.org.uk/GBP-CAD-31_12_2009-exchange-rate-history.html. Accessed January 2016.

[57] Statistics Canada. *Consumer Price Index, Health and Personal Care, by Province (Monthly) (British Columbia)*. 2013. Available at http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/cpis13f-eng.htm. Accessed January 2016.

[58] Krueger H, Krueger J and 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): 171-7.

- Discount rate of 3%.

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 overweight or obese is $41,106 / QALY (Table 1-6, row ac).

Table 1-6: CE of Screening for and Management of Obesity in Children / Youth in a Birth Cohort of 40,000

Row Label	Variable	Base Case	Data Source
a	Years of life lived in birth cohort from 0-17	716,707	Table 1-2
b	BC families with a regular primary care provider (PCP)	89%	Table 1-5, row ad
c	Proportion of PCPs who regularly assess BMI	30%	Table 1-5, row ae
d	Number of assessments per year	1	Assumed
e	Total number of screens	191,361	= a * b * c * d
	Costs of Screening		
f	Cost of 10-minute office visit	$34.00	√
g	Value of patient time and travel for office visit	$57.56	√
h	Portion of 10-minute office visit for screen/referral	30%	Assumed
i	Estimated cost of screening	**$5,256,296**	= (e * f * h)+(e * g * h)
	Costs of Intervention		
j	Number of obese individuals successfully completing a weight management program	146	Table 1-5, row ai
k	Number of overweight individuals successfully completing a weight management program	289	Table 1-5, row ah
l	Cost of intervention per obese individual	$653	√
m	Cost of intervention per overweight individual	$653	√
n	Cost of intervention	**$284,637**	= (j * l)+(k *m)
o	Value of patient time and travel per intervention	$863	√
p	Total value of patient time and travel for interventions	**$376,349**	= (j + k) *o
	Cost avoided		
q	Years of overweight avoided	2,677	Table 1-5, row ah * Table 1-5, row aj * Table 1-5, row ak
r	Medical care costs per year associated with overweight	$235	√
s	Costs avoided	$629,090	= q * r
t	Years of obesity avoided	661	Table 1-5, row ai * Table 1-5, row aj * Table 1-5, row al
u	Medical care costs per year associated with obesity	$794	√
v	Costs avoided	$525,031	= t * u
	CE calculation		
w	Cost of intervention over lifetime of birth cohort	$5,917,282	= i + n + p
x	Costs avoided	$1,154,121	= s + v
y	QALYs saved	318	Table 1-5, row ar
z	Cost of intervention over lifetime of birth cohort (3% discount)	$4,720,286	Calculated
aa	Costs avoided (3% discount)	$382,782	Calculated
ab	QALYs saved (3% discount)	106	Calculated
ac	**CE ($/QALY saved)**	**$41,106**	= (z - aa) / ab

√ = Estimates from the literature

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

- Assume the disutility associated with overweight is reduced from 2.3% to 1.5% and the disutility associated with obesity is reduced from 6.8% to 5.5% (Table 1-5, row g & h): CE = $52,426.

- Assume the disutility associated with overweight is increased from 2.3% to 3.7% and the disutility associated with obesity is increased from 6.8% to 8.1% (Table 1-5, row g & h): CE = $31,504.
- Assume that the proportion of children/youth who successfully complete a weight management program after being referred is reduced from 39% to 29% (Table 1-5, row ag): CE = $54,808.
- Assume that the proportion of children/youth who would successfully complete a weight management program after being referred is increased from 39% to 49% (Table 1-5, row ag): CE = $32,997.
- Assume that the proportion of children/youth who maintain improvement in QoL after successfully completing a weight management program is reduced from 22% to 12.5% and 6.1% for children / youth who are overweight/obese (Table 1-5, row an & ao): CE = $84,837.
- Assume that the proportion of children/youth who maintain improvement in QoL after successfully completing a weight management program is increased from 22% to 30% (Table 1-5, row an & ao): CE = $31,398.
- Assume that the proportion of an office visit for weight measurement is decreased from 30% to 20% (Table 1-6, row h): CE = $27,860.
- Assume that the proportion of an office visit for weight measurement is increased from 30% to 40% (Table 1-6, row h): CE = $54,352.
- Assume that the cost of the weight management program per individual is reduced from $2,295 to $1,836 (Table 1-6, row l & m): CE = $39,557.
- Assume that the cost of the weight management program per individual is increased from $2,295 to $2,754 (Table 1-6, row l & m): CE = $42,652.
- Assume that the annual medical care costs avoided associated with overweight are reduced from $235 to $165 (Table 1-6, row r) and from $794 to $599 for obesity (Table 1-6, row u): CE = $42,105.
- Assume that the annual medical care costs avoided associated with overweight are increased from $235 to $300 (Table 1-6, row r) and from $794 to $986 for obesity (Table 1-6, row u): CE = $40,159.
- Assume that costs avoided would only last for five years, rather than a lifetime, after a successful weight management program (Table 1-6, rows s and v): CE = $42,645.

Summary

Table 1-7: Screening for and Management of Obesity in Children / Youth in a Birth Cohort of 40,000

Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Assume No Current Service			
3% Discount Rate	106	51	141
0% Discount Rate	318	154	424
Gap between B.C. Current (15%) and Best in the World (30%)			
3% Discount Rate	53	26	71
0% Discount Rate	159	77	212
CE ($/QALY) **including** patient time costs			
3% Discount Rate	$41,106	$27,860	$84,837
0% Discount Rate	$14,971	$9,464	$30,899
CE ($/QALY) **excluding** patient time costs			
3% Discount Rate	$13,280	$8,361	$27,408
0% Discount Rate	$3,402	$1,357	$7,022

Screening for Asymptomatic Disease or Risk Factors

Screening for Lung Cancer

Canadian Task Force on Preventive Health Care (2016)[59]

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.)

United States Preventive Services Task Force Recommendations (2014)[60]

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)

Utilization of This Clinical Preventive Service

Currently in British Columbia

Screening for lung cancer is not routinely provided in BC. The BC Cancer Agency is enrolling patients in the Lung Health Study who are current or former smokers, are between 45-74 years of age and have smoked at least 30 pack-years.[61] This study uses a lung imaging fluorescence endoscope to detect precancerous or early cancers in the lung.

Screening for lung cancer using low-dose computed tomography (LDCT) is available privately at the False Creek Healthcare Centre.[62]

[59] Canadian Task Force on Preventive Health Care. Recommendations on screening for lung cancer. *Canadian Medical Association Journal*. 2016: 1-8.
[60] Moyer VA. Screening for lung cancer: US Preventive Services Task Force recommendation statement. *Annals of Internal Medicine*. 2014; 160(5): 330-8.
[61] BC Cancer Agency. *Lung*. 2015. Available at http://www.bccancer.bc.ca/health-info/types-of-cancer/lung/lung. Accessed December 2015.
[62] False Creek Healthcare Centre. *CT Lung Cancer Screening*. 2015. Available at http://www.falsecreekdiagnostics.com/services/ct-scan-cat-scan/ct-lung-cancer-screening/. Accessed December 2015.

The Vancouver general Hospital (VGH) Early Lung Cancer Screening Pilot Program will use LDCT and is expected to launch in 2016. An estimated 2,000 high risk individuals will be enrolled over a three year period with follow-up for two years.[63]

Best in the World

There is limited information on actual screening rates using LDCT, particularly following the 2014 recommendation by the USPSTF (see above).

Several research projects have asked high-risk smokers whether or not they would be willing to undergo screening with LDCT. In the US, 82% of high-risk smokers said they would participate in screening if their physician recommended it.[64] However, only 32% said they would undergo screening if they had to pay for it. In Ireland, this proportion reached 98%, with 67% willing to pay for the screening.[65] Similarly high 'willingness to screen' rates (96%) have also been noted in Australia.[66]

Models assessing the cost-effectiveness of lung cancer screening make a variety of assumptions with respect to adherence to lung cancer screening, with adherence estimates ranging from 60% to 100%.[67,68,69] Given the research noted above, 80% adherence is a realistic assumption, with sensitivity analysis ranging from 70-90%.

Relevant British Columbia Population in 2013

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 in 2010, 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).[70] 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.

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[63] VGH UBC Hospital Foundation. *Innovative Lung Cancer Screening Pilot Protram to Launch at VGH*. 2015. Available at http://vghfoundation.ca/news/innovative-lung-cancer-screening-pilot-program-to-launch-at-vgh/. Accessed December 2015.

[64] Jonnalagadda S, Bergamo C, Lin JJ et al. Beliefs and attitudes about lung cancer screening among smokers. *Lung Cancer*. 2012; 77(3): 526-31.

[65] Pallin M, Walsh S, O'Driscoll MF et al. Overwhelming support among urban Irish COPD patients for lung cancer screening by low-dose CT scan. *Lung*. 2012; 190(6): 621-8.

[66] Flynn AE, Peters MJ, Morgan LC. Attitudes towards lung cancer screening in an Australian high-risk population. *Lung Cancer International*. 2013; doi: 10.1155/2013/789057

[67] 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.

[68] McMahon PM, Kong CY, Bouzan C et al. Cost-effectiveness of computed tomography screening for lung cancer in the United States. *Journal of Thoracic Oncology*. 2011; 6(11): 1841-8.

[69] Goffin JR, Flanagan WM, Miller AB et al. Cost-effectiveness of lung cancer screening in Canada. *JAMA Oncology*. 2015; 1(6): 807-13.

[70] 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.

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 2-1).

Table 2-1: 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 79**
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 F(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.[71]

Modelling CPB and CE

In this section, we will calculate the CPB and 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 estimating CPB, we made the following assumptions:

- Sex and age-specific lung cancer incidence and mortality rates were calculated based on data from the BC Cancer Agency for the five-year period from 2004 to 2008 (see Table 2-2).[72]

Table 2-2: Lung Cancer Incidence and Mortality
British Columbia, 2004-2008

Average Age within Age Group	Population		Incidence		Mortality		Rate per 100,000 Incidence		Rate per 100,000 Mortality	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
57.5	706,049	719,661	609	574	452	398	86.3	79.8	64.0	55.3
62.5	551,372	560,328	839	771	631	565	152.2	137.6	114.4	100.8
67.5	420,580	435,814	993	989	800	749	236.1	226.9	190.2	171.9
72.5	350,289	368,768	1,084	990	1,032	786	309.5	268.5	294.6	213.1

Source: Woods R. Age-Period-Cohort Analysis of Cancer Incidence and Mortality in British Columbia. BC Cancer Agency, December, 2011.

[71] Goffin JR, Flanagan WM, Miller AB et al. Cost-effectiveness of lung cancer screening in Canada. *JAMA Oncology*. 2015; 1(6): 807-13.

[72] Woods R. *Age-Period-Cohort Analysis of Cancer Incidence and Mortality in British Columbia*. 2011. Canadian Partnership Against Cancer and BC Cancer Agency. Available at http://www.cancerview.ca/idc/groups/public/documents/webcontent/cproj_c11_apc_analysis_bc.pdf. Accessed December 2015.

- The data on lung cancer incidence and mortality from Table 2-2 was combined with data on the proportion of each sex within the population that is expected to survive to a given age group (based on life tables for 2009 to 2011 for BC[73]) within a BC birth cohort of 40,000. There would be an estimated 1,035 deaths from lung cancer between the ages of 55 and 74 in a birth cohort of 40,000 (see Table 2-3). That is, 2.59% (1,035 / 40,000) of individuals within the birth cohort are currently expected to die of lung cancer. Each death from lung cancer would be associated with 19.5 years of life lost for a total of 20,188 life years lost.

