THE HEALTH AND ECONOMIC IMPACT OF A TAX ON SUGARY DRINKS IN CANADA

TECHNICAL REPORT

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METHODS

The study's methods are presented in two sections. The first section, *Sugary Drink Data and Analyses*, describes the data and analyses used to examine sales data and dietary intake data for sugary drinks in Canada. The second section, *Health and Economic Costs Model*, presents the simulation modelling methods used for determining the potential impacts of sugary drink consumption and a sugary drink tax intervention in Canada.

SUGARY DRINK DATA AND ANALYSES

SUGARY DRINK SALES

Sales data were purchased from Euromonitor International for the years 2001 to 2015. Euromonitor provides market reports for food and beverage sales in Canada and globally.[1] Euromonitor 'ready-to-drink' (RTD) volume represents the final liquid volume that the consumer drinks. For most soft drinks sold pre-packaged in liquid form, such as carbonated beverages, bottled water, or juices, RTD volume will be equal to the volume sold. For both powder and liquid concentrates, a dilution ratio is applied to the volume sold to calculate the estimated RTD volume. RTD volume allows like-for-like volume comparisons to be made across all categories.

The Euromonitor data captures both 'on-trade' and 'off-trade' sources. On-trade sales—often used interchangeably with the term HORECA—include sales through bars, restaurants, cafés, hotels and other catering establishments. Off-trade sales are through retail outlets, such as supermarkets/hypermarkets, discounters, convenience stores, independent small grocers, forecourt retailers, food/drink/tobacco specialists, other grocery retailers, non-grocery retailers, vending, home shopping, internet retailing and direct selling. Euromonitor sources its data from a range of industry sources; however, the methods used are proprietary and cannot be independently validated.

Euromonitor data was purchased for the following beverage categories: non-diet cola and non-cola carbonated soft drinks, ready-to-drink tea and coffee, energy drinks, sports drinks, flavoured bottled water, flavoured milk, drinkable yogurt, concentrates (defined as fruit drinks), juice drinks (up to 24% juice), nectars (24-99% juice), and 100% juice.[2] Volumes for powder and liquid concentrates were translated into drinkable volumes. Powder concentrates, reported in tonnes, were reconstituted based on preparation instructions for current purchasable products using the most conservative ratio identified (8,181.8 litres of drink per tonne of concentrate). The same approach was used for liquid concentrates (105.2 litres of drink per litre of concentrate). The resulting numbers were reported as total volume (millions of litres) of beverage sales per calendar year, and consistent with all other beverage categories. The correspondence between population-based beverage intake data and Euromonitor estimates of food and beverages sales is not known. Sales estimates include any 'waste' from beverages sold but not consumed. In the current study, some assumptions were made about product ingredients due to the absence of detailed nutrition information.

Sugary drink sales were defined as the total sales volume from the following beverage categories, consistent with the World Health Organization's definition of 'free sugars': regular carbonated soft drinks, regular fruit drinks, non-diet sports drinks, non-diet energy drinks, sugar-sweetened coffee and tea, hot chocolate, non-diet flavoured water, sugar-sweetened milk (e.g., chocolate milk), sugar-sweetened drinkable yogurt, and 100% juice. Estimates for *sugar-sweetened beverage* (SSB) sales were the same as sugary drinks, except that 100% juice was omitted (see Figure 1). Comparisons were made between beverage categories, and for changes over time. Per capita sales volume and adjustments for population growth used Statistics Canada population numbers.[3]

The Euromonitor data was purchased in August 2016. Due to Euromonitor's standard data agreement, specific estimates of individual beverage categories for a given year cannot be reported. Therefore, data are presented showing changes in a single beverage category over time, or showing aggregated beverage categories within a single year.

FIGURE 1

SUGAR-SWEETENED BEVERAGES (SSBs)

REGULAR SOFT DRINKS, SWEETENED TEA & COFFEE, SPORTS DRINKS, FRUIT DRINKS, ENERGY DRINKS, FLAVOURED WATER, FLAVOURED MILK & DRINKABLE YOGURT

SUGARY DRINKS

REGULAR SOFT DRINKS, SWEETENED TEA & COFFEE, SPORTS DRINKS, FRUIT DRINKS, ENERGY DRINKS, FLAVOURED WATER, FLAVOURED MILK & DRINKABLE YOGURT
100% JUICE

SUGARY DRINK INTAKE

SURVEY

The most recent national estimates of beverage intake are from the 2004 Canadian Community Health Survey (CCHS 2004, Cycle 2.2).[4] CCHS 2004 used a stratified multistage cluster design with probability sampling of Canadians residing in the 10 provinces. Excluded persons were those living on reserve and other Indigenous peoples' settlements, full-time members of the Canadian Forces, and the institutionalized population. Using a computer-assisted interviewing tool, respondents were administered a General Health Survey and a dietary recall of all foods and beverages consumed over the previous day's 24-hour period (24-hour recall). The 24-hour recall used the five steps of the Automated Multiple-Pass Method: quick list, forgotten foods and beverages, time and occasion, detailed information including amounts consumed and preparation method, and a final review.[5] A proxy (e.g., parent or guardian) provided information for respondents below age 6 and assisted respondents aged 6 to 11. Respondents aged 12 and older provided their own information. Using probability sampling, approximately 30% of respondents were selected to complete a second dietary recall, conducted 3 to 10 days later.[4] The current study included all respondents with a valid first

dietary recall. Data was accessed through the South-Western Ontario Research Data Centre (SWO-RDC) at the University of Waterloo.

MEASURES

In the scientific literature, sugary drinks are classified using different criteria, particularly with respect to 100% juice. In the current study, *sugary drinks* were classified using 10 mutually-exclusive categories: regular carbonated soft drinks, regular fruit drinks, sports drinks (non-diet), energy drinks (non-diet), sugar-sweetened coffee, sugar-sweetened tea (e.g., Arizona Iced Tea), hot chocolate, flavoured water (non–diet; e.g., Vitaminwater), sugar-sweetened milk (e.g., chocolate milk), sugar-sweetened drinkable yogurt, and 100% juice.

CCHS 2004 survey files with data on ingredients in recipes were used to identify sugary drinks through links to existing food codes and descriptions in the Canadian Nutrient File.[4] A total of 227 unique food codes pertained to sugary drinks. The survey files that reported ingredients for each respondents' food items (files 'FID' and 'FRL') were combined. Second dietary recalls were excluded, resulting in a total of 1,299,994 cases. After using variable 'FIDD_CDE' to add food descriptions to each case (variables 'FDCD_DEN' and 'FDCDDCOD'), sugary drinks were identified using the 227 'FIDD_CDE' sugary drink codes. Double-counting due to combining the ingredient files was eliminated. Survey cases were aggregated to form one case per respondent that included, for each of the study's 10 beverage categories, quantity and energy variables derived from 'FDCD_WTG' (quantity consumed of a food or beverage, grams) and 'FDCD_EKC' (energy per food item, kilocalories). Grams were converted to millilitres (ml) based on 1 gram of water equalling 1 ml of water.[6]

The dietary intake data from CCHS 2004 are more than a decade old; therefore, Euromonitor sales data were used to estimate projected drink intake for 2015. According to Euromonitor data, the per capita volume of sugary drink sales decreased by 12.6% between 2004 and 2015, after accounting for population growth. Accordingly, the volume and energy of SSB and sugary drink intake assessed in 2004 was reduced by 12.6% for each individual who consumed any of the 10 beverages. To permit the calculation of per capita estimates, non-consumers of sugary drinks were assigned zero values for respective volume and energy variables. Beverage categories were aggregated into two groups to estimate 'total' sugary drink consumption: total SSBs and total sugary drinks (Figure 1). The file was merged with the General Health Survey to examine differences by age and sex (final sample size = 35,041). Socio-demographic variables included age (variable 'DHHD_AGE': continuous) and sex ('DHHD_SEX': male, female). Age was recoded into age groups used by Health Canada (0-3 years, 4-8, 9-13, 14-18, 19-30, 31-50, 51-70, 71 or older)[6,7] and, for use in the simulation model, 10-year age groups (0-9, 10-19, 20-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80-89, 90+).

Dietary recall data entails important assumptions and limitations. Group-level analysis of unadjusted means can be assumed to reflect the mean of the population distribution of usual intake, since data was collected throughout the year, and the days of week were evenly represented.[4,8] However, underreporting of food energies is a common limitation of dietary recall data, and no standard

adjustment currently exists for correcting underreporting.[9] Therefore, sugary drink intake based on CCHS data may underestimate actual intake levels.

ANALYSIS

The means and standard errors of per capita daily intake (volume and energy) of total SSBs and total sugary drinks were calculated for representative age and sex sub-groups using IBM SPSS Statistics Version 23.0 software. Data was weighted using scaled weights and was representative of the majority of the 10 provinces.[4]

HEALTH AND ECONOMIC COSTS MODEL

The study used simulation modelling to estimate the health and economic impacts of sugary drinks in Canada (i.e., the 'avoidable burden' due to sugary drinks), and the health and economic benefits of an excise tax on sugary drinks. The model simulated the 2015 Canadian population over their remaining lifetime.

The primary outcomes estimated by the model are changes in disease-specific incidence, prevalence and mortality, disability adjusted life years (DALYs), overall mortality, and cases of obesity and overweight. Cost outcomes show changes in direct health care costs resulting from changes in disease morbidity and mortality, while accounting for additional health costs due to longer lives. Estimated revenue from the tax intervention is reported.

MODEL OVERVIEW

The Assessing Cost-Effectiveness (ACE) model was used to generate estimates of health care costs and burdens from sugary drinks. Originally created for Australia to examine the effectiveness of key strategies to reduce health risk factors,[10,11,12] the current study adapted the model for the Canadian context. This Markov cohort macrosimulation is a proportional multi-state life table. The ACE model simulates groups of people (cohorts) as they transition between multiple health states (hence, 'multi-state'). It does not use inputs or estimates at the individual-level. The ACE model simultaneously simulates different trajectories for two identical populations: a counterfactual scenario of 'business as usual', and a scenario in which beverage consumption is changed, either through eliminating it entirely or applying a tax intervention. The difference between the two scenarios shows the avoidable burden associated with sugary drink consumption or the effect of tax intervention, respectively.

In the ACE model, population impact fractions link the relevant diseases to the causative risk factors (i.e., high body mass index from sugary drink consumption and, for type 2 diabetes, the direct effects of sugary drink consumption). Price elasticity of demand links the increase in price from the tax to consumer behaviour. Due to data limitations, the model simulates effects on the Canadian adult population (age 20 and older) only. However, children were included when estimating tax revenue. The model's starting reference year is 2015. Results presented are for a 25-year period, from 2016-2041.

LIFE TABLE ANALYSIS

The ACE model consists of a main life table populated with a closed cohort that replicates the 2015 Canadian adult resident population, aging it over time. The population transitions through four primary health states, based on annual transition probabilities, until death or age 95. The main life table incorporates all-cause mortality rates by sex and age. Running parallel to the main life table are life tables for each modelled sugary drink-related disease. Proportions of the population simultaneously reside in the disease life tables.

The projected health impact of the intervention—sugary drink taxation—is tracked through two primary outcomes. First, the model calculates the difference in the number of years lived by the population with the intervention compared to the population without the intervention. Age-sex mortality rates, specific to each disease and for death from 'all other causes,' determine the number of years lived. Second, the model tracks the years of life lived in poor health due to disease or injury, called years lived with disability (YLD). The average YLD for a given age and sex is referred to as prevalent YLD (pYLD), and may pertain to a specific disease or group of diseases. Like mortality, the model uses these age- and sex-specific morbidity rates for each disease and all other causes of illness. Disability weights for each disease are used to calculate YLDs and represent the severity of health loss associated with the disease state.

Disability adjusted life years (DALYs) are constructed from these two outcomes. DALYs are a population summary measure that conveys the burden of disease from premature death (years of life lost) and the disabling results of an illness (years lived with disability). An effective intervention reduces the number of DALYs compared to the business as usual scenario.

The intervention affects overall rates for mortality and morbidity as the intervention lowers the incidence of diseases. The improved disease mortality and morbidity rates are added to the 'all other causes' rates in the main life table, thereby improving the entire population's rates (Figure 2). These improved rates translate into a reduction in years of life lost and disability.

The model also calculates the difference in health care costs between an intervention and the business as usual case. For an effective intervention, these cost offsets will be negative–i.e., costs averted. Two types of costs are assigned: age- and sex-specific annual cost for those alive and not having one of the modelled diseases, and age- and sex-specific cost of having one of the modelled diseases.

DISEASE MODELS

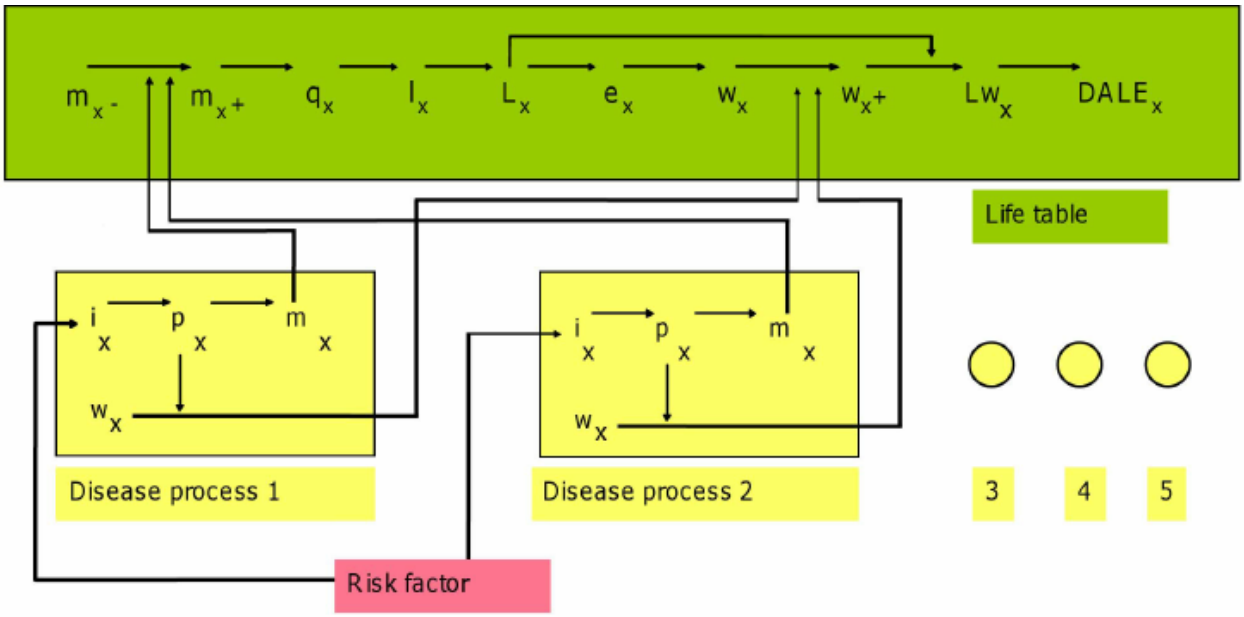
The ACE model includes 19 diseases for which high body mass index (BMI) is a risk factor. The diseases modelled parallel those examined in the 2015 Global Burden of Disease (GBD) study. The GBD study was the source of key model parameters, including relative risk ratios, years lived with disability, and other epidemiological parameters. The modelled diseases are: type 2 diabetes, 11 cancers [breast (females), colon and rectum, esophageal, gallbladder and biliary tract, kidney, leukemia, liver, ovarian,

pancreatic, thyroid, uterine], 4 cardiovascular conditions (ischemic heart disease, ischemic stroke, hemorrhagic stroke, hypertensive heart disease), chronic kidney disease, osteoarthritis, and low back pain (Table 1).[13] The model accounted for non-BMI-mediated health effects on type 2 diabetes from sugary drink consumption. Other non-BMI-mediated risks from sugary drinks were not included in the model. Accordingly, the model outputs may be considered conservative estimates of the health burden associated with sugary drinks and the potential health improvements from a sugary drink tax.

Consistent with the GBD study, specific types of diseases were distinct, and modelled separately. Chronic kidney disease (CKD) was modelled as four types: CKD due to diabetes mellitus, CKD due to hypertension, CKD due to glomerulonephritis, and CKD due to other causes. Osteoarthritis was modelled as osteoarthritis of the hip and osteoarthritis of the knee. Disease definitions specified by the GBD study using International Classification of Diseases (ICD) codes guided the selection of other model inputs, enabling the greatest possible consistency in disease definitions for different data sources (see Appendix A, Table A1). Osteoarthritis and low back pain are nonfatal conditions.