Table 2-3: Estimated Lung Cancer Incidence, Mortality and Life Years Lost
In a BC Birth Cohort of 40,000

Age Group	Incidence Rate per 100,000		Mortality Rate per 100,000		# of Life Years Lived from Age x to x+5 in Birth Cohort of 40,000*		# of Incident Cancers			# of Deaths			Average Life Expectancy*			Life Years Lost		
	Males	Females	Males	Females	Males	Females	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total
55-59	86.3	79.8	64.0	55.3	91,787	96,375	79	77	156	59	53	112	26.29	29.37	27.75	1,545	1,566	3,110
60-64	152.2	137.6	114.4	100.8	88,655	94,335	135	130	265	101	95	197	22.08	24.92	23.46	2,241	2,371	4,611
65-69	236.1	226.9	190.2	171.9	83,935	91,159	198	207	405	160	157	316	18.12	20.66	19.38	2,894	3,237	6,131
70-74	309.5	268.5	294.6	213.1	76,895	86,173	238	231	469	227	184	410	14.47	16.65	15.44	3,278	3,057	6,336
							650	645	1,295	546	489	1,035	18.22	20.93	19.50	9,957	10,231	20,188

* Statistics Canada. Life Tables, British Columbia, 2009 to 2011. Available at http://www.statcan.gc.ca/pub/84-537-x/84-537-x2013005-eng.htm. Accessed December 2015.

- 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 2-5, row j) with LDCT (CT group) or single-view posteroanterior chest radiography (X-ray group).[74] 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 2-5, 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 2-5, row m). Of these positive screens, 96.4% were false positives (see Table 2-5, row o).
- 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).[75]
- At least four ongoing RCTs assessing LDCT lung cancer screening should provide additional evidence in the near future.[76]
- 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 2-4).[77,78]

[73] See http://www.statcan.gc.ca/pub/84-537-x/2013005/tbl-eng.htm. Accessed December 2015.
[74] 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.
[75] 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.
[76] Ibid.
[77] Ibid.
[78] Field J, Duffy S, Baldwin D et al. UK Lung Cancer RCT Pilot Screening Trial: baseline findings from the screening arm provide evidence for the potential implementation of lung cancer screening. *Thorax*. 2016; 71: 161-70.

Table 2-4: 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.

- We have assumed that adherence with screening would be 80% (see Table 2-5, row k), with sensitivity analysis using a range from 70-90%, as noted above.
- Screening with LDCT is also associated with a number of 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.[79]
- **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."[80] 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 2-5, 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."[81] 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."[82] 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."[83] 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.

[79] 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.
[80] Ibid.
[81] Ibid.
[82] Ibid.
[83] Ibid.

- Minor (e.g., fine-needle aspiration biopsy or fine-needle aspiration cytology, thoracic or lymph node biopsy, bronchoscopy) and major (e.g., video-assisted thoracoscopic surgery, thoracotomy, surgical resection) **invasive procedures initiated as a result of false positive screening tests**. Based on a review of seven studies, the CTFPHC found that 0.72% (95% CI of 0.33% to 1.11%) of individuals with benign conditions underwent minor invasive procedures. Based on a further review of 17 studies, the CTFPHC found that 0.50% (95% CI of 0.37% to 0.63%) of individuals with benign conditions underwent major invasive procedures. [84]
- We have assumed no changes in **QoL** associated with a false positive screen[85] but adjusted this to a disutility of 0.05 in the sensitivity analysis (see Table 2-5, row q).[86]
- 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.[87] 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.[88] 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%. 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.[89] Based on this approach, 80% of first screens placed patients in Category I (<1.5% lung cancer risk over

[84] 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.
[85] 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 then National Lung Screening Trial. *Cancer*. 2014; November 1: 3401-09.
[86] 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.
[87] 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.
[88] 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.
[89] 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.

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).[90]

- The PAN-CAN lung cancer risk model has been validated in at least two studies.[91,92] 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.[93]
- 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.[94,95]

Based on the above assumptions drawn from the NLST and the CTFPHC, the CPB is 2,736 quality-adjusted life years saved (see Table 2-5, row z). The CPB of 2,736 represents the gap between the existing coverage (no coverage) and the 'best in the world' coverage, which was estimated at 80%.

[90] Tammemagi MC and Lam S. Screening for lung cancer using low dose computed tomography. *BMJ* 2014; 348: g2253-63.
[91] 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.
[92] 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.
[93] Tammemagi MC and Lam S. Screening for lung cancer using low dose computed tomography. *BMJ* 2014; 348: g2253-63.
[94] 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.
[95] Field JK and Duffy SW. Lung cancer CT screening: is annual screening necessary? *The Lancet Oncology*. 2016: Published online March 18, 2016.

Table 2-5. Calculation of Clinically Preventable Burden (CPB) Estimate for Lung Cancer Screening in a Birth Cohort of 40,000 (B.C.)			
Row Label	Variable	Base Case	Data Source
a	Age 55-59: # of individuals alive in cohort	37,632	Table 2-3
b	Age 55-59: % of individuals eligible for screening	10.5%	Table 2-1
c	Age 60-64: # of individuals alive in cohort	36,598	Table 2-3
d	Age 60-64: % of individuals eligible for screening	8.6%	Table 2-1
e	Age 65-69: # of individuals alive in cohort	35,019	Table 2-3
f	Age 65-69: % of individuals eligible for screening	8.7%	Table 2-1
g	Age 70-74: # of individuals alive in cohort	32,614	Table 2-3
h	Age 70-74: % of individuals eligible for screening	5.2%	Table 2-1
i	# of individuals eligible for screening	2,960	= ((a * b)+ (c * d) + (e * f) + (g * h))/4
j	Average # of screens per eligible individual	3	√
k	Adherence with offers to receive screening	80.0%	√
l	Total # of screens in cohort	7,105	= i * j * k
m	Proportion of screens positive	24.2%	√
n	# of positive screens	1,719	= l * m
o	Proportion of screens false positive	96.4%	√
p	# of false positive screens	1,657	= n * o
q	QALYs lost per false positive test	0.00	√
r	QALYs lost due to false positive test	0	= 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	22	= p * s
u	Lung cancer deaths ages 55-74	1,035	Table 2-3
v	Remaining life expectancy at death from lung cancer (in years)	19.50	Table 2-3
w	Effectiveness of screening in reducing LC deaths	19.6%	√
x	LC deaths avoided due to LC screening	162	= u * w * k
y	Net deaths avoided due to LC screening	140	= x - t
z	Potential QALYs saved (CPB) - Utilization increasing from 0% to 80%	2,736	= (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 2-5, row w): CPB = 814.
- Assume the estimated effectiveness of lung cancer screening in reducing deaths due to lung cancers is increased from 19.6% to 30.0% (Table 2-5, row w): CPB = 4,415.
- Assume the adherence rate is reduced from 80% to 70% (Table 2-5, row k): CPB = 2,394.
- Assume the adherence rate is increased from 80% to 90% (Table 2-5, row k): CPB = 3,077.
- Assume that the disutility associated with a false positive results is increase from 0 to 0.05 (Table 2-5, row q): CPB = 2,653.

In estimating CE, we made the following assumptions:

- **Assessment of patient risk** – Data on the proportion of the population that would survive to age 55 within a BC birth cohort of 40,000 is based on life tables for 2009 to 2011 for BC (see Table 2-7, row a).[96] Each of the 37,640 survivors would undergo

[96] See http://www.statcan.gc.ca/pub/84-537-x/2013005/tbl-eng.htm. Accessed January 2016.

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 2-7, row c).

- **Cost of office visit** - We estimated the average cost of a visit to a general practitioner to be $34.00[97] (see Table 2-7, row d) and that 50% of an office visit would be required for the assessment of patient risk (see Table 2-7, row f).
- **Patient time and travel costs for screening** - For patient time and travel costs, we assumed an hourly wage of $24.39 (the BC average in 2013)[98] plus 18% benefits for the estimated two hours of patient time required. This resulted in a cost per physician visit of $57.56 (Table 2-7, row e).
- **Costs of screening** - We assumed an annual LDCT screening exam would cost $193 (all costs are in 2013 Canadian $ unless otherwise stated) (see Table 2-7, row i).[99]
- **Physician visits** - LDCT screening results in an additional 14 physician visits per 100 persons screened (see Table 2-7, row j).[100]
- Positive findings on the screening CT result in the **ensuing follow-up procedures** (Table 2-6 rows c to k):[101]
    - 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 2-6, rows u to ac):[102]
    - Follow-up chest radiograph – $65
    - Follow-up chest CT – $160
    - Follow-up PET/CT scan – $1,361

[97] Medical Services Commission. *Payment Schedule: Section 7 General Practice*. 2013. Available at http://www.health.gov.bc.ca/msp/infoprac/physbilling/payschedule/pdf/7-general-practice.pdf. Accessed December 2013.
[98] Statistics Canada. *Average Hourly Wages of Employees by Selected Characteristics and Occupation, Unadjusted Data, by Province (Monthly) (British Columbia)*. 2013. Available at http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/labr69k-eng.htm. Accessed December 2013.
[99] 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.
[100] Ibid.
[101] 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.
[102] 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.

- Percutaneous biopsy – CT-guided = $1,054, US-guided = $664
- Bronchoscopy without biopsy – $727
- Bronchoscopy with biopsy – $782
- Mediastinoscopy – $950
- Thoracoscopy – $16,361
- Thoracotomy – $18,186

- **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. The time valued per day was truncated at 7.5 hours and did not include weekends. For patient time and travel costs, we assumed an hourly wage of $24.39 (the BC average in 2013)[103] plus 18% benefits, for a cost per hour of $28.78 (see Table 2-6, rows ae to am and ao).

[103] Statistics Canada. *Average Hourly Wages of Employees by Selected Characteristics and Occupation, Unadjusted Data, by Province (Monthly) (British Columbia)*. 2013. Available at http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/labr69k-eng.htm. Accessed December 2013.

Table 2-6. Calculation of Costs Associated with Follow-up Procedures			
Row Label	**Variable**	**Base Case**	**Data Source**
a	Number of positive screens	1,719	Table 2-5, row n
b	Number of false positive screens	1,657	Table 2-5, 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	248	= a * c
m	Follow-up chest radiograph	856	= a * d
n	Follow-up PET/CT scan	143	= a * e
o	Percutaneous biopsy	30	= a * f
p	Bronchoscopy without biopsy	30	= a * g
q	Bronchoscopy with biopsy	30	= a * h
r	Mediastinoscopy	12	= a * i
s	Thoracoscopy	22	= a * j
t	Thoracotomy	48	= a * k
	Unit cost of procedures following a positive screen		
u	Follow-up chest radiograph	$65	√
v	Follow-up chest CT	$160	√
w	Follow-up PET/CT scan	$1,361	√
x	Percutaneous biopsy	$859	√
y	Bronchoscopy without biopsy	$727	√
z	Bronchoscopy with biopsy	$782	√
aa	Mediastinoscopy	$950	√
ab	Thoracoscopy	$16,361	√
ac	Thoracotomy	$18,186	√
ad	Follow-up costs of positive screens	**$1,655,637**	= 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	16,044	= 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	$28.78	√
ap	Total cost of patient time for follow-up procedures	**$461,758**	= ao * ap
aq	**Cost of follow-up procedures**	**$2,117,396**	= ad + ap

- **Costs avoided due to early detection of lung cancers** – As noted in Table 2-4, screening with LDCT results in the earlier detection of lung cancers, thus potentially reducing the cost of treatment. Research by Cressman et al. suggests that the mean per person cost of treating stage I & II lung cancer is $33,344 (95% CI of $31,553 - $34,935).[104] This increases to $47,792 (95% CI of $43,254 - $52,200) 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 2-4, the weighted cost would be $41,957 for the usual care group and $36,283 for the CT group, resulting in costs avoided of $5,674 per lung cancer associated with LDCT screening (see Table 2-7, row n).
- Discount rate of 3%.

Based on these assumptions, the estimated cost per QALY would be $1,556 (see Table 2-7, row u).

Table 2-7. Summary of Cost Effectiveness (CE) Estimate for Lung Cancer Screening (B.C.)