FIGURE 2

SCHEMATIC OF A PROPORTIONAL MULTI-STATE LIFE TABLE



* Interaction between disease parameters and lifetable parameters, where x is age, i is incidence, p is prevalence, m is mortality, w is disability-adjustment, q is probability of dying, l is number of survivors, L is life years, Lw is disability-adjusted life years and DALE is disability-adjusted life expectancy, and where '-' denotes a parameter that specifically excludes modelled diseases, and '+' denotes a parameter for all diseases (i.e., including modelled diseases). From Lee et al (2013) The cost-effectiveness of laparoscopic adjustable gastric banding in the morbidly obese adult population of Australia

A separate life table was generated for each disease, for a total of 23 disease life tables. The proportion of the Canadian population assigned to each disease life table is determined by disease incidence (inflow) and case-fatality (outflow) rates. Together, the main life table and disease life tables

encompass the ACE model's four health states: healthy, diseased, dead from the disease, and dead from all other causes (Figure 3). Transitions between states are based on annual transition probabilities: incidence, remission, case-fatality, and mortality from all other causes. Remission from disease is assumed to be generally unlikely and set to zero. As the intervention has an effect and the population ages, the incidence of diseases is reduced and, subsequently, mortality and morbidity rates are improved. The disease life tables also track disease health care costs and report outcomes of disease incidence, prevalence and mortality.

TABLE 1

DISEASES ASSOCIATED WITH HIGH BODY MASS INDEX

GLOBAL BURDEN OF DISEASE 2015 STUDY

Esophageal cancer
Colon and rectum cancer
Liver cancer
Gallbladder and biliary tract cancer
Pancreatic cancer
Breast cancer (before menopause; after menopause)
Uterine cancer
Ovarian cancer
Kidney cancer
Thyroid cancer
Leukemia
Ischemic heart disease
Ischemic stroke
Hemorrhagic stroke
Hypertensive heart disease
Type 2 diabetes mellitus
Chronic kidney disease
Osteoarthritis
Low back pain

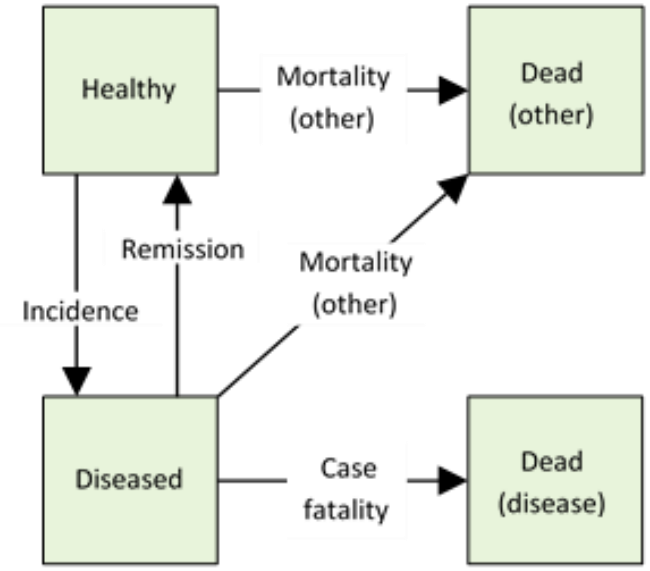
EFFECT OF RISK FACTOR EXPOSURE

In the current model, the intervention—taxation—operates via two physiological mechanisms. First, energy intake is reduced through lower sugary drink intake, thereby causing a corresponding reduction in average BMI and, subsequently, reduction in BMI-mediated diseases. Second, a lower volume of sugary drink intake reduces type 2 diabetes through a direct non-BMI-mediated effect. Within these pathways, the changes in BMI and sugary drink volume are linked to changes in annual transition probabilities through population impact fraction (PIF) estimates. A PIF is the percentage change in future disease incidence from a risk factor with a given relative risk. When the intervention is applied, the intervention's effect is applied through PIFs such that the relative risk of disease incidence due to the risk factor is affected. For type 2 diabetes, PIFs for BMI- and non-BMI effects were combined in the disease life table to produce a single effect on incidence. The relationship between the change in risk

factor exposure (primarily BMI, but also simply sugary drink consumption) and disease risk is captured in relative risk ratios for the relevant diseases.

FIGURE 3

CONCEPTUAL MODEL OF FOUR HEALTH STATES



*Each disease is modelled by a conceptual model with four states (healthy, diseased, dead from the disease, and dead from all other causes) and transition hazards between states of incidence, remission, case fatality, and mortality from all other causes. From Forster et al (2011) Cost-effectiveness of diet and exercise interventions to reduce overweight and obesity.

INTERVENTION SPECIFICATION AND PARAMETERS

TYPE OF TAX

The modeled intervention is an excise tax: a tax levied on manufacturers, distributors, or retailers, which these parties may pass on to consumers. Assuming it is passed on, the price increase is reflected in the product's price tag. Conversely, sales taxes in Canada and the U.S. are added at the point of purchase, leading consumers to often overlook the price increase. Excise taxes have a greater influence on consumer purchasing behaviour than sales taxes, since the higher price appears on the price tag, thereby providing a more visible and consistent price signal to consumers.[14] An *ad valorem* excise tax is set equal to a percentage of the beverage's pre-tax value: for example, 20% of the price. A volumetric tax, a type of specific excise tax, is set equal to a percentage of the beverage's volume: for example, $0.30 per litre. *Ad valorem* excise taxes were modelled for each of the two beverage groups: SSBs and sugary drinks. The models use an average pre-tax price of $2.50/litre. Sensitivity analyses modelled other pre-tax beverage prices.

TAXATION LEVELS MODELLED

An *ad valorem* excise tax was modelled at the following levels: 10%, 20% and 30% of the beverage's pre-tax price. These tax levels are consistent with existing measures in other jurisdictions. For example, based on an average price of $2.50/litre, the 10% increase is similar to the taxes in Mexico, Cook County (Illinois), and four Californian cities (approximately 1 cent per ounce or 34 cents per litre); the 20% tax is similar to the tax implemented in Philadelphia (1.5 cents per ounce or 51 cents a litre); and, the 30% tax is similar to the tax passed in Boulder, Colorado (2 cents per ounce or 68 cents per litre).[15,16,17,18,19] Note that these comparisons may vary based on actual price per litre, and that many existing taxes are designed as specific volumetric excise taxes which account for price per litre. The ACE model simulates *ad valorem* excise taxes set at rates consistent with existing volumetric taxes. Based on the best available evidence, the World Health Organization recommends a minimum 20% tax as best practice, as it has been found substantive enough to change behaviour.[20]

PRICE ELASTICITY OF DEMAND

A pooled own-price elasticity of demand for sugary drinks of -1.20 [95% Confidence Interval (CI): -1.34, -1.06] was used in the model, based on a meta-analysis of studies from the United States, Mexico, Brazil and France.[21] A price elasticity of -1.20 indicates that for every 1% price increase, demand for sugary drinks decreases by 1.2%. Given the broad definition of sugary drinks, the model did not incorporate caloric compensation from switching to non-taxed beverages and foods. Using the upper boundary for own-price elasticity of demand (-1.06), sensitivity analyses tested the impact of consumers being less responsive to price increases. A 100% tax pass-on rate was assumed; however, sensitivity analyses modelled 80% and 120% pass-on rates.

TAX REVENUE

Tax revenue estimates were calculated for each tax intervention scenario. Tax revenue was based on beverage consumption for the entire Canadian population, not limited to Canadian adults. Tax revenue calculations did not adjust for secular trends in beverage consumption or changes in population demographics. Costs are reported in 2015 Canadian dollars.[22]

AVOIDABLE BURDEN

To determine the disease and economic burden of sugary drink consumption, the ACE model was used to calculate the 'avoidable burden.' The avoidable burden is the future disease and economic costs that could be eliminated if a risk factor were eliminated today. It accounts for the risk factor's lagged effects on disease. Though different from 'attributable burden,' for simplicity, the current study at times uses the terms 'attributable' and 'avoidable' interchangeably.

To estimate the avoidable burden, the model simultaneously simulated two cases: a population in which sugary drink consumption was reduced to zero, and the business as usual population with 2015 consumption levels. The difference between these two cases represents the avoidable burden. The avoidable burden was calculated separately for SSB consumption and sugary drink consumption.