Row Label	Variable	Base Case	Data Source
	Assessment of patient risk		
a	Proportion of cohort alive at age 55	94.1%	√
b	Total number of primary care provider screens (100% adherence)	37,640	= a * 40,000
c	Adherence with screening	85%	Assumed
d	Cost of 10-minute office visit	$34.00	√
e	Value of patient time and travel for office visit	$57.56	√
f	Portion of 10-minute office visit for screen	50%	Assumed
g	Cost of primary care provider screening	$1,464,685	=(b*c) + ((d*e) * f)
	Screening for Lung Cancer		
h	Potential screens with 80% adherence	7,105	=Table 2-5, row l
i	Cost per screen	$193	√
j	Additional physician visits per screening exam	0.14	√
k	Cost of screening	$1,462,284	=(i*h) + ((h*j) * (d+e))
l	Costs Asspociated with Follow-up Procedures	$2,117,396	=Table 2-6, row aq
m	Total Costs of Screening and Follow-up	$5,044,365	= g + k + l
	Costs Avoided		
n	Treatment costs avoided with earlier detection, per cancer	-$5,674	√
o	Number of incident lung cancers detected earlier	140	= Table 2-5, row y
p	Treatment costs avoided with earlier detection	-$795,903	= n * o
q	Net screening and patient costs (undiscounted)	$4,248,462	= m + p
r	QALYs saved (undiscounted)	2,736	Table 2-5, row z
s	Net screening and patient costs (3% discount)	$3,260,596	Calculated
t	QALYs saved (3% discount)	2,096	Calculated
u	**CE ($/QALY saved)**	$1,556	= s / t

√ = Estimates from the literature

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 2-5, row w): CE = $5,911.
- Assume the estimated effectiveness of lung cancer screening in reducing deaths due to lung cancers is increased from 19.6% to 30.0% (Table 2-5, row w): CE = $854.

[104] 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.

- Assume the adherence rate is reduced from 80% to 70% (Table 2-5, row k): CE = $1,632.
- Assume the adherence rate is increased from 80% to 90% (Table 2-5, row k): CE = $1,496.
- Assume the adherence rate with the assessment of patient risk is reduced from 85% to 75% (Table 2-7, row c): CE = $1,493.
- Assume the adherence rate with the assessment of patient risk is increased from 85% to 95% (Table 2-7, row c): CE = $1,619.
- Assume that the portion of a 10-minute office visit for the assessment of patient risk is reduced from 50% to 40% (Table 2-7, row f): CE = $1,449.
- Assume that the portion of a 10-minute office visit for the assessment of patient risk is increased from 50% to 60% (Table 2-7, row f): CE = $1,663.

Summary

Table 2-8: Lung Cancer Screening Being Offered to a Birth Cohort of 40,000 Between the Ages of 55 and 79
Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Gap between B.C. Current (0%) and 'Best in the World' (80%)			
3% Discount Rate	2,096	623	3,383
0% Discount Rate	2,736	814	4,415
CE ($/QALY) **including** patient time costs			
3% Discount Rate	$1,556	$854	$5,911
0% Discount Rate	$1,553	$852	$5,909
CE ($/QALY) **excluding** patient time costs			
3% Discount Rate	$1,029	$528	$4,142
0% Discount Rate	$1,027	$525	$4,139

Canadian Task Force on Preventive Health Care (2013)[105]

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,[106] 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,[107] we recommend not routinely screening for depression.[108] (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:[109]

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).

United States Preventive Services Task Force Recommendations (2016)[110]

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)

[105] Canadian Task Force on Preventive Health Care. Recommendations on screening for depression in adults. *Canadian Medical Association Journal*. 2013; 185(9): 775-82.
[106] 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.
[107] 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.
[108] 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.
[109] 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.
[110] 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.

Utilization of This Clinical Preventive Service

Currently in British Columbia

We were unable to find any information that specifically identifies what proportion of nonpregnant adults ages 18 and older are being routinely screened for depression in BC. A 2002 article in the *BC Medical Journal* reviewed a number of screening tools to help BC physicians improve their diagnosis of depression.[111] In 2009, a report by the BC Medical Association noted that "efforts to increase the use of depression screening and case-finding tools should not be promoted in isolation, but rather as part of broader organizational enhancements."[112]

Best in the World

Based on the National Ambulatory Medical Care Survey in the US, an estimated 929 million physician office visits occurred in 2012.[113] Approximately 13.3 million of these visits included depression screening. That is, depression screening was provided during 1.43% of physician office visits. The 1.43% represents an increase from 1.36% in 2010[114] and 1.07% in 2008.[115]

Of the 929 million visits provided in 2012, 507 million visits were provided by a primary care physician. If we assume that all visits which included depression screening were provided by a primary care physician, then 2.62% of visits to a primary care physician included depression screening. Finally, an average of 1.64 visits per year are made to a primary care physician.[116] This suggests that approximately 4.3% (2.62% * 1.64) of the US population were screened for depression by their primary care physician in 2012.

The US Affordable Care Act, signed into law on March 23, 2010, amends the US Social Security Act to remove "barriers to preventive services in Medicare" (Section 4104-5) and improve "access to preventive services for eligible adults in Medicaid" (Section 4106). A common amendment is the incorporation of "diagnostic, screening, preventive and rehabilitative services including any clinical preventive services that are assigned a grade of A or B by the United States Preventive Services Task Force" [Section 4106 (a)(13)].[117]

Despite the implementation of the Affordable Care Act and the focus on preventive services, only 2.62% of primary care physician visits in the US include screening for depression

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[111] Anderson J, Michalak E and Lam R. Depression in primary care: Tools for screening, diagnosis, and measuring response to treatment. *British Columbia Medical Journal*. 2002; 44(8): 415-9.
[112] British Columbia Medical Association. *Stepping Out of the Shadows: Collaborating to Improve Services for Patients with Depression*. 2009. Available at https://www.doctorsofbc.ca/sites/default/files/depression_paper_aug13.pdf. Accessed December 2015.
[113] National Center for Health Statistics. *National Ambulatory Medical Care Survey: 2012 Summary Tables*. 2012. Available at http://www.cdc.gov/nchs/data/ahcd/namcs_summary/2012_namcs_web_tables.pdf. Accessed December 2015.
[114] National Center for Health Statistics. *National Ambulatory Medical Care Survey: 2010 Summary Tables*. 2010. Available at http://www.cdc.gov/nchs/data/ahcd/namcs_summary/2010_namcs_web_tables.pdf. Accessed December 2015.
[115] National Center for Health Statistics. *National Ambulatory Medical Care Survey: 2008 Summary Tables*. 2008. Available at http://www.cdc.gov/nchs/data/ahcd/namcs_summary/2008_namcs_web_tables.pdf. Accessed December 2015.
[116] National Center for Health Statistics. *National Ambulatory Medical Care Survey: 2012 Summary Tables*. 2012. Available at http://www.cdc.gov/nchs/data/ahcd/namcs_summary/2012_namcs_web_tables.pdf. Accessed December 2015.
[117] U.S. Department of Health & Human Services. *The Affordable Care Act*. 2010. Available at http://www.hhs.gov/healthcare/about-the-law/read-the-law/index.html. Accessed December 2015.

resulting in an estimated annual screening rate of 4.3%. That is, even in a population where screening for depression is encouraged, rates are quite low.

Relevant British Columbia Population in 2013

The USPSTF recommends screening nonpregnant 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.

The 2013 population aged 18 and older in BC was 3,743,000. During that same year, the population aged less than one year was 44,000. We have used this as an approximation for the number of pregnant females in the province that year. Furthermore, screening would not be applicable for the population with known/diagnosed depression. Based on the 2012 CCHS, 11.6% of the BC population ages 15 and older has been diagnosed with a major depressive disorder[118] at some point during their lifetime.[119] This equates to approximately 434,000 individuals ages 18 and older (3,743,000 * 11.6%). The maximum relevant population in BC in 2013 for whom depression screening would be applicable would therefore be 3,265,000. *This assumes that staff-assisted depression care supports are in place to assure accurate diagnosis, effective treatment, and follow-up throughout the province.*

Modelling CPB and CE

In this section, we will calculate the CPB and CE associated with screening nonpregnant 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 estimating 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).[120]
- 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 3-1).[121]

[118] A major depressive disorder is characterized by one or more major depressive episodes (at least two weeks of depressed mood and/or loss of interest in usual activities accompanied by at least four additional symptoms of depression such as depressed mood, feeling worthless, helpless or hopeless, loss of interest or pleasure (including hobbies and sexual desire), change in appetite, sleep disturbances, decreased energy or fatigue [without significant physical exertion], sense of worthlessness or guilt, thoughts of death, poor concentration or difficulty making decisions).

[119] 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.

[120] 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.

[121] Patten SB. A major depression prognosis calculator based on episode duration. *Clinical Practice and Epidemiology in Mental Health*. 2006; 2(1): 13-20.

Table 3-1: 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.[122] On average, half of individuals experiencing at least one MDE during their lifetime will experience between 5-9 recurrent episodes during their lifetime.[123,124,125] For modelling purposes, we assumed that 50% of individuals experiencing an initial MDE would experience 7 recurrent episodes during their lifetime.
- The proportion of each sex within the population that is expected to survive to a given age group is based on life tables for 2009 to 2011 for BC (see Tables 3-2 and 3-3).[126]
- 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 diagnosed depression (see Tables 3-2). For females, an estimated 1.33% of life years lived between the age of 18 and death would be with diagnosed depression (see Tables 3-3).

[122] Burcusa SL and Iacono WG. Risk for recurrence in depression. *Clinical Psychology Review*. 2007; 27(8): 959-85.
[123] 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.
[124] 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.
[125] Colman I, Naicker K, Zeng Y et al. Predictors of long-term prognosis of depression. *Canadian Medical Association Journal*. 2011; 183(17): 1969-76.
[126] See http://www.statcan.gc.ca/pub/84-537-x/2013005/tbl-eng.htm. Accessed December 2015.

Table 3-2: Years of Life Lived with Depression
in a British Columbia Male Birth Cohort of 20,000

Males

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
18-19	0.994	19,876	58.7	205.4	377.0	39,751	0.95%
20-24	0.991	19,814	146.2	511.9	939.7	99,072	0.95%
25-29	0.987	19,736	145.7	509.8	935.9	98,679	0.95%
30-34	0.983	19,652	145.1	507.7	932.0	98,262	0.95%
35-39	0.977	19,548	144.3	505.0	927.0	97,742	0.95%
40-44	0.971	19,410	143.3	501.4	920.5	97,052	0.95%
45-49	0.961	19,218	141.8	496.5	911.4	96,090	0.95%
50-54	0.947	18,938	139.8	489.2	898.1	94,690	0.95%
55-59	0.926	18,519	136.7	478.4	878.2	92,594	0.95%
60-64	0.894	17,887	132.0	462.1	848.2	89,435	0.95%
65-69	0.847	16,935	125.0	437.5	803.1	84,673	0.95%
70-74	0.776	15,514	114.5	400.8	735.7	77,572	0.95%
75-79	0.673	13,453	99.3	347.5	638.0	67,263	0.95%
80+	0.296	5,918	17.5	61.2	112.3	11,836	0.95%
Total Ages 18+			**1,690**	**5,914**	**10,857**	**1,144,710**	**0.95%**

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

Females

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
18-19	0.995	19,897	82.6	289.0	530.4	39,794	1.33%
20-24	0.993	19,869	206.1	721.4	1,324.2	99,345	1.33%
25-29	0.992	19,836	205.8	720.2	1,322.0	99,180	1.33%
30-34	0.990	19,798	205.4	718.8	1,319.5	98,992	1.33%
35-39	0.987	19,744	204.8	716.8	1,315.9	98,721	1.33%
40-44	0.983	19,665	204.0	713.9	1,310.6	98,324	1.33%
45-49	0.977	19,547	202.8	709.7	1,302.8	97,736	1.33%
50-54	0.969	19,372	201.0	703.3	1,291.1	96,861	1.33%
55-59	0.955	19,108	198.2	693.8	1,273.5	95,542	1.33%
60-64	0.935	18,704	194.0	679.1	1,246.6	93,520	1.33%
65-69	0.904	18,074	187.5	656.2	1,204.6	90,371	1.33%
70-74	0.854	17,086	177.2	620.3	1,138.7	85,428	1.33%
75-79	0.777	15,540	161.2	564.2	1,035.7	77,698	1.33%
80+	0.384	7,677	95.6	334.5	614.0	46,063	1.33%
Total Ages 18+			**2,526**	**8,841**	**16,230**	**1,217,575**	**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 increase to 27 times.[127] Individuals living with depression also have higher rates of overall excess mortality with an early meta-analysis suggesting a RR of 1.81 (95% CI of 1.58 to 2.07).[128] 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 (HR 1.6, 95% CI of 0.8 to 3.1).[129] Other research has found that the effect of depression on mortality is independent of chronic illnesses such as

[127] Lépine J-P and Briley M. The increasing burden of depression. *Neuropsychiatric Disease and Treatment*. 2011; 7(Suppl 1): 3-7.
[128] Cuijpers P and Smit F. Excess mortality in depression: a meta-analysis of community studies. *Journal of Affective Disorders*. 2002; 72(3): 227-36.
[129] 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.

diabetes[130] and congestive heart failure.[131] 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.[132] 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).[133] 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, 22 deaths and 495 life years lost in the cohort are attributable to depression (see Table 3-4). In females, 19 deaths and 482 life years lost are attributable to depression (see Table 3-5).

Table 3-4: 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	19,876							
20-24	19,814	61	0.95%	0.6	0.9	0.3	58.9	18
25-29	19,736	79	0.95%	0.7	1.1	0.4	54.1	21
30-34	19,652	83	0.95%	0.8	1.2	0.4	49.3	20
35-39	19,548	104	0.95%	1.0	1.5	0.5	44.6	23
40-44	19,410	138	0.95%	1.3	2.0	0.7	39.9	27
45-49	19,218	192	0.95%	1.8	2.8	0.9	35.2	33
50-54	18,938	280	0.95%	2.7	4.0	1.4	30.7	42
55-59	18,519	419	0.95%	4.0	6.0	2.1	26.3	54
60-64	17,887	632	0.95%	6.0	9.1	3.1	22.1	69
65-69	16,935	952	0.95%	9.0	13.7	4.7	18.1	85
70-74	15,514	1,420	0.95%	13.5	20.5	7.0	14.5	101
Total		**4,361**		**41**	**63**	**22**		**495**

Table 3-5: 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	19,897							
20-24	19,869	28	1.33%	0.4	0.6	0.2	62.9	12
25-29	19,836	33	1.33%	0.4	0.7	0.2	58.0	13
30-34	19,798	38	1.33%	0.5	0.8	0.3	53.1	14
35-39	19,744	54	1.33%	0.7	1.1	0.4	48.2	18
40-44	19,665	80	1.33%	1.1	1.6	0.6	43.4	24
45-49	19,547	118	1.33%	1.6	2.4	0.8	38.6	32
50-54	19,372	175	1.33%	2.3	3.5	1.2	34.0	41
55-59	19,108	264	1.33%	3.5	5.3	1.8	29.4	54
60-64	18,704	404	1.33%	5.4	8.2	2.8	24.9	70
65-69	18,074	630	1.33%	8.4	12.8	4.4	20.7	90
70-74	17,086	989	1.33%	13.2	20.0	6.9	16.6	114
Total		**2,811**		**37**	**57**	**19**		**482**

[130] 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.
[131] 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.
[132] 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.
[133] 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.

- 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."[134]
- Based on a meta-analysis of 41 studies including 50,371 patients, for every 100 patients, GPs identify 10 true positive cases of depression, diagnoses 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.[135]
- 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.[136,137] 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.[138]
- 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.[139] Scores on the HDRS can be interpreted as follows: no depression (0-7), mild depression (8-16), moderate depression (17-23) and severe depression (≥24).[140]
- 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.[141,142,143] For modelling purposes, we assumed that 14% of depression is undiagnosed treatable depression (see Table 3-6, row i) and increased this to 30% in the sensitivity analysis.
- We assumed adherence with screening to be 5% (see above *Utilization of This Clinical Preventive Service - Best in the World*) and varied this from 3% to 10% in the sensitivity analysis (see Table 3-6, row l).

[134] Kessler D, Sharp D and Lewis G. Screening for depression in primary care. *British Journal of General Practice*. 2005; 55(518): 659-60.
[135] Mitchell AJ, Vaze A and Rao S. Clinical diagnosis of depression in primary care: a meta-analysis. *The Lancet*. 2009; 374(9690): 609-19.
[136] 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.
[137] Simon GE and VonKorff M. Recognition, management, and outcomes of depression in primary care. *Archives of Family Medicine*. 1995; 4(2): 99-105.
[138] 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.
[139] Zimmerman M, Posternak MA and Chelminski I. Symptom severity and exclusion from antidepressant efficacy trials. *Journal of Clinical Psychopharmacology*. 2002; 22(6): 610-4.
[140] 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.
[141] 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.
[142] 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.
[143] 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.

- 85% of patients diagnosed with depression were prescribed anti-depressant medication (ADM) in 2011/12 in Canada.[144]
- Approximately 60% of patients stay on ADM for at least 3 months and 45% for at least 6 months.[145,146]
- 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[147] and a 70% (OR = 0.30, 95% CI of 0.1 to 1.0) reduced risk after 10 years.[148]
- 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.[149,150] 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 3-6, 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.[151,152] 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."[153] 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.[154] Whiteford and colleagues[155] 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)

[144] 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.
[145] 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.
[146] 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.
[147] 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.
[148] 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.
[149] 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.
[150] 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.
[151] 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.
[152] 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.
[153] 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.
[154] 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.
[155] 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.

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) (see Table 3-6, row p).

Based on these assumptions, the CPB is 50 quality-adjusted life years saved (see Table 3-6, row s). The CPB of 50 represents the gap between existing coverage (no coverage) and the 'best in the world' coverage estimated at 5%.

Table 3-6: 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	1,144,710	Table 3-2
b	Life years lived from age 18 to death in a birth cohort of 20,000 females	1,217,575	Table 3-3
c	Life years lived with depression in a birth cohort of 20,000 males	10,857	Table 3-2
d	Life years lived with depression in a birth cohort of 20,000 females	16,230	Table 3-3
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	495	Table 3-4
h	Life years lost attributable to depression in a birth cohort of 20,000 females	482	Table 3-5
i	Proportion of treatable depression undiagnosed	14%	√
j	Life years lived with undiagnosed treatable depression in a birth cohort of 20,000 males	1,520	= c * i
k	Life years lived with undiagnosed treatable depression in a birth cohort of 20,000 females	2,272	= d * i
l	Adherence with screening	5%	√
m	Life years lived with undiagnosed treatable depression identified by screening	190	= (j + k) * l
n	Effectiveness of ADM in achieving remission	56%	√
o	Life years lived in remission with treated depression identified by screening	106	= m * n
p	Quality of life adjustment	41%	√
q	QALYs gained	44	= o * p
r	Life-years gained / death averted	7	= (g + h) * i * l
s	**Potential QALYs gained, Screening increasing from 0% to 5%**	**50**	= 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 3-4 and 3-5): CPB = 49.
- Assume that the RR of excess mortality associated with depression is increased from 1.52 to 1.59 (Table 3-4 and 3-5): CPB = 51.
- Assume the proportion of treatable depression that is undiagnosed is increased from 14% to 30% (Table 3-6, row i): CPB = 108.
- Assume the adherence rate is reduced from 5% to 3% (Table 3-6, row l): CPB = 30.
- Assume the adherence rate is increased from 5% to 10% (Table 3-6, row l): CPB = 101.
- Assume the effectiveness of ADM in achieving remission is reduced from 56% to 37% (Table 3-6, row l): CPB = 36.
- Assume the effectiveness of ADM in achieving remission is increased from 56% to 67% (Table 3-6, row n): CPB = 59.

- Assume the QoL adjustment is reduced from 41% to 28% (Table 3-6, row p): CPB = 37.
- Assume the QoL adjustment is increased from 41% to 53% (Table 3-6, row p): CPB = 63.

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.[156] 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.[157] This represents a disutility of between 0.17 and 0.28. For modelling purposes we assumed a disutility rate of 0.22 (the midpoint) and varied this assumption from 0.17 and 0.28 in the sensitivity analysis (Table 3-7, 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.[158] For modelling purposes, we have assumed a ratio of 1.5 to 1 false positives to true positives (Table 3-7, 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.[159] We have not included this potential harm in the modelling.

Based on these additional assumptions, the calculation of CPB is reduced from 50 quality-adjusted life years saved to **54 quality-adjusted life years *lost*** (see Table 3-7, row v). The CPB of -54 represents the gap between no coverage and the 'best in the world' coverage estimated at 5%. **That is, based on these additional assumptions, screening for depression does more harm than good**. The disutility associated with taking ADM would need to be reduced from 0.22 to 0.11 to achieve a CPB of 0 or a balance between harms and good.

[156] 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.
[157] 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.
[158] Mitchell AJ, Vaze A and Rao S. Clinical diagnosis of depression in primary care: a meta-analysis. *The Lancet*. 2009; 374(9690): 609-19.
[159] Bell JR. Underdiagnosis of depression in primary care: by accident or design? *Journal of the American Medical Association*. 1997; 277(18): 1433-33.

Table 3-7: 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	1,144,710	Table 3-2
b	Life years lived from age 18 to death in a birth cohort of 20,000 females	1,217,575	Table 3-3
c	Life years lived with depression in a birth cohort of 20,000 males	10,857	Table 3-2
d	Life years lived with depression in a birth cohort of 20,000 females	16,230	Table 3-3
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	495	Table 3-4
h	Life years lost attributable to depression in a birth cohort of 20,000 females	482	Table 3-5
i	Proportion of treatable depression undiagnosed	14%	√
j	Life years lived with undiagnosed treatable depression in a birth cohort of 20,000 males	1,520	= c * i
k	Life years lived with undiagnosed treatable depression in a birth cohort of 20,000 females	2,272	= d * i
l	Adherence with screening	5%	√
m	Life years lived with undiagnosed treatable depression identified by screening	190	= (j + k) * l
n	Life years treated for depression - false positives	284	= m * 1.5
o	Effectiveness of ADM in achieving remission	56%	√
p	Life years lived in remission with treated depression identified by screening	106	= m * o
q	Quality of life adjustment	41%	√
r	QALYs gained	44	= p * q
s	Life-years gained / death averted	7	= (g + h) * i * l
t	Disutility associated with ADM	-22%	√
u	QALYs lost associated with ADM	-104	= (m + n) * t
v	**Potential QALYs gained, Screening increasing from 0% to 5%**	**-54**	= r + s + u

√ = Estimates from the literature

In estimating CE, we did not include false positives or the potential disutility associated with taking ADM, as identified in Table 3-7. We made the following assumptions (see Table 3-8):

- **Expected screens** - We assumed that screening would occur annually (Table 3-8, row c).
- **Cost of office visit** - We estimated the average cost of a visit to a General Practitioner to be $34.00[160] (Table 3-8, row f). We assumed that 30% of a 10-minute office visit would be required for the screening and varied this from 20-40% in the sensitivity analysis (Table 3-8, row h).
- **Patient time and travel costs** - For patient time and travel costs, we assumed an hourly wage of $24.39 (the BC average in 2013)[161] plus 18% benefits applied to the estimated two hours of patient time required for a cost per screening visit or a cost per physician visit of $57.56 (Table 3-8, row g).
- **Cost of anti-depressant medication (ADM)** - The cost/day for antidepressant prescriptions in BC ranges from $1.00 for prescriptions paid by the provincial

[160] Medical Services Commission. *Payment Schedule: Section 7 General Practice*. 2013. Available at http://www.health.gov.bc.ca/msp/infoprac/physbilling/payschedule/pdf/7-general-practice.pdf. Accessed December 2013.

[161] Statistics Canada. *Average Hourly Wages of Employees by Selected Characteristics and Occupation, Unadjusted Data, by Province (Monthly) (British Columbia)*. 2013. Available at http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/labr69k-eng.htm. Accessed December 2013.

government to $1.19 for prescription paid for by uninsured patients and $1.27 paid for by private insurers.[162] The weighted average is $1.15/day or $420/year (Table 3-8, row k).