BASELINE SPECIFICATION AND PARAMETERS

POPULATION

The model replicated the 2015 Canadian population through the inclusion of three parameters: population size, mortality rate, and prevalent years lived with disability (pYLD) for all causes. The model's population size was Statistics Canada's estimated 2015 population size, by sex and 1-year age groups.[3] All-cause mortality rates were calculated by dividing Statistics Canada's 2012 all-cause deaths by the 2012 population size for corresponding sex and age groups.[23,23] Using the epidemiology software DisMod II (EpiGear, Version 1.05, Brisbane, Australia), data was interpolated to obtain mortality rates by sex and 1-year age groups (0-100+). From the GBD Results Tool, the rate of 'all cause' pYLD was calculated per capita (2015 population) by sex and 5-year age groups.[24]

DISEASE RISK & EPIDEMIOLOGY

Relative risk ratios capture the relationship between changes in an exposure and a given disease outcome. For BMI-related relative risks, the study used meta-analyses or pooled analyses of prospective observational studies reported by the GBD 2015 Risk Factors Collaborators (see Appendix Table 6a in the GBD publication).[i,13] For sex and age group, mean relative risks (RRs) and 95% confidence intervals (95% CIs) were reported as the relative risk of morbidity or mortality from a high-BMI-related disease, per 5 BMI-unit (5 kg/m^2) increase above a BMI of 22.5 kg/m^2. The GBD study estimated separate relative risks for pre-menopausal and post-menopausal breast cancer. Assuming an average age of 50 years for menopause, the relative risks were combined by using pre-menopausal RRs for ages >50 years and post-menopausal RRs for ages ≥50 years (see Appendix A, Table A2 for relative risk parameters).

The model accounted for direct non-BMI-mediated health effects from sugary drink consumption through the inclusion of SSB-related relative risk of type 2 diabetes. Using meta-analyses estimates from Imamura et al., the relative risk of type 2 diabetes incidence increased by 1.13 (95% CI: 1.06, 1.21) per serving (250ml/day) of beverage,.[25] In the same publication, the authors identified a non-BMI-related increased relative risk of type 2 diabetes from 100% juice of 1.07 (1.01, 1.14) per serving of juice.[25] However, in the current study, the SSB-related relative risk was applied to both SSB and sugary drink consumption due to model design limitations. Other risks from sugary drinks, independent of BMI, such as high blood pressure,[26] were not included in the model due to an absence of suitable parameter inputs. Accordingly, some model outputs may be considered conservative estimates of the health burden associated with sugary drinks and the potential health improvements from a sugary drink tax. Also, it is assumed that relative risks are uniform across countries for a given age-sex group.

[i] Appendix Table 6a in the GBD report did not include relative risks for liver cancer, breast cancer (pre-menopausal) and osteoarthritis, presumably due to an oversight. A complete table of BMI-related relative risks was obtained from the Institute for Health Metrics and Evaluation, Seattle, Washington, USA.

The model required age- and sex-specific data on incidence, prevalence, mortality and case fatality for each disease. Epidemiological data at this level of detail is limited. To yield the necessary data inputs, DisMod was used to estimate epidemiologically- and mathematically-coherent set of parameters for each disease. DisMod uses background population size and mortality, and a minimum of three input variables, to calculate epidemiologically-consistent outputs. Data was assembled and prepared in several steps. First, data on incidence, prevalence and mortality was identified and compiled. Sources consistent with ICD disease definitions were selected. The most recent data was used, with preference given to surveillance data from Canada. After preliminary processing, inputs were added to DisMod by 5-year age group and sex for each disease. Across diseases, remission was input as 0. Where necessary, the most reliable input parameters were weighted more heavily. DisMod outputs—incidence, prevalence, mortality and case fatality—presented by sex and 1-year age groups were added to the model. (Appendix A, Table A3 summarizes these steps for each disease.)

Data limitations necessitate that some of the model's disease output be reported by incident cases or prevalent cases only. For example, prevalent cases of hypertensive heart disease are reportable, but not incident cases. To avoid double counting mortality among other modelled diseases (e.g., strokes and ischemic heart disease), mortality from type 2 diabetes was not included in the life table. Accordingly, mortality from type 2 diabetes cannot be reported.

Canada-specific disability weights for each disease of interest were calculated using GBD data and DisMod output. For each age and sex group, the number of years lived with disability due to a given disease was divided by the number of prevalent cases of that disease. The raw disability weights were adjusted using pYLD for 'all other causes' to fix artificially low weights for older ages. Final adjustments levelled incongruent peaks for a small number of weights. Disability weights were input by sex and 5-year age groups.

BODY WEIGHT

To account for existing secular changes in BMI, the model incorporated predicted BMI trends using existing age- and sex-specific regression coefficients[27] derived from measured and self-reported BMI data in serial cross-sectional surveys: CCHS 2001-2010.[28,29,30,31,32,33,34] This predicted BMI trend was applied for 25 years into the future; however, sensitivity analyses examined the implications of not applying this BMI trend.

Population estimates of BMI were calculated using Canadian Health Measures Survey (CHMS) 2012-2013 Cycle 3, the most recent national data available on measured BMI.[35] CHMS Cycle 3 is a representative multi-stage sample of Canadians aged 3 to 79 years living in the ten provinces, excluding persons living on reserve and other Indigenous peoples' settlements, full-time members of the Canadian Forces, the institutionalized population, and individuals in some remote locations. Data was accessed through SWO-RDC. A total of 5,737 participants from the Clinic Full Sample file were included in the current analysis (after excluding 48 due to pregnancy or unreported BMI). Using SPSS, mean measured BMI (and standard deviation) was calculated for sex-specific 10-year age groups, using

scaled weights to represent the survey's target population. Mean BMI (in 10-year age subgroups) was input into the model with standard deviations to permit uncertainty analyses on this parameter. Within the model, BMI was modelled as lognormally distributed for the Canadian adult population. Results were exponentiated for display and reporting.

The effect of energy intake on weight was modelled using an energy equation for adults from Swinburn et al.[36,37] This formula provides empirical-derived values for the daily intake of energy [measured in kilojoules (kJ)] required for a weight change of 1 kilogram (kg): 94 kJ per kg per day (95% CI: 88.2, 99.8). Among adults, 50% of weight change is in the first year of reduced energy intake, and 95% by 3 years. Swinburn et al.'s estimate is very close to the commonly cited results from Hall et al. of 100 kJ per kg per day; however, Hall et al. do not give uncertainty around the estimate.[38] Physical activity levels were assumed stable, so as to not contribute to changes in energy intake or expenditure.

BEVERAGE CONSUMPTION

Sugary drink consumption data was analyzed as described. Mean (and standard error) beverage intake for each sex-specific 10-year age group was converted to litres. Energy density from beverage consumption was calculated in kilocalories (kcal) per litre for each sex-specific 10-year age group, and converted into kilojoules (1 kcal = 4.184 kJ) (Appendix A, Table A4).

HEALTH CARE COSTS

Direct health care costs for each disease were calculated using estimates from Canada's most recent national disease-specific costs study, the *Economic Burden of Illness in Canada* (EBIC) 2005-2008, and the Canadian Institute for Health Information's *National Health Expenditure Database*. EBIC costs are reported according to diagnostic category, sex and age group. Health conditions are based on ICD codes and organized into diagnostic categories.[39,40,41]

To estimate disease-specific costs, modelled diseases were matched with the closest-fitting EBIC diagnostic category using ICD codes. For each relevant EBIC category, 2008 costs were generated by sex and age category using the EBIC online tool. Some costs required adjustment to improve alignment with ICD disease definitions.

EBIC costs do not include direct costs that could not be allocated to a specific health condition. Using a method developed by Krueger et al.,[42] the proportion of each disease's contribution to total EBIC cost was calculated. By applying this proportion to unallocated direct costs, total direct costs were calculated for each disease. The allocated direct costs consisted of hospital care, physician care and drugs. The unallocated direct costs consisted of other institutions, other professionals, capital, public health, administration and other health spending. Indirect costs, such as the value of lost production due to one's illness, injury or premature death, were not included.

Since EBIC reports the total cost of a disease, to determine the cost per disease case, each disease-specific direct cost was divided by the number of incident or prevalent cases in 2008 for a given sex-

age group. Incident cases were used for each cancer type. Prevalent cases were used for ischemic heart disease, ischemic stroke, hemorrhagic stroke, hemorrhagic heart disease, type 2 diabetes mellitus, chronic kidney disease, osteoarthritis, and low back pain. Some disease case data required adjustment to improve alignment with ICD disease definitions. Incidence and prevalence data was obtained from the Canadian Chronic Disease Surveillance System, CANSIM tables and the GBD Results Tool.[24,43,44]

Lastly, health care costs were inflated to 2015 dollars using the Statistics Canada Consumer Price Index 'health care' sub-index.[22] Costs increased by 9.13% from 2008 to 2015.

EBIC costs data is based on the most responsible diagnosis and therefore does not account for co-morbidities. The current study's analysis did not account for uncertainty in cost estimates. However, EBIC data was deemed the most suitable because it provided clear disease-specific costs for the entire Canadian population.

MODEL ANALYSIS

Analyses used Microsoft Excel (Microsoft Corporation, Redmond, Washington, USA) and two add-ins: Risk Factor (EpiGearXL 5.0) and Ersatz (Version 1.34), both from EpiGear (Brisbane, Australia). Risk Factor calculated potential impact fractions. For each scenario, Ersatz performed a Monte Carlo simulation with bootstrapping (2000 iterations) while incorporating probabilistic uncertainty from model inputs: mean BMI, relative risks, effect of change in energy intake on weight, beverage intake and price elasticity of demand. Uncertainty intervals (i.e., 95% uncertainty intervals) were calculated, reflecting parameter uncertainties. Ethics approval was not required for this analysis.

SENSITIVITY ANALYSES

Univariate sensitivity analyses examined the impact of modifying key assumptions and parameters. Each scenario used SSBs or sugary drinks and applied a tax level of 20%. Parameters varied as follows: (1) BMI remained at 2015 levels, removing the assumed secular trend toward increased BMI, apart from the intervention's impact; (2) the intervention's effectiveness stopped after the first 10 years, by capping the effect of the tax on BMI; (3) simulated consumers were less responsive to beverage price increases, by using the upper boundary for own-price elasticity of demand; (4) the assumed 100% pass-on rate changed to 80%, and 120%; (5) to test the effect of price on revenue and other outcomes, pre-tax beverage price varied; and (6) consistent with economic practice, a 3% discount rate was applied to DALYs, costs and revenue to demonstrate how benefits in the future can be deemed lower value compared to benefits in the present.

APPENDIX A: MODEL PARAMETERS

TABLE A1

ICD CODES FOR MODELLED DISEASES

GLOBAL BURDEN OF DISEASE 2015 STUDY

Disease	GBD ICD Codes CAUSES OF DEATH	GBD ICD Codes NONFATAL CAUSES
Esophageal cancer	C15-C15.9, D00.1, D13.0 Garbage code: None	None
Colon and rectum cancer	C18-C21.9, D01.0-D01.3, D12-D12.9, D37.3-D37.5 Garbage code: C26	None
Liver cancer	C22-C22.9, D13.4 Garbage code: None	None
Gallbladder and biliary tract cancer	C23-C24.9, D13.5 Garbage code: None	None
Pancreatic cancer	C25-C25.9, D13.6-D13.7 Garbage code: None	None
Breast cancer	C50-C50.929, D05-D05.92, D24-D24.9, D48.6-D48.62, D49.3, N60-N60.99 Garbage code: None	None
Uterine cancer	C54-C54.9, D07.0-D07.2, N87-N87.9 Garbage code: C55	None
Ovarian cancer	C56-C56.9, D27-D27.9, D39.1-D39.12 Garbage code: None	None
Kidney cancer	C64-C65.9, D30.0-D30.12, D41.0-D41.12 Garbage code: None	None
Thyroid cancer	C73-C73.9, D09.3, D09.8, D34-D34.9, D44.0 Garbage code: None	None
Leukemia	C91-C95.92 Garbage code: None	None
Ischemic heart disease	I20-I25.9 Garbage code: None	Prevalence: I20-I20.1, I20.8-I20.9, I23.7, I25-I25.9 Incidence: I21-I21.4, I21.9, I22-I22.2, I22.8-I22.9 Garbage code: None
Ischemic stroke	G45-G46.8, I63-I63.9, I65-I66.9, I67.2-I67.3, I67.5-I67.6, I69.3-I69.398 Garbage code: I64-I64.9, I67, I67.4, I67.8-I68	Incidence: I63-I63, I63-I63.6, I63.8-I63.8, I63.8-I63.9 Garbage code: None
Hemorrhagic stroke	I60-I61.9, I62.0-I62.03, I67.0-I67.1, I68.1-I68.2, I69.0-I69.298 Garbage code: , I62, I62.1-I62.9, I64-I64.9, I68.8-I69, I69.4-I70.1	Incidence: I60-I60, I60-I60.9, I61-I61, I61-I61.6, I61.8-I61.8, I61.8-I61.9 Garbage code: None
Hypertensive heart disease	I11-I11.9 Garbage code: None	In heart failure impairment envelope: B57.2, I09.8, I11.0, I50-I50.4, I50.9, J81-J81.1 Garbage code: None
Type 2 diabetes mellitus	E10-E10.11, E10.3-E11.1, E11.3-E12.1, E12.3-E13.11, E13.3-E14.1, E14.3-E14.9, P70.0-P70.2, R73-R73.9 Garbage code: None	Prevalence: E08-E08.1, E08.3-E08.3, E08.3-E08.3, E08.3-E08.6, E08.8-E08.9, E09.3-E09.3, E09.3-E09.6, E10-E10.1, E10.3-E10.3, E10.3-E10.3, E10.3-E10.9, E11-E11.1, E11.3-E11.3, E11.3-E11.3, E11.3-E11.9, E12-E12.1, E12.3-E12.3, E12.3-E12.9, E13-

Disease	GBD ICD Codes CAUSES OF DEATH	GBD ICD Codes NONFATAL CAUSES
		E13.1, E13.3-E13.3, E13.3-E13.3, E13.3-E13.9, E14-E14.1, E14.3-E14.3, E14.3-E14.9 Garbage code: None
CKD	D63.1, E10.2-E10.29, E11.2-E11.29, E12.2, E13.2-E13.29, E14.2, I12-I13.9, N02-N08.8, N15.0, N18-N18.9 Garbage code: None	Prevalence: N18-N18.6 Garbage code: None
CKD due to diabetes mellitus	E10.2-E10.29, E11.2-E11.29, E12.2, E13.2-E13.29, E14.2 Garbage code: None	None
CKD due to hypertension	I12-I13.9 Garbage code: None	None
CKD due to glomerulonephritis	N03-N06.9 Garbage code: None	None
CKD due to other causes	N02-N02.9, N07-N08.8, N15.0 Garbage code: None	None
Osteoarthritis	None Garbage code: M12.2-M29	M16-M16.7, M16.9, M17-M17.5, M17.9 Note: M15 is in Other musculoskeletal disorders Garbage code: None
Low back pain	None Garbage code: M43.2-M49, M49.2-M64, M90-M99.9	G54.4, M47-M47.2, M47.8, M48-M48.5, M49.8, M51-M51.4, M51.8, M53.3, M53.8, M54-M54.1, M54.3-M54.5, M99-M99.8 Note: M45, M46 are in Other musculoskeletal disorders Garbage code: None

TABLE A2

RELATIVE RISKS FOR DISEASES ASSOCIATED WITH HIGH BODY MASS INDEX (BMI)