- **Physician visits** - 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 3-8, row m).
- Discount rate of 3%.

Based on these assumptions, the estimated cost per QALY would be $67,322 (see Table 3-8, row s).

Table 3-8: 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	1,133,853	Table 3-6, row a - row c
b	Life years lived from age 18 to death without diagnosed depression in a birth cohort of 20,000 females	1,201,345	Table 3-6, row b - row d
	Costs of intervention		
c	Frequency of screening (every x years)	1	Assumed
d	Total number of screens (100% adherence)	2,335,198	= (a + b) / c
e	Adherence with screening	5%	Table 3-6, row l
f	Cost of 10-minute office visit	$34.00	√
g	Value of patient time and travel for office visit	$57.56	√
h	Portion of 10-minute office visit for screen	30%	Assumed
i	Cost of screening	$3,207,161	= (d * e) * (f + g) * h
j	Life years treated for depression	190	Table 3-6, row m
k	Annual cost of ADM	$420	√
l	Cost of ADM	$79,587	= 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	$104,162	= (m * j) * (f + g)
	CE calculation		
o	Cost of intervention over lifetime of birth cohort	$3,390,911	= (i + l + n)
p	QALYs saved	50	Table 3-6, row s
q	Cost of intervention over lifetime of birth cohort (3% discount)	$1,482,678	Calculated
r	QALYs saved (3% discount)	22	Calculated
s	**CE ($/QALY saved)**	**$67,322**	= 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 3-6, row i): CE = $33,363.
- Assume the adherence rate is reduced from 5% to 3% (Table 3-6, row l): CE = $67,322.
- Assume the adherence rate is increased from 5% to 10% (Table 3-6, row l): CE = $67,322.
- Assume the effectiveness of ADM in achieving remission is reduced from 56% to 37% (Table 3-6, row n): CE = $95,256.

[162] 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.

- Assume the effectiveness of ADM in achieving remission is increased from 56% to 67% (Table 3-6, row n): CPB = CE = $57,552.
- Assume the QoL adjustment is reduced from 41% to 28% (Table 3-6, row p): CE = $92,737.
- Assume the QoL adjustment is increased from 41% to 53% (Table 3-6, row p): CE = $53,730.
- Assume that the proportion of an office visit required for screening is reduced from 30% to 20% (Table 3-8, row h): CE = $46,098.
- Assume that the proportion of an office visit required for screening is increased from 30% to 40% (Table 3-8, row h): CE = $88,547.
- Assume that diagnosed depression results in an additional 4 physician visits per year rather than 6 (see Table 3-8, row m): CE = $66,633.
- Assume that diagnosed depression results in an additional 8 physician visits per year rather than 6 (see Table 3-8, row m): CE = $68,012.

Summary – Excluding Harms

Table 3-9: 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' (5%)			
3% Discount Rate	22	13	47
0% Discount Rate	50	30	108
CE ($/QALY) **including** patient time costs			
3% Discount Rate	$67,322	$33,363	$95,256
0% Discount Rate	$67,322	$33,363	$95,256
CE ($/QALY) **excluding** patient time costs			
3% Discount Rate	$25,993	$13,382	$36,778
0% Discount Rate	$25,993	$13,382	$36,778

Summary – Including Harms

Table 3-10: 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' (5%)			
3% Discount Rate	-24	-14	-51
0% Discount Rate	-54	-32	-116
CE ($/QALY) **including** patient time costs			
3% Discount Rate		Dominated	
0% Discount Rate			
CE ($/QALY) **excluding** patient time costs			
3% Discount Rate		Dominated	
0% Discount Rate			

Canadian Task Force on Preventive Health Care (2013)[163]

> *For adults in subgroups of the population who may be at increased risk of depression,* [including pregnant and postpartum women, phrase added][164] *we recommend not routinely screening for depression.*[165] *(Weak recommendation; very-low-quality evidence)*

United States Preventive Services Task Force Recommendations (2016)[166]

> *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)*

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 modeling of population health impact and cost effectiveness of screening and treatment for depression in perinatal and postpartum women.

Utilization of This Clinical Preventive Service

Currently in British Columbia

The BC Reproductive Mental Health Program recommends screening during pregnancy at 28-32 weeks and again at six to eight weeks postnatally using the EPDS.[167] We were unable to find information on formal screening rates for depression in perinatal and postpartum women in BC.

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

[164] 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.

[165] 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.

[166] 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.

[167] 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.

Best in the World

Eighty percent of mothers are comfortable with the idea of being screened for postpartum depression (PPD).[168,169] Eighty-three percent of family practitioners and 73% of paediatricians are willing to screen for PPD.[170] The theoretical maximum screening rate might therefore be 66% (0.8 * 0.83). In actual practice, however, screening rates using a validated screening tool appear to be closer to 20%.[171,172] Even in an outpatient academic medical center, the screening rate only reached 39%.[173]

Relevant British Columbia Population in 2013

Based on the most recently available BC vital statistics, there were 43,991 live births and 441 stillbirths in 2011 in the province.[174] Of the 43,991 live births, 1,385 resulted in multiple births. This would therefore be equivalent to approximately 43,735 pregnancies in a year in BC.

Modelling CPB and CE

In this section, we will calculate the CPB and CE associated with screening pregnant and postpartum women for depression in a BC birth cohort of 40,000.

In estimating 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 4-1, row a).[175]
- The proportion of females expected to survive to age 20 is based on life tables for 2009 to 2011 for BC (Table 4-1, row b).[176]
- 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 to 9 months after giving birth).[177]

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[168] Buist A, Condon J, Brooks J et al. Acceptability of routine screening for perinatal depression. *Journal of Affective Disorders*. 2006; 93(1): 233-7.
[169] Gemmill AW, Leigh B, Ericksen J et al. A survey of the clinical acceptability of screening for postnatal depression in depressed and non-depressed women. *BMC Public Health*. 2006; 6: 211.
[170] Glasser S, Levinson D, Bina R et al. Primary care physicians' attitudes toward postpartum depression is it part of their job? *Journal of Primary Care & Community Health*. 2016; 7(1): 24-9.
[171] Seehusen DA, Baldwin L-M, Runkle GP et al. Are family physicians appropriately screening for postpartum depression? *The Journal of the American Board of Family Practice*. 2005; 18(2): 104-12.
[172] Psaros C, Geller PA, Sciscione AC et al. Screening practices for postpartum depression among various health care providers. *The Journal of Reproductive Medicine*. 2009; 55(11-12): 477-84.
[173] Delatte R, Cao H, Meltzer-Brody S et al. Universal screening for postpartum depression: an inquiry into provider attitudes and practice. *American Journal of Obstetrics and Gynecology*. 2009; 200(5): e63-e4.
[174] 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.
[175] 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.
[176] See http://www.statcan.gc.ca/pub/84-537-x/2013005/tbl-eng.htm. Accessed December 2015.
[177] 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.

- A 2004 systematic review found prevalence rates of depression of 7.4%, 12.8% and 12.0% during the first, second and third trimesters.[178]
- 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.[179] MDE is a distinct clinical syndrome for which treatment is clearly indicated.[180]
- 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.[181]
- For modelling purposes we assumed that screening would occur at 7 weeks post birth (Table 4-1, row d) and modified this to screen at 30 weeks pregnancy in the sensitivity analysis (Table 4-1, 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 4-1, 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 4-1, 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 4-1, row e).
- Depression is associated with the following disutility:[182]
    - 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 (Table 4-1, row f).
- 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 4-1, 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 4-1, row j).[183] Women who commit suicide during the perinatal period are

[178] Bennett HA, Einarson A, Taddio A et al. Prevalence of depression during pregnancy: systematic review. *Obstetrics & Gynecology*. 2004; 103(4): 698-709.
[179] 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.
[180] 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.
[181] 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.
[182] 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.
[183] See http://www.statcan.gc.ca/pub/84-537-x/2013005/tbl-eng.htm. Accessed December 2015.

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 4-1, row k).[184]

- 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.[185]
- 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.[186,187]
- Postpartum depression is associated with a 59% (OR of 1.59, 95% CI of 1.24 to 2.04) increase in unintentional injury (Table 4-1, row o) and a 41% (OR of 1.41, 95% CI of 1.02 to 1.95) increase in falls in infants.[188]
- 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 4-1, row m). The rate of deaths due to unintentional injuries is 10.7 per 100,000 (Table 4-1, row n).[189] If we assume that the average death occurs at age 2, then each death results in 80 years of life lost (Table 4-1, row r).[190]
- Pregnancy and postpartum depression are associated with a shorter duration of breastfeeding.[191] 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.[192] 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.[193] For modelling purposes, we assumed a 27% reduction of exclusive breastfeeding to six months associated with maternal depression (Table 4-1, 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

[184] 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.
[185] McLennan JD and Kotelchuck M. Parental prevention practices for young children in the context of maternal depression. *Pediatrics*. 2000; 105(5): 1090-5.
[186] 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.
[187] 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.
[188] 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.
[189] 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.
[190] See http://www.statcan.gc.ca/pub/84-537-x/2013005/tbl-eng.htm. Accessed December 2015.
[191] Dias CC and Figueiredo B. Breastfeeding and depression: A systematic review of the literature. *Journal of Affective Disorders*. 2015; 171: 142-54.
[192] Henderson JJ, Evans SF, Straton JA et al. Impact of postnatal depression on breastfeeding duration. *Birth*. 2003; 30(3): 175-80.
[193] 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.

and ovarian cancers in the mother.[194,195] In a previous analysis of the promotion of breastfeeding, we calculated that exclusive breastfeeding to six months is associated with an increase of 0.43 QALYs per infant/mother pair (Table 4-1, row t).[196]

- 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.[197] 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.[198,199]
- 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.[200,201,202]
- 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.[203]
- 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, 26% reduced odds of talking to the infant and 39% reduced odds of following routines, compared to mothers without depressive symptoms.[204]

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[194] 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.
[195] Bartick M and Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics*. 2010; 125(5): e1048-e56.
[196] 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.
[197] Howard LM, Kirkwood G and Latinovic R. Sudden infant death syndrome and maternal depression. *The Journal of Clinical Psychiatry*. 2007; 68(8): 1279-83.
[198] 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.
[199] 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.
[200] 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.
[201] McGowan JE, Alderdice FA, Holmes VA et al. Early childhood development of late-preterm infants: a systematic review. *Pediatrics*. 2011; 127(6): 1111-24.
[202] 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.
[203] 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.
[204] 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.

- 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."[205]
- 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.[206] 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 4-1, row y).
- We have assumed adherence with screening would be 40% and varied this from 30% to 60% in the sensitivity analysis (Table 4-1, row z).
- 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 4-1, row ab).[207]
- The use of second generation antidepressants during pregnancy may be associated with increased risk of some serious side-effects,[208] although the research remains unclear.[209,210]
- 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.[211]

Based on these assumptions, the CPB is 102 quality-adjusted life years saved (see Table 4-1, row ae). The CPB of 102 represents the gap between existing estimated coverage (unknown, assume 0%) and the 'best in the world' coverage estimated at 40%.

[205] 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.
[206] 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.
[207] 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.
[208] 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.
[209] Molyneaux E, Trevillion K and Howard LM. Antidepressant treatment for postnatal depression. *JAMA*. 2015; 313(19): 1965-6.
[210] 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.
[211] 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 4-1: 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	99.43%	√
c	Number of pregnancies in the birth cohort	28,238	= (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	0.53	√
g	QALYs lost due to moderate to severe perinatal depression	675	= 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	0.43	√
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	259	= v * c * t * u
x	**Total QALYs lost due to moderate to severe perinatal depression**	**1,132**	= g + j + s + w
y	Proportion of true positive cases identified by using the EPDS	79%	√
z	Adherence with screening	40%	√
aa	Years lived with moderate to severe perinatal depression identified	358	= (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	114	= aa * ab
ad	% of years lived with moderate to severe perinatal depression reduced by screening	9.0%	= ac / d
ae	**Potential QALYs saved (CPB) - Screening increasing from 0% to 40%**	**102**	= 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 4-1, row e): CPB = 116.
- Assume that the disutility associated with moderate to severe depression is reduced from 0.53 to 0.38 (Table 4-1, row f): CPB = 69.