GLOBAL BURDEN OF DISEASE 2015 STUDY

Males

Unit: 5 kg/m^2 Age

Risk - Outcome	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80+
Esophageal cancer												
Input RR - mean	1.391	1.391	1.391	1.391	1.391	1.391	1.391	1.391	1.391	1.391	1.391	1.391
Interval (LL)	1.076	1.076	1.076	1.076	1.076	1.076	1.076	1.076	1.076	1.076	1.076	1.076
Interval (UL)	1.758	1.758	1.758	1.758	1.758	1.758	1.758	1.758	1.758	1.758	1.758	1.758
Colon and rectum cancer												
Input RR - mean	1.177	1.177	1.177	1.177	1.177	1.177	1.177	1.177	1.177	1.177	1.177	1.177
Interval (LL)	1.145	1.145	1.145	1.145	1.145	1.145	1.145	1.145	1.145	1.145	1.145	1.145
Interval (UL)	1.208	1.208	1.208	1.208	1.208	1.208	1.208	1.208	1.208	1.208	1.208	1.208
Liver cancer												
Input RR - mean	1.289	1.289	1.289	1.289	1.289	1.289	1.289	1.289	1.289	1.289	1.289	1.289
Interval (LL)	1.109	1.109	1.109	1.109	1.109	1.109	1.109	1.109	1.109	1.109	1.109	1.109
Interval (UL)	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491
Gallbladder and biliary track cancer												
Input RR - mean	1.155	1.155	1.155	1.155	1.155	1.155	1.155	1.155	1.155	1.155	1.155	1.155
Interval (LL)	1.033	1.033	1.033	1.033	1.033	1.033	1.033	1.033	1.033	1.033	1.033	1.033
Interval (UL)	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282
Pancreatic cancer												
Input RR - mean	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071
Interval (LL)	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999
Interval (UL)	1.154	1.154	1.154	1.154	1.154	1.154	1.154	1.154	1.154	1.154	1.154	1.154
Kidney cancer												
Input RR - mean	1.240	1.240	1.240	1.240	1.240	1.240	1.240	1.240	1.240	1.240	1.240	1.240
Interval (LL)	1.171	1.171	1.171	1.171	1.171	1.171	1.171	1.171	1.171	1.171	1.171	1.171
Interval (UL)	1.313	1.313	1.313	1.313	1.313	1.313	1.313	1.313	1.313	1.313	1.313	1.313
Thyroid cancer												
Input RR - mean	1.221	1.221	1.221	1.221	1.221	1.221	1.221	1.221	1.221	1.221	1.221	1.221
Interval (LL)	1.067	1.067	1.067	1.067	1.067	1.067	1.067	1.067	1.067	1.067	1.067	1.067
Interval (UL)	1.382	1.382	1.382	1.382	1.382	1.382	1.382	1.382	1.382	1.382	1.382	1.382
Leukemia												
Input RR - mean	1.086	1.086	1.086	1.086	1.086	1.086	1.086	1.086	1.086	1.086	1.086	1.086
Interval (LL)	1.053	1.053	1.053	1.053	1.053	1.053	1.053	1.053	1.053	1.053	1.053	1.053
Interval (UL)	1.119	1.119	1.119	1.119	1.119	1.119	1.119	1.119	1.119	1.119	1.119	1.119
Ischemic heart disease												
Input RR - mean	2.274	2.018	1.724	1.599	1.567	1.520	1.466	1.414	1.364	1.319	1.274	1.170
Interval (LL)	1.257	1.296	1.532	1.418	1.457	1.417	1.372	1.324	1.287	1.242	1.187	1.091
Interval (UL)	3.686	3.109	1.932	1.785	1.680	1.631	1.557	1.504	1.448	1.400	1.365	1.253
Ischemic stroke												
Input RR - mean	2.472	2.235	1.979	1.826	1.733	1.635	1.543	1.455	1.380	1.304	1.228	1.068
Interval (LL)	1.399	1.454	1.694	1.600	1.581	1.479	1.441	1.345	1.310	1.233	1.159	0.992
Interval (UL)	3.980	3.334	2.313	2.076	1.898	1.796	1.653	1.566	1.458	1.376	1.305	1.143
Hemorrhagic stroke												
Input RR - mean	3.066	2.913	2.597	2.389	2.199	1.996	1.805	1.665	1.523	1.410	1.295	1.070
Interval (LL)	1.750	1.860	1.974	1.869	1.821	1.625	1.573	1.437	1.377	1.265	1.162	0.928
Interval (UL)	5.337	4.399	3.387	3.002	2.673	2.419	2.060	1.933	1.684	1.571	1.439	1.220
Hypertensive heart disease												
Input RR - mean	3.122	3.000	2.769	2.573	2.407	2.281	2.159	2.035	1.955	1.860	1.792	1.697
Interval (LL)	1.588	1.748	1.814	1.741	1.716	1.597	1.499	1.451	1.342	1.296	1.169	1.067
Interval (UL)	5.502	4.912	4.217	3.647	3.296	3.189	3.039	2.822	2.700	2.617	2.553	2.620

Males

Unit: 5 kg/m^2 Age

Risk - Outcome	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80+
Type 2 diabetes mellitus												
Input RR - mean	3.547	3.455	3.349	3.160	2.864	2.624	2.417	2.215	2.046	1.896	1.740	1.461
Interval (LL)	2.308	2.509	2.803	2.694	2.450	2.224	2.086	1.865	1.724	1.596	1.444	1.207
Interval (UL)	5.228	4.693	3.919	3.700	3.314	3.038	2.779	2.608	2.382	2.229	2.079	1.760
Chronic kidney disease due to diabetes mellitus												
Input RR - mean			1.746	1.746	1.746	1.746	1.746	2.036	2.036	1.621	1.621	1.431
Interval (LL)			1.053	1.053	1.053	1.053	1.053	1.298	1.298	1.061	1.061	0.800
Interval (UL)			2.748	2.748	2.748	2.748	2.748	3.056	3.056	2.380	2.380	2.404
Chronic kidney disease due to hypertension												
Input RR - mean			1.763	1.763	1.763	1.763	1.763	2.044	2.044	1.605	1.605	1.437
Interval (LL)			1.088	1.088	1.088	1.088	1.088	1.302	1.302	1.066	1.066	0.828
Interval (UL)			2.760	2.760	2.760	2.760	2.760	3.089	3.089	2.327	2.327	2.426
Chronic kidney disease due to glomerulonephritis												
Input RR - mean			1.742	1.742	1.742	1.742	1.742	2.044	2.044	1.604	1.604	1.452
Interval (LL)			1.019	1.019	1.019	1.019	1.019	1.254	1.254	1.108	1.108	0.851
Interval (UL)			2.791	2.791	2.791	2.791	2.791	3.155	3.155	2.255	2.255	2.350
Chronic kidney due to other causes												
Input RR - mean			1.732	1.732	1.732	1.732	1.732	2.032	2.032	1.625	1.625	1.433
Interval (LL)			1.047	1.047	1.047	1.047	1.047	1.214	1.214	1.068	1.068	0.776
Interval (UL)			2.684	2.684	2.684	2.684	2.684	3.105	3.105	2.368	2.368	2.345
Osteoarthritis of the hip												
Input RR - mean	1.109	1.109	1.109	1.109	1.109	1.109	1.109	1.109	1.109	1.109	1.109	1.109
Interval (LL)	1.059	1.059	1.059	1.059	1.059	1.059	1.059	1.059	1.059	1.059	1.059	1.059
Interval (UL)	1.160	1.160	1.160	1.160	1.160	1.160	1.160	1.160	1.160	1.160	1.160	1.160
Osteoarthritis of the knee												
Input RR - mean	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370
Interval (LL)	1.198	1.198	1.198	1.198	1.198	1.198	1.198	1.198	1.198	1.198	1.198	1.198
Interval (UL)	1.556	1.556	1.556	1.556	1.556	1.556	1.556	1.556	1.556	1.556	1.556	1.556
Low back pain												
Input RR - mean	1.100	1.100	1.101	1.100	1.099	1.100	1.100	1.101	1.100	1.100	1.100	1.100
Interval (LL)	1.073	1.073	1.076	1.074	1.075	1.075	1.075	1.077	1.075	1.076	1.075	1.074
Interval (UL)	1.126	1.127	1.128	1.126	1.123	1.128	1.126	1.126	1.126	1.124	1.124	1.125

Females

Unit: 5 kg/m^2 Age

Risk - Outcome	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80+
Esophageal cancer												
Input RR - mean	1.351	1.351	1.351	1.351	1.351	1.351	1.351	1.351	1.351	1.351	1.351	1.351
Interval (LL)	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012
Interval (UL)	1.745	1.745	1.745	1.745	1.745	1.745	1.745	1.745	1.745	1.745	1.745	1.745
Colon and rectum cancer												
Input RR - mean	1.059	1.059	1.059	1.059	1.059	1.059	1.059	1.059	1.059	1.059	1.059	1.059
Interval (LL)	1.031	1.031	1.031	1.031	1.031	1.031	1.031	1.031	1.031	1.031	1.031	1.031
Interval (UL)	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083
Liver cancer												
Input RR - mean	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176
Interval (LL)	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030
Interval (UL)	1.334	1.334	1.334	1.334	1.334	1.334	1.334	1.334	1.334	1.334	1.334	1.334

Females

Unit: 5 kg/m^2 Age

Risk - Outcome	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80+
Gallbladder and biliary track cancer												
Input RR - mean	1.344	1.344	1.344	1.344	1.344	1.344	1.344	1.344	1.344	1.344	1.344	1.344
Interval (LL)	1.223	1.223	1.223	1.223	1.223	1.223	1.223	1.223	1.223	1.223	1.223	1.223
Interval (UL)	1.478	1.478	1.478	1.478	1.478	1.478	1.478	1.478	1.478	1.478	1.478	1.478
Pancreatic cancer												
Input RR - mean	1.092	1.092	1.092	1.092	1.092	1.092	1.092	1.092	1.092	1.092	1.092	1.092
Interval (LL)	1.037	1.037	1.037	1.037	1.037	1.037	1.037	1.037	1.037	1.037	1.037	1.037
Interval (UL)	1.144	1.144	1.144	1.144	1.144	1.144	1.144	1.144	1.144	1.144	1.144	1.144
Breast cancer												
Input RR - mean	0.890	0.890	0.890	0.890	0.890	1.345	1.345	1.345	1.345	1.345	1.345	1.345
Interval (LL)	0.868	0.868	0.868	0.868	0.868	1.121	1.121	1.121	1.121	1.121	1.121	1.121
Interval (UL)	0.914	0.914	0.914	0.914	0.914	1.601	1.601	1.601	1.601	1.601	1.601	1.601
Uterine cancer												
Input RR - mean	1.613	1.613	1.613	1.613	1.613	1.613	1.613	1.613	1.613	1.613	1.613	1.613
Interval (LL)	1.543	1.543	1.543	1.543	1.543	1.543	1.543	1.543	1.543	1.543	1.543	1.543
Interval (UL)	1.681	1.681	1.681	1.681	1.681	1.681	1.681	1.681	1.681	1.681	1.681	1.681
Ovarian cancer												
Input RR - mean	1.038	1.038	1.038	1.038	1.038	1.038	1.038	1.038	1.038	1.038	1.038	1.038
Interval (LL)	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998
Interval (UL)	1.077	1.077	1.077	1.077	1.077	1.077	1.077	1.077	1.077	1.077	1.077	1.077
Kidney cancer												
Input RR - mean	1.320	1.320	1.320	1.320	1.320	1.320	1.320	1.320	1.320	1.320	1.320	1.320
Interval (LL)	1.254	1.254	1.254	1.254	1.254	1.254	1.254	1.254	1.254	1.254	1.254	1.254
Interval (UL)	1.395	1.395	1.395	1.395	1.395	1.395	1.395	1.395	1.395	1.395	1.395	1.395
Thyroid cancer												
Input RR - mean	1.136	1.136	1.136	1.136	1.136	1.136	1.136	1.136	1.136	1.136	1.136	1.136
Interval (LL)	1.094	1.094	1.094	1.094	1.094	1.094	1.094	1.094	1.094	1.094	1.094	1.094
Interval (UL)	1.178	1.178	1.178	1.178	1.178	1.178	1.178	1.178	1.178	1.178	1.178	1.178
Leukemia												
Input RR - mean	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131
Interval (LL)	1.061	1.061	1.061	1.061	1.061	1.061	1.061	1.061	1.061	1.061	1.061	1.061
Interval (UL)	1.208	1.208	1.208	1.208	1.208	1.208	1.208	1.208	1.208	1.208	1.208	1.208
Ischemic heart disease												
Input RR - mean	2.274	2.018	1.724	1.599	1.567	1.520	1.466	1.414	1.364	1.319	1.274	1.170
Interval (LL)	1.257	1.296	1.532	1.418	1.457	1.417	1.372	1.324	1.287	1.242	1.187	1.091
Interval (UL)	3.686	3.109	1.932	1.785	1.680	1.631	1.557	1.504	1.448	1.400	1.365	1.253
Ischemic stroke												
Input RR - mean	2.472	2.235	1.979	1.826	1.733	1.635	1.543	1.455	1.380	1.304	1.228	1.068
Interval (LL)	1.399	1.454	1.694	1.600	1.581	1.479	1.441	1.345	1.310	1.233	1.159	0.992
Interval (UL)	3.980	3.334	2.313	2.076	1.898	1.796	1.653	1.566	1.458	1.376	1.305	1.143
Hemorrhagic stroke												
Input RR - mean	3.066	2.913	2.597	2.389	2.199	1.996	1.805	1.665	1.523	1.410	1.295	1.070
Interval (LL)	1.750	1.860	1.974	1.869	1.821	1.625	1.573	1.437	1.377	1.265	1.162	0.928
Interval (UL)	5.337	4.399	3.387	3.002	2.673	2.419	2.060	1.933	1.684	1.571	1.439	1.220
Hypertensive heart disease												
Input RR - mean	3.122	3.000	2.769	2.573	2.407	2.281	2.159	2.035	1.955	1.860	1.792	1.697
Interval (LL)	1.588	1.748	1.814	1.741	1.716	1.597	1.499	1.451	1.342	1.296	1.169	1.067
Interval (UL)	5.502	4.912	4.217	3.647	3.296	3.189	3.039	2.822	2.700	2.617	2.553	2.620
Type 2 diabetes mellitus												
Input RR - mean	3.547	3.455	3.349	3.160	2.864	2.624	2.417	2.215	2.046	1.896	1.740	1.461
Interval (LL)	2.308	2.509	2.803	2.694	2.450	2.224	2.086	1.865	1.724	1.596	1.444	1.207

Females

Unit: 5 kg/m^2 Age

Risk - Outcome	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80+
Interval (UL)	5.228	4.693	3.919	3.700	3.314	3.038	2.779	2.608	2.382	2.229	2.079	1.760
Chronic kidney disease due to diabetes mellitus												
Input RR - mean			1.746	1.746	1.746	1.746	1.746	2.036	2.036	1.621	1.621	1.431
Interval (LL)			1.053	1.053	1.053	1.053	1.053	1.298	1.298	1.061	1.061	0.800
Interval (UL)			2.748	2.748	2.748	2.748	2.748	3.056	3.056	2.380	2.380	2.404
Chronic kidney disease due to hypertension												
Input RR - mean			1.763	1.763	1.763	1.763	1.763	2.044	2.044	1.605	1.605	1.437
Interval (LL)			1.088	1.088	1.088	1.088	1.088	1.302	1.302	1.066	1.066	0.828
Interval (UL)			2.760	2.760	2.760	2.760	2.760	3.089	3.089	2.327	2.327	2.426
Chronic kidney disease due to glomerulonephritis												
Input RR - mean			1.742	1.742	1.742	1.742	1.742	2.044	2.044	1.604	1.604	1.452
Interval (LL)			1.019	1.019	1.019	1.019	1.019	1.254	1.254	1.108	1.108	0.851
Interval (UL)			2.791	2.791	2.791	2.791	2.791	3.155	3.155	2.255	2.255	2.350
Chronic kidney due to other causes												
Input RR - mean			1.732	1.732	1.732	1.732	1.732	2.032	2.032	1.625	1.625	1.433
Interval (LL)			1.047	1.047	1.047	1.047	1.047	1.214	1.214	1.068	1.068	0.776
Interval (UL)			2.684	2.684	2.684	2.684	2.684	3.105	3.105	2.368	2.368	2.345
Osteoarthritis of the hip												
Input RR - mean	1.111	1.111	1.111	1.111	1.111	1.111	1.111	1.111	1.111	1.111	1.111	1.111
Interval (LL)	1.060	1.060	1.060	1.060	1.060	1.060	1.060	1.060	1.060	1.060	1.060	1.060
Interval (UL)	1.161	1.161	1.161	1.161	1.161	1.161	1.161	1.161	1.161	1.161	1.161	1.161
Osteoarthritis of the knee												
Input RR - mean	1.371	1.371	1.371	1.371	1.371	1.371	1.371	1.371	1.371	1.371	1.371	1.371
Interval (LL)	1.178	1.178	1.178	1.178	1.178	1.178	1.178	1.178	1.178	1.178	1.178	1.178
Interval (UL)	1.550	1.550	1.550	1.550	1.550	1.550	1.550	1.550	1.550	1.550	1.550	1.550
Low back pain												
Input RR - mean	1.100	1.100	1.101	1.100	1.099	1.100	1.100	1.101	1.100	1.100	1.100	1.100
Interval (LL)	1.073	1.073	1.076	1.074	1.075	1.075	1.075	1.077	1.075	1.076	1.075	1.074
Interval (UL)	1.126	1.127	1.128	1.126	1.123	1.128	1.126	1.126	1.126	1.124	1.124	1.125

TABLE A3

DISEASE DATA SOURCES AND PROCESSING NOTES

Disease	Data Sources	Pre-DisMod II Processing	DisMod II Manipulation
Esophageal cancer	**Incidence rates:** CANSIM Table 103-0500 (2013)[44] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[45] **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	Mortality rates calculated using 2012 population. Prevalence rates calculated using 2015 population. GBD provided data (prevalent cases) in 5-year age groups up to age 80+ only. Prevalence rates were extrapolated to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.
Colon and rectum cancer	**Incidence rates:** CANSIM Table 103-0500 (2013)[44] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[45] **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	Mortality rates calculated using 2012 population. Prevalence rates calculated using 2015 population. Extrapolated prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.
Liver cancer	**Incident cases:** GBD Results Tool (2015)[24] **Disease-specific deaths:** GBD Results Tool (2015)[24] **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	Incidence, mortality and prevalence rates calculated using 2015 population. Extrapolated incidence, mortality and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.
Gallbladder and biliary track cancer	**Incident cases:** GBD Results Tool (2015)[24] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[45] **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	Mortality rates calculated using 2012 population. Incidence and prevalence rates calculated using 2015 population. Extrapolated incidence and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.
Pancreatic cancer	**Incidence rates:** CANSIM Table 103-0500 (2013)[44] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[45] **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	Mortality rates calculated using 2012 population. Prevalence rates calculated using 2015 population. Extrapolated prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.
Breast cancer	**Incidence rates:** CANSIM Table 103-0500 (2013)[44] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[45] **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	Mortality rates calculated using 2012 population. Prevalence rates calculated using 2015 population. Extrapolated prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.
Uterine cancer	**Incidence rates:** CANSIM Table 103-0500 (2013)[44] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[45] **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	Mortality rates calculated using 2012 population. Prevalence rates calculated using 2015 population. Extrapolated prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.
Ovarian cancer	**Incidence rates:** CANSIM Table 103-0500 (2013)[44] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[45] **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	Mortality rates calculated using 2012 population. Prevalence rates calculated using 2015 population. Extrapolated prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.