- Assume that the disutility associated with moderate to severe depression is increased from 0.53 to 0.69 (Table 4-1, row f): CPB = 140.
- Assume that the increased risk of unintentional injuries in children (mothers with depression) is reduced from 59% to 24% (Table 4-1, row o): CPB = 87.
- Assume that the increased risk of unintentional injuries in children (mothers with depression) is increased from 59% to 104% (Table 4-1, row o): CPB = 122.
- Assume that adherence with screening is reduced from 40% to 30% (Table 4-1, row z): CPB = 76.
- Assume that adherence with screening is increased from 40% to 60% (Table 4-1, row z): CPB = 153.
- Assume that the effectiveness of screening in reducing the risk of moderate to severe depression is reduced from 32% to 18% (Table 4-1, row ab): CPB = 57.
- Assume that the effectiveness of screening in reducing the risk of moderate to severe depression is increased from 32% to 59% (Table 4-1, row ab): CPB = 188.
- Assume that the reduced risk of exclusive breastfeeding to six months associated with maternal depression is reduced from 27% to 12% (Table 4-1, row u): CPB = 77.
- Assume that the reduced risk of exclusive breastfeeding to six months associated with maternal depression is increased from 27% to 39% (Table 4-1, row u): CPB = 123.

In estimating CE, we made the following assumptions:

- **Expected screens** - We assumed that screening would occur once per pregnancy (Table 4-2, row a) and modified this to twice in the sensitivity analysis. [212,213]
- **Cost of office visit** - We estimated the average cost of a visit to a General Practitioner to be $34.00 (Table 4-2, row f).[214] Screening with the EPDS takes approximately 5 minutes.[215] We therefore assumed that 50% of a 10-minute office visit would be required for the screening and varied this from 40% to 60% in the sensitivity analysis (Table 4-2, row h).
- **Patient time and travel costs** - For patient time and travel costs, we assumed an hourly wage of $24.39 (the BC average in 2013)[216] plus 18% benefits applied to the

[212] British Columbia. *Healthy Start Initiative: Provincial Perinatal, Child and Family Public Health Services.* April 2013

[213] 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.

[214] Medical Services Commission. *Payment Schedule: Section 7 General Practice*. 2013. Available at http://www.health.gov.bc.ca/msp/infoprac/physbilling/payschedule/pdf/7-general-practice.pdf. Accessed December 2013.

[215] 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.

[216] Statistics Canada. *Average Hourly Wages of Employees by Selected Characteristics and Occupation, Unadjusted Data, by Province (Monthly) (British Columbia)*. 2013. Available at http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/labr69k-eng.htm. Accessed December 2013.

estimated two hours of patient time required for a cost per screening visit or psychiatric diagnostic assessment of $57.56 (Table 4-2, row g).

- **Evaluation of women with positive screens** – Women who test positive for depression on the EPDS should be offered a psychiatric diagnostic assessment.[217] We assumed a cost of $217 for this assessment, based on fee code 00610 – full diagnostic interview by a psychiatrist in the BC MSC Payment Schedule (Table 4-2, row o).[218] 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.[219] The cost of psychiatric treatment in BC is $167 per hour[220] for a total cost of $3,173 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.[221] The cost of group therapy in BC with eight clients is $264 per hour.[222] The cost of group therapy would therefore be $1,077 per person (Table 4-2, 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.[223] 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 4-2, row u).[224]
- **Costs avoided due to increased duration of breastfeeding** - In a previous analysis of the promotion of breastfeeding, we calculated that exclusive breastfeeding to six

[217] 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.
[218] Medical Services Commission. *MSC Payment Schedule Index*. 2015. Available at http://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msc_payment_schedule.pdf. Accessed March 2016.
[219] 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.
[220] Medical Services Commission. *MSC Payment Schedule Index*. 2015. Available at http://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msc_payment_schedule.pdf. Accessed March 2016.
[221] 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.
[222] Medical Services Commission. *MSC Payment Schedule Index*. 2015. Available at http://www2.gov.bc.ca/assets/gov/health/practitioner-pro/medical-services-plan/msc_payment_schedule.pdf. Accessed March 2016.
[223] 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.
[224] 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.

months is associated with costs avoided of $3,284 per infant/mother pair (Table 4-2, row w).[225]

- Discount rate of 3%.

Based on these assumptions, the estimated cost per QALY would be $26,670 (Table 4-2, row ad).

Table 4-2. 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	28,238	= Table 4-1, row c
c	Total # of screens in birth cohort - 100% adherence	28,238	= a * b
d	Adherence with screening	40%	= Table 4-1, row z
e	Total # of screens in birth cohort - 40% adherence	11,295	= c * d
f	Cost of 10-minute office visit	$34.00	√
g	Value of patient time and travel for office visit	$57.56	√
h	Portion of 10-minute office visit for screen	50%	√
i	Cost of screening	$517,096	= e* (f + g) * h
j	Estimated prevalence of perinatal depression	7.9%	= Table 4-1, row v
k	EPDS true positive %	79%	= Table 4-1, row y
l	EPDS false positive %	13%	√
m	# of true positive screens	705	= b * d * j * k
n	# of false positive screens	116	= b * d * j * l
o	Cost per psychiatric assessment	$217	√
p	Cost of psychiatric assessment	$225,568	= (m + n) * o + (m + n) * g
q	Cost of CBT / ADM per individual	$1,077	√
r	Costs of patient time for CBT per individual	$1,180	= 41 * (g / 2)
s	Cost of CBT	$1,592,236	= (q + r) *m
t	Hospitalizations due to unintentional injuries avoided with screening	10.0	= Table 4-1, row p * Table 4-1, row ad
u	Cost of hospital treatment	$20,524	√
v	Costs avoided due to unintentional injury hospitalizations avoided	-$206,178	= t * u
w	Costs avoided due to exclusive breastfeeding to six months per mother / infant pair	-$3,284	√
x	Reduced risk of exclusive breastfeeding associated with maternal depression	27%	= Table 4-1, row u
y	Costs avoided due to longer duration of breastfeeding	-$177,881	= Table 4-1, row v * Table 4-1, row c * Table 4-1, row ad * w * x
z	Net screening and patient costs (undiscounted)	$1,950,841	= i + p + s + v + y
aa	QALYs saved (undiscounted)	102	= Table 4-1, row ae
ab	Net screening and patient costs (3% discount)	$2,065,503	Calculated
ac	QALYs saved (3% discount)	77	Calculated
ad	**CE ($/QALY saved)**	**$26,670**	= 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 4-1, row e): CE = $27,472.
- Assume that the disutility associated with moderate to severe depression is reduced from 0.53 to 0.38 (Table 4-1, row f): CE = $42,856.
- Assume that the disutility associated with moderate to severe depression is increased from 0.53 to 0.69 (Table 4-1, row f): CE = $18,056.

[225] 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.

- Assume that the increased risk of unintentional injuries in children (mothers with depression) is reduced from 59% to 24% (Table 4-1, row o): CE = $31,855.
- Assume that the increased risk of unintentional injuries in children (mothers with depression) is increased from 59% to 104% (Table 4-1, row o): CE = $21,023.
- Assume that the effectiveness of screening in reducing the risk of depression is reduced from 32% to 18% (Table 4-1, row ab): CE = $50118.
- Assume that the effectiveness of screening in reducing the risk of depression is increased from 32% to 59% (Table 4-1, row ab: CE = $12,873.
- Assume that the portion of a 10-minute office visit required for screening is reduced from 50% to 40% (Table 4-2, row h): CE = $25,334.
- Assume that the portion of a 10-minute office visit required for screening is increased from 50% to 60% (Table 4-2, row h): CE = $28,005.
- Assume that the cost of CBT per individual is increased from $1,077 to $3,173 (Table 4-2, row q): CE = $45,762.
- Assume that 50% of individuals use group CBT and 50% ADM (Table 4-2, row q): CE = $23,682.
- Assume that the reduced risk of exclusive breastfeeding to six months associated with maternal depression is reduced from 27% to 12% (Table 4-1, row u): CE = $33,753.
- Assume that the reduced risk of exclusive breastfeeding to six months associated with maternal depression is increased from 27% to 39% (Table 4-1, row u): CE = $22,327.

Summary

Table 4-3: 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 B.C. Current (0%) and 'Best in the World' (40%)			
3% Discount Rate	77	44	143
0% Discount Rate	102	57	188
CE ($/QALY) **including** patient time costs			
3% Discount Rate	$26,670	$12,873	$50,118
0% Discount Rate	$19,181	$8,675	$37,036
CE ($/QALY) **excluding** patient time costs			
3% Discount Rate	$11,113	$4,436	$22,462
0% Discount Rate	$7,335	$2,250	$15,977

Canadian Task Force on Preventive Health Care (2013)[226]

Recommendations are presented for the use of cervical cytology (Papanicolaou [Pap] tests) for women with no symptoms of cervical cancer who are or have been sexually active, regardless of sexual orientation. The recommendations do not apply to women with symptoms of cervical cancer (e.g., abnormal vaginal bleeding), women with previous abnormal results on screening (unless they have been cleared to return to normal screening), women who do not have a cervix (because of hysterectomy), women who are immunosuppressed (e.g., as a result of organ transplantation, chemotherapy, chronic corticosteroid treatment, HIV infection) or women who have limited life expectancy such that they would not benefit from screening.

> ***The recommendations do not address screening with human papilloma virus (HPV) testing (alone or in combination with Pap testing). In our judgment, such a recommendation would be premature until the evidence in this area is further developed.***
>
> *For women aged less than 20 years, we recommend not routinely screening for cervical cancer. (Strong recommendation; high-quality evidence)*
>
> *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 70 years of age or older who have undergone adequate screening (i.e., 3 successive negative Pap test results in the last 10 years), we recommend that routine screening may stop. For all other women 70 years of age or older, we recommend continued screening until 3 negative test results have been obtained. (Weak recommendation; low-quality evidence)*

United States Preventive Services Task Force Recommendations (2012)[227]

This recommendation statement applies to women who have a cervix, regardless of sexual history. This recommendation statement does not apply to women who have received a diagnosis of a high-grade precancerous cervical lesion or cervical cancer, women with in utero exposure to diethylstilbestrol, or women who are immunocompromised (such as those who are HIV positive).

> *The USPSTF recommends screening for cervical cancer in women aged 21 to 65 years with cytology (Papanicolaou smear) every 3 years or, for women aged 30 to 65 years who want to lengthen the screening interval, screening with a combination of cytology*

[226] Canadian Task Force on Preventive Health Care. Recommendations on screening for cervical cancer. *Canadian Medical Association Journal*. 2013; 185(1): 35-45.
[227] Moyer VA. Screening for cervical cancer: US Preventive Services Task Force recommendation statement. *Annals of Internal Medicine*. 2012; 156(12): 880-91.

and HPV testing every 5 years. See the Clinical Considerations for discussion of cytology method, HPV testing, and screening interval. (A recommendation)

The USPSTF recommends against screening for cervical cancer in women younger than age 21 years. (D recommendation)

The USPSTF recommends against screening for cervical cancer in women older than age 65 years who have had adequate prior screening and are not otherwise at high risk for cervical cancer. (D recommendation)

The USPSTF recommends against screening for cervical cancer in women who have had a hysterectomy with removal of the cervix and who do not have a history of a high-grade precancerous lesion (cervical intraepithelial neoplasia grade 2 or 3) or cervical cancer. (D recommendation)

The USPSTF recommends against screening for cervical cancer with HPV testing, alone or in combination with cytology, in women younger than age 30 years. (D recommendation)

Utilization of This Clinical Preventive Service

Currently in British Columbia

The average participation rate in cervical cancer screening in BC for women age 20-69 was 70.2% between 2011 and 2013, after adjusting for hysterectomy (see Table 5-1). The majority of these women (78.4%) are re-screened every 36 months.[228]

Table 5-1: Pap Smear Participation Rates (%) by Age Groups in BC

2011 – 2013

Age (Years)	Overall	Adjusted for Hysterectomy
20-29	65.4%	65.4%
30-39	72.2%	72.2%
40-49	64.9%	75.4%
50-59	56.9%	71.1%
60-69	44.5%	65.5%
20-69	61.2%	70.2%

Primary screening using HPV testing is not currently available in BC. The BC Cervical Cancer Screening Guidelines Committee is in the process of recommending the inclusion of HPV testing as a component of the provincial cervical cancer screening program.

Best in the World

The Health and Social Care Information Centre in the U.K. reported participation rates (less than 5 years since the last adequate test) of 78.6% for the population aged 25 to 64 in 2012.

[228] BC Cancer Agency. *Cervical Cancer Screening Program 2014 Annual Report*. 2015. Available at http://www.screeningbc.ca/NR/rdonlyres/21BBF070-6504-4A37-A1BB-45563BF387C7/75254/20151205_CCSP_AnnualReport2014_V03_PRINT1.pdf. Accessed January 2016.

Previous years had slightly higher percentages with 79.2% in 2007 and 81.6% in 2002.[229] Screening rates in Norway are also at approximately 80%.[230]

It appears that the Netherlands will be the first country to implement a national HPV based screening program. The program is expected to start in the second half of 2016.[231] The United Kingdom began a review process in June 2014 to determine if it will replace liquid based cytology with testing for HPV as the primary screening test.[232]

Relevant British Columbia Population in 2013

There were an estimated 1,446,402 females aged 25-69 living in BC in 2013.[233] We adjusted for women who have had a hysterectomy using data provided in Table 4-1 above. Based on this adjustment, there are 1,238,579 women between the ages of 25 and 69 currently living in BC who have not had a hysterectomy and thus would be eligible for cervical screening (see Table 5-2).

Table 5-2: British Columbia Females 2013

Age (Years)	Overall	Adjusted for Hysterectomy
25-39	474,967	474,967
40-49	334,392	287,404
50-59	360,124	287,993
60-69	276,919	188,215
Total	**1,446,402**	**1,238,579**

Modelling CPB and CE

In this section, we will calculate the CPB and CE associated with incorporating HPV-based screening in females ages 30-69 in a BC birth cohort of 40,000.

In estimating CPB, we made the following assumptions:

- Cervical cancer incidence and mortality rates are based on Canadian data for the five-year period from 2002 to 2006 (see Table 5-3).[234]

[229] Health and Social Care Information Centre. *Cervical Screening Programme, England 2011-2012*. 2012. Available at http://www.hscic.gov.uk/catalogue/PUB07990. Accessed January 2016.
[230] Machii R and Saito H. Time trends in cervical cancer screening rates in the OECD countries. *Japanese Journal of Clinical Oncology*. 2011; 41(5): 731-2.
[231] F. Hoffmann - La Roche Ltd. *Media Release - Roche Wins the First HPV Primary Screening Tender in Europe*. 2015. Available at http://www.roche.com/media/store/releases/med-cor-2015-10-12.htm. Accessed January 2016.
[232] UK National Screening Committee. *The UK NSC recommendation on Cervical Cancer screening in women (currently under review)*. Available at http://legacy.screening.nhs.uk/cervicalcancer. Accessed January 2016.
[233] BC Stats. *Population Projections*. 2013. Available at http://www.bcstats.gov.bc.ca/StatisticsBySubject/Demography/PopulationProjections.aspx. Accessed January 2016.
[234] Dickinson JA, Stankiewicz A, Popadiuk C et al. Reduced cervical cancer incidence and mortality in Canada: national data from 1932 to 2006. *BMC Public Health*. 2012; 12(1): 1.

Table 5-3: Cervical Cancer Incidence and Mortality Canada, 2002-2006					
				Rate / 100,000	
Age group	Population	Cases	Deaths	Incidence	Mortality
15-19	5,242,502	9	0	0.17	0.00
20-24	5,384,845	70	9	1.30	0.17
24-29	5,267,961	355	31	6.74	0.59
30-34	5,448,001	689	65	12.65	1.19
35-39	6,018,803	794	105	13.19	1.74
40-44	6,782,303	982	172	14.48	2.54
45-49	6,439,447	821	197	12.75	3.06
50-54	5,676,335	694	223	12.23	3.93
55-59	4,863,881	532	186	10.94	3.82
60-64	3,738,125	404	145	10.81	3.88
65-69	3,059,521	329	141	10.75	4.61
70-74	2,779,167	279	149	10.04	5.36
75-79	2,420,438	288	145	11.90	5.99
80-84	1,860,210	246	155	13.22	8.33
Total	**64,981,539**	**6,492**	**1,723**	**9.99**	**2.65**
Source: Dickinson et al. Reduced cervical cancer incidence and mortality in Canada: National data from 1932 to 2006. *BMC Public Health* , 2012.					

- The data on cervical cancer incidence and mortality from Table 5-3 was combined with data on the proportion of females within the population that is expected to survive to a given age group (based on life tables for 2009 to 2011 for BC[235]) within a BC birth cohort of 40,000. There would be an estimated 95 new cervical cancers in the birth cohort between the ages of 30 and 69, with 24 deaths (see Table 5-4). Each death from cervical cancer would be associated with 33.11 years of life lost for a total of 789 life years lost.

Table 5-4: Estimated Cervical Cancer Incidence, Mortality and Life Years Lost In a BC Birth Cohort of 40,000 (Women Ages 30-69)							
	Rate per 100,000		# of Life Years Lived from Age x to x+5 in Birth	# of New	# of	Average Life	Life Years
Age Group	Incidence	Mortality	Cohort of 40,000*	Cancers	Deaths	Expectancy	Lost
30-34	12.65	1.19	99,855	13	1	53.10	63
35-39	13.19	1.74	99,582	13	2	48.23	84
40-44	14.48	2.54	99,181	14	3	43.41	109
45-49	12.75	3.06	98,588	13	3	38.65	117
50-54	12.23	3.93	97,705	12	4	33.96	130
55-59	10.94	3.82	96,375	11	4	29.37	108
60-64	10.81	3.88	94,335	10	4	24.92	91
65-69	10.75	4.61	91,159	10	4	20.66	87
			776,781	**95**	**24**	**33.11**	**789**
* Statistics Canada. Life Tables, British Columbia, 2009 to 2011. Available at http://www.statcan.gc.ca/pub/84-537-x/84-537-x2013005-eng.htm. Accessed February 2016.							

- HPV-based screening is associated with a 55% reduction (see Table 5-5, row e) in the incidence of cervical cancers (RR of 0.45, 95% CI of 0.25 to 0.81) in females ages 30

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

– 64.[236] 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 the incidence of cervical cancers would be the same as the observed effectiveness in reducing mortality from 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.[237]
- We have assumed that adherence with HPV-based screening would be similar to current adherence with cytology-based screening (i.e. 70%, see Table 5-1) and modified this assumption in the sensitivity analysis from 50% to 80% (see Table 5-5, row i).[238]
- We have assumed that the cancers avoided with HPV-based screening would consist of 58% Stage I cancers and 42% Stage II-IV cancers (see Table 5-5, rows m and n).[239]
- The disutility associated with diagnosis and treatment is as follows:[240,241,242]
    - False-positive screening test result – 0.004 QALYs
    - CIN 1 – 0.015 QALYs
    - CIN 2 – 0.07 QALYs
    - CIN 3 – 0.07 QALYs
    - Stage I cancer – 1.20 QALYs (see Table 5-5, row o)
    - Stage II-IV cancer – 1.65 QALYs (see Table 5-5, row p)

Based on these assumptions, the additional CPB associated with incorporating HPV-based screening in females ages 30-69 in a BC birth cohort of 40,000 is 355 quality-adjusted life years saved (see Table 5-5, row r).

[236] 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.
[237] Ibid.
[238] Ogilvie GS, Smith LW, Van Niekerk DJ et al. Women's intentions to receive cervical cancer screening with primary human papillomavirus testing. *International Journal of Cancer*. 2013; 133(12): 2934-43.
[239] Subramanian S, Trogdon J, Ekwueme DU et al. Cost of cervical cancer treatment: implications for providing coverage to low-income women under the Medicaid expansion for cancer care. *Women's Health Issues*. 2010; 20(6): 400-5.
[240] Kulasingam SL, Rajan R, St Pierre Y et al. Human papillomavirus testing with Pap triage for cervical cancer prevention in Canada: a cost-effectiveness analysis. *BMC Medicine*. 2009; 7(1): 1.
[241] de Kok IM, van Rosmalen J, Dillner J et al. Primary screening for human papillomavirus compared with cytology screening for cervical cancer in European settings: cost effectiveness analysis based on a Dutch microsimulation model. *BMJ*. 2012; 344: e670-82.
[242] van Rosmalen J, de Kok I and Van Ballegooijen M. Cost-effectiveness of cervical cancer screening: cytology versus human papillomavirus DNA testing. *BJOG: An International Journal of Obstetrics & Gynaecology*. 2012; 119(6): 699-709.

Table 5-5: Calculation of Clinically Preventable Burden (CPB) Estimate for HPV-based Cervical Cancer Screening in a Birth Cohort of 40,000 (B.C.)			
Row Label	**Variable**	**Base Case**	**Data Source**
a	New cervical cancer cases ages 30-69	95	Table 5-4
b	Cervical cancer deaths ages 30-69	24	Table 5-4
c	Remaining life expectancy at death from cervical cancer (in years)	33.11	Table 5-4
d	Life years lost	789	= a * b
e	Effectiveness of screening with HPV in reducing cervical cancer cases and deaths	55%	√
f	Cervical cancer cases avoided with 100% adherence to screening	52.3	= e * a
g	Cervical cancer deaths avoided with 100% adherence to screening	13.1	= e * b
h	Life years lost avoided with 100% adherence to screening	434	= c * g
i	Adherence with offers to receive screening	70.0%	√
j	Cervical cancer cases prevented	36.6	= i * f
k	Deaths prevented	9.2	= i * g
l	Life-years gained	304	= c * k
m	Proportion of cancer cases avoided Stage I	58%	√
n	Proportion of cancer cases avoided Stage II-IV	42%	√
o	Disutility associated with Stage I cervical cancer (in QALYs)	1.20	√
p	Disutility associated with Stage II-IV cervical cancer (in QALYs)	1.65	√
q	QALYs gained by avoiding cervical cancers	51	= (j * m * o) + (j * n * p)
r	Potential QALYs saved (CPB) - HPV-based screening increasing from 0% to 70%	355	= l + q

√ = Estimates from the literature

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

- Assume that the effectiveness of screening with HPV in reducing cervical cancer cases and deaths is reduced from 55% to 19% (Table 5-5, row e): CPB = 123.
- Assume that the effectiveness of screening with HPV in reducing cervical cancer cases and deaths is increased from 55% to 75% (Table 5-5, row e): CPB = 484.
- Assume that adherence with offers to receive screening is reduced from 70% to 50% (Table 5-5, row i): CPB = 253.
- Assume that adherence with offers to receive screening is increased from 70% to 80% (Table 5-5, row i): CPB = 406.

In estimating CE, we made the following assumptions:

Note that in estimating costs we are trying to tease out the additional costs associated with HPV-based screening, i.e. those over and above current costs for cytology-based screening. These additional costs will then be divided by the additional QALYs gained by incorporating HPV-based screening to generate a cost/QALY associated with moving from the current cytology-based screening to HPV-based screening.

- **Number of cytology-based screens** – A total of 776,781 life years are lived by females between the ages of 30 and 69 in a BC birth cohort of 40,000 (see Table 5-4). We assumed a screening rate of once every 3 years (see Table 5-6, row b) starting at age 30, for a lifetime average total of 13 screens per woman. We have also assumed that 5% of screens would have a mildly abnormal Pap resulting in a rescreen (see Table 5-6, row c).[243] Total cytology-based screens in this cohort are

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

therefore estimated at 188,408 (Table 5-6, row f) assuming 70% adherence with invitations to screening (Table 5-6, row e).

- **Number of HPV-based screens** – We assumed a screening rate of once every 5 years starting at age 30 for a lifetime average total of 8 screens per woman (Table 5-6, row t). 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 are reflexed to cytology (Table 5-6, row x). Cytology results are negative for 64% of these women (Table 5-6, row z). 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 either/or HPV and cytology positive are referred to colposcopy.[244] This approach results in 114,387 HPV-based screens (Table 5-6, row ad) and 14,446 cytology-based screens (Table 5-6, row ae) in females between the ages of 30 and 69 in a BC birth cohort of 40,000.
- **Number of colposcopies** – Cytology-based screening is associated with 3.32 (95% CI of 2.87 to 3.77) colposcopies per 100 screens (Table 5-6, row i) while HPV-based screening is associated with 5.72 (95% CI of 5.28 to 6.17) colposcopies per 100 screens (Table 5-6, row ah).[245]
- **Number of CIN2+ detected** – Cytology-based screening is associated with the detection of 1.10 (95% CI of 0.83 to 1.37) cases of CIN2+ per 100 screens (Table 5-6, row m) while the initial round of HPV-based screening is associated with 1.61 (95% CI of 1.32 to 1.89) cases of CIN2+ per 100 screens (Table 5-6, row ak).[246]
- **Cost estimates** for cytology, HPV testing, colposcopy and LEEP are based on Popadiuk et al.,[247] adjusted from 2008 Canadian dollars to 2013 Canadian dollars using the health care component of the BC Consumer Price Index (CPI) (+2.5%).[248] Adjusted costs are as follows:
    - Cytology - $61.04 (Table 5-6, row g)
    - HPV test - $90.07 (Table 5-6, row af), this cost was adjusted by +/- 25% in the sensitivity analysis
    - Colposcopy - $981 (Table 5-6, row k)
    - Loop electrosurgical excision procedure (LEEP) - $1,936 (Table 5-6, row o)
- **Cost estimates** for the treatment of cervical cancers are based on Cromwell et al.[249] All costs from diagnosis to death or 5-year discharge are included.
    - Stage I cancer - $16,241
    - Stage II cancer - $22,072
    - Stage III cancer - $24,043

[244] 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.
[245] Ibid.
[246] Ibid.
[247] Popadiuk C, Gauvreau C, Bhavsar M et al. Using the Cancer Risk Management Model to evaluate the health and economic impacts of cytology compared with human papillomavirus DNA testing for primary cervical cancer screening in Canada. *Current Oncology*. 2016; 23(Supp.1): S56-S63.
[248] Statistics Canada. *Consumer Price Index, Health and Personal Care, by Province (Monthly) (British Columbia)*. 2013. Available at http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/cpis13f-eng.htm. Accessed December 2013.
[249] Cromwell I, Ferreira Z, Smith L et al. Cost and resource utilization in cervical cancer management: a real-world retrospective cost analysis. *Current Oncology*. 2016; 23(Supp.1): S14-S22.

- Stage IV cancer - $41,022

61% of cancers are Stage I, 24% Stage II, 12% Stage III and 3% Stage IV for a weighted average treatment cost per cancer of $19,276 (Table 5-6, row ao).

- **Costs avoided due to cancers prevented** – We assumed that 58% of cancers avoided were Stage I cancers and 42% were Stage II-III cancers.[250] The average treatment cost of $14,781 (Table 5-6, row ao) was based on the weighted average cost assuming a treatment cost per cancer of $11,878 for Stage I cancers and $18,791 for Stage II-III cancers.[251]
- **Costs avoided due to deaths prevented** - In Ontario, the health system costs incurred during the 3 months before diagnosis until death for patients with cervical cancers was estimated at $41,536 (95% CI $38,642 – $44,429) in 2009 Canadian dollars.[252] Ontario costs in this area tend to be approximately 20% higher than those in BC,[253] so we adjusted these Ontario costs, multiplying them by 0.834 and then adjusting the costs to 2013 Canadian dollars using the health and personal care component of the BC Consumer Price Index (CPI) (+3.5%).[254] The adjusted costs were $35,853 (Table 5-6, row aq).
- **Patient time and travel costs** - For patient time and travel costs, we assumed an hourly wage of $24.39 (the BC average in 2013)[255] plus 18% benefits applied to the estimated two hours of patient time required for a cost per screening visit of $57.56, or $28.78 per hour (Table 5-6, row q). We also assumed an estimated two hours of patient time required for a colposcopy and a LEEP procedure.
- Discount rate of 3%.

Based on these assumptions, the estimated cost per QALY would be -$5,181 (Table 5-6, row ax).

[250] Subramanian S, Trogdon J, Ekwueme DU et al. Cost of cervical cancer treatment: implications for providing coverage to low-income women under the Medicaid expansion for cancer care. *Women's Health Issues*. 2010; 20(6): 400-5.
[251] Kulasingam SL, Rajan R, St Pierre Y et al. Human papillomavirus testing with Pap triage for cervical cancer prevention in Canada: a cost-effectiveness analysis. *BMC Medicine*. 2009; 7(1): 1.
[252] de Oliveira C, Bremner KE, 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 Open Access Journal*. 2013; 1(1): E1-E8.
[253] Pataky R, de Oliveira C, Bremmer K et al. *Comparing the Costs of Cancer Care in British Columbia and Ontario: a Phase-based Approach*. 2013. Canadian Centre for Applied Research in Cancer Control. Available at https://www.cc-arcc.ca/common/pages/UserFile.aspx?fileId=281285. Accessed December 2013.
[254] Statistics Canada. *Consumer Price Index, Health and Personal Care, by Province (Monthly) (British Columbia)*. 2013. Available at http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/cpis13f-eng.htm. Accessed December 2013.
[255] Statistics Canada. *Average Hourly Wages of Employees by Selected Characteristics and Occupation, Unadjusted Data, by Province (Monthly) (British Columbia)*. 2013. Available at http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/labr69k-eng.htm. Accessed December 2013.

Table 5-6. Summary of Cost Effectiveness (CE) Estimate for HPV-based Cervical Cancer Screening			
Row Label	**Variable**	**Base Case**	**Data Source**
a	Life years lived from ages 30-69 in a birth cohort of 40,000	776,781	Table 5-4
	Cytology-Based Screening		
b	Annual frequency of cytology-based screening	33%	√
c	% with mildly abnormal Pap resulting in a rescreen	5%	√
d	Number of cytology-based screens - 100% adherence	269,155	= (a * b) + (a * b * c)
e	Adherence with cytology-based screening	70%	Table 5-5, row i
f	Number of cytology-based screens - 70% adherence	188,408	= d * e
g	Cost per cytology-based screen	$61	√
h	Cost for cytology-based screening	$11,499,829	= f * g
i	# of colposcopies per 100 cytology-based screens	3.32	√
j	Cytology-based screening - number of colposcopies	6,255	= f/100 * i
k	Cost per colposcopy	$981	√
l	Cost of colposcopy	$6,133,546	= j * k
m	# of CIN2+ per 100 cytology-based screens	1.10	√
n	Cytology-based screening - number of CIN2+	2,072	= f/100 * m
o	Cost of treatment per CIN2+	$1,936	√
p	Cost of treating CIN2+	$4,012,876	= n * o
q	Cost per hour of patient time	$28.78	√
r	Cost of patient time	$5,662,061	= (f + j + n) * q
s	**Cost of Cytology-Based Screening**	**$27,308,313**	= h + l + p + r
	HPV-Based Screening		
t	Annual frequency of HPV-based screening	20%	√
u	Number of HPV-based screens - 100% adherence	155,356	= a * t
v	Adherence with HPV-based screening	70%	Table 5-5, row i
w	Number of HPV-based screens - 70% adherence	108,749	= u * v
x	Proportion of screens hrHPV-positive	8.1%	√
y	Number of reflex cytology screens	8,809	= w * x
z	Proportion of reflex cytology screens negative	64%	√
aa	Number of reflex cytology screens negative	5,638	= y * z
ab	Number of follow-up cytology screens	5,638	= aa
ac	Number of follow-up HPV screens	5,638	= aa
ad	HPV-based screening - number of HPV-based screens	114,387	= w + ac
ae	HPV-based screening - number of cytology-based screens	14,446	= y + ab
af	Cost per HPV-based screen	$90	√
ag	Cost for HPV-based screening	$11,176,579	= (ad * af) + (ae * g)
ah	# of colposcopies per 100 HPV-based screens	5.72	√
ai	HPV-based screening - number of colposcopies	7,023	= (ad/100 * ah) + (ae/100 * i)
aj	Cost of colposcopy	$6,886,021	= ai * k
ak	# of CIN2+ per 100 HPV-based screens	1.61	√
al	HPV-based screening - number of CIN2+	2,001	= (ad/100 * ak) + (ae/100 * m)
am	Cost of treating CIN2+	$3,873,557	= al * o
an	Cost of patient time	$3,967,505	= (ad + ae + ai + al) * q
ao	Cost of treatment per cervical cancer avoided	-$19,276	√
ap	Costs avoided due to cervical cancers avoided	-$706,343	= ao * Table 5-5, row j
aq	Cost of treatment per death from cervical cancer avoided	-$35,853	√
ar	Costs avoided due to cervical cancers deaths avoided	-$329,131	= aq * Table 5-5, row k
as	**Cost of HPV-Based Screening**	**$24,868,188**	= ag + aj + am + an + ap + ar
at	**Net HPV-based screening and patient costs (undiscounted)**	**-$2,440,124**	= as - s
au	QALYs saved (undiscounted)	355	= Table 5-5, row r
av	Net screening and patient costs (3% discount)	-$1,094,124	Calculated
aw	QALYs saved (3% discount)	211	Calculated
ax	**CE ($/QALY saved)**	**-$5,181**	= av / aw

√ = Estimates from the literature

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

- Assume that the effectiveness of screening with HPV in reducing cervical cancer cases and deaths is reduced from 55% to 19% (Table 5-5, row e): CE = -$10,831.
- Assume that the effectiveness of screening with HPV in reducing cervical cancer cases and deaths is increased from 55% to 75% (Table 5-5, row e): CE = -$4,385.
- Assume that the cost per HPV-based screen is reduced from $90 to $68 (Table 5-5, row af): CE = -$10,524.
- Assume that the cost per HPV-based screen is increased from $90 to $113 (Table 5-5, row af): CE = $405.

Summary

Table 5-7: HPV-based Cervical Cancer Screening Being Offered to a Birth Cohort of 40,000 Between the Ages of 30 and 69
Summary

	Base Case	Range	
CPB (Potential QALYs Gained)			
Gap between B.C. Current (0%) and 'Best in the World' (70%)			
3% Discount Rate	211	73	288
0% Discount Rate	355	123	484
CE ($/QALY) **including** patient time costs			
3% Discount Rate	-$5,181	-$10,524	$405
0% Discount Rate	-$6,877	-$13,969	$538
CE ($/QALY) **excluding** patient time costs			
3% Discount Rate	-$1,583	-$6,926	$4,003
0% Discount Rate	-$2,101	-$9,194	$5,313

The Lifetime Prevention Schedule

Establishing Priorities among Effective Clinical Prevention Services in British Columbia

Summary and Technical Report
March 2016 Update

Screening for and Management of Obesity in Children and Youth, Screening for Lung Cancer, Screening for Depression in Adults, Screening for Depression in Pregnant and Postpartum Women and HPV-Based Screening for Cervical Cancer

Participating partner organizations:

BC Cancer Agency
CARE + RESEARCH
An agency of the Provincial Health Services Authority

BRITISH COLUMBIA

BC Centre for Disease Control
An agency of the Provincial Health Services Authority

CHILD HEALTH BC
LEAD BENEFACTOR
save on foods

GPSC
General Practice Services Committee

Perinatal Services BC
An agency of the Provincial Health Services Authority

Provincial Health Services Authority
Province-wide solutions. Better health.

SSC
SPECIALIST SERVICES COMMITTEE

UBC THE UNIVERSITY OF BRITISH COLUMBIA

University of Victoria