Disease	Data Sources	Pre-DisMod II Processing	DisMod II Manipulation
Kidney cancer	**Incidence rates:** CANSIM Table 103-0500 (2013)[44] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[45] **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	Mortality rates calculated using 2012 population. Prevalence rates calculated using 2015 population. Extrapolated prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.
Thyroid cancer	**Incidence rates:** CANSIM Table 103-0500 (2013)[44] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[45] **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	Mortality rates calculated using 2012 population. Prevalence rates calculated using 2015 population. Extrapolated prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.
Leukemia	**Incidence rates:** CANSIM Table 103-0500 (2013)[44] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[45] **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	Mortality rates calculated using 2012 population. Prevalence rates calculated using 2015 population. Extrapolated prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.
Ischemic heart disease	**Incident cases:** CCDSS (2011)[43] **Disease-specific deaths:** CANSIM Table 102-0529 (2012)[46] **Prevalent cases:** CCDSS (2011)[43] **Remission:** Inputted as 0	Incidence and prevalence rates calculated using 2011 population. Mortality rates calculated using 2012 population. CCDSS provided data (incident and prevalent cases) in 5-year age groups up to age 85+ only. Incidence and prevalence rates were extrapolated to age 100+ using a polynomial trend line.	Lowest weighting for incidence, mortality and prevalence. Remission set to Exact.
Ischemic stroke	**Incident cases:** GBD Results Tool (2015)[24] **Disease-specific deaths:** GBD Results Tool (2015)[24] **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	Incidence, mortality and prevalence rates calculated using 2015 population. Extrapolated incidence, mortality and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Lowest weighting for incidence, mortality and prevalence. Remission set to Exact.
Hemorrhagic stroke	**Incident cases:** GBD Results Tool (2015)[24] **Disease-specific deaths:** GBD Results Tool (2015)[24] **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	Incidence, mortality and prevalence rates calculated using 2015 population. Extrapolated incidence, mortality and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Lowest weighting for incidence, mortality and prevalence. Remission set to Exact.
Hypertensive heart disease	**Incident cases:** CCDSS (2011)[43] **Disease-specific deaths:** CANSIM Table 102-0529 (2012)[46] **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	CCDSS incident cases rescaled using GBD data to improve alignment with disease definition. Incidence, mortality and prevalence rates calculated using 2011, 2012 and 2015 populations, respectively. Extrapolated incidence and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence set to Ignore and remission set to Exact.
Type 2 diabetes mellitus	**Incident cases:** GBD Results Tool (2015)[24] **Disease-specific deaths:** CANSIM Tables: 102-0524, 102-0536 & 102-0538 (2012)[47,48,49] **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	Incidence and prevalence rates calculated using 2015 population. Mortality rates calculated using 2012 population. Determined type 2 diabetes from diabetes data by assuming that among individuals <20 years of age, 10% of diabetes cases were type 2 diabetes and among individauls ≥20 years,	Lowest weighting for incidence, mortality and prevalence. Remission set to Exact.

Disease	Data Sources	Pre-DisMod II Processing	DisMod II Manipulation
		90% of diabetes cases were type 2 diabetes. Extrapolated incidence and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	
CKD due to diabetes mellitus	**Incident cases:** GBD Results Tool (2015)[24] **Disease-specific deaths:** GBD Results Tool (2015)[24] **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	Incidence, mortality and prevalence rates calculated using 2015 population. Extrapolated incidence, mortality and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence has lowest weighting, mortality weighted mid-level, prevalence weighted heavily and remission set to Exact.
CKD due to hypertension	**Incident cases:** GBD Results Tool (2015)[24] **Disease-specific deaths:** GBD Results Tool (2015)[24] **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	Incidence, mortality and prevalence rates calculated using 2015 population. Extrapolated incidence, mortality and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence has lowest weighting, mortality weighted mid-level, prevalence weighted heavily and remission set to Exact.
CKD due to glomerulonephritis	**Incident cases:** GBD Results Tool (2015)[24] **Disease-specific deaths:** GBD Results Tool (2015)[24] **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	Incidence, mortality and prevalence rates calculated using 2015 population. Extrapolated incidence, mortality and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence has lowest weighting, mortality weighted mid-level, prevalence weighted heavily and remission set to Exact.
CKD due to other causes	**Incident cases:** GBD Results Tool (2015)[24] **Disease-specific deaths:** GBD Results Tool (2015)[24] **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	Incidence, mortality and prevalence rates calculated using 2015 population. Extrapolated incidence, mortality and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence has lowest weighting, mortality weighted mid-level, prevalence weighted heavily and remission set to Exact.
Osteoarthritis of the hip	**Incidence:** No data inputted **Disease-specific mortality:** Inputted as 0 **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	GBD prevalence data does not differentiate between hip OA and knee OA. Split data based on Cross et al: for males 66% of OA is knee OA; for females 70% of OA is knee OA.[50] Prevalence rates calculated using 2015 population. Extrapolated prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Remission set to Exact.
Osteoarthritis of the knee	**Incidence:** No data inputted **Disease-specific mortality:** Inputted as 0 **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	GBD prevalence data does not differentiate between hip OA and knee OA. Split data based on Cross et al: for males 66% of OA is knee OA; for females 70% of OA is knee OA.[50] Prevalence rates calculated using 2015 population. Extrapolated prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Remission set to Exact.
Low back pain	**Incident cases:** GBD Results Tool (2015)[24] **Disease-specific mortality:** Inputted as 0 **Prevalent cases:** GBD Results Tool (2015)[24] **Remission:** Inputted as 0	Incidence and prevalence rates calculated using 2015 population. Extrapolated incidence and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence set to Ignore and remission set to Exact.

*CKD: CHRONIC KIDNEY DISEASE

TABLE A4

SUGARY DRINK CONSUMPTION AND ENERGY DENSITY

CCHS 2004

	SUGAR-SWEETENED BEVERAGES		SUGARY DRINKS	
Males Age	**Consumption (SE)** Millilitre/person/day	**Energy density** Kcal/litre	**Consumption (SE)** Millilitre/person/day	**Energy density** Kcal/litre
0-9	231.4 (5.6)	510.2	381.8 (6.2)	487.9
10-19	512.9 (8.2)	460.6	675.0 (8.8)	455.6
20-29	458.8 (14.4)	440.3	608.4 (15.7)	437.9
30-39	348.0 (14.2)	434.0	462.2 (15.2)	432.0
40-49	237.7 (10.2)	427.2	336.9 (11.0)	424.8
50-59	163.8 (7.5)	427.6	265.4 (8.9)	417.4
60-69	130.5 (7.8)	416.7	228.5 (9.7)	427.5
70-79	79.8 (5.7)	428.9	153.0 (6.8)	419.9
80-89	67.7 (6.7)	451.3	143.4 (8.4)	445.4
90+	40.2 (12.1)	469.5	127.3 (32.6)	418.6
Females Age				
0-9	169.4 (4.2)	516.0	296.2 (5.0)	490.7
10-19	369.0 (6.4)	469.3	506.4 (6.9)	463.5
20-29	272.8 (9.6)	438.5	390.2 (10.4)	436.0
30-39	214.8 (10.5)	433.1	300.6 (11.2)	427.3
40-49	151.0 (6.9)	429.3	234.2 (7.9)	423.9
50-59	106.6 (5.3)	453.2	186.2 (6.3)	435.7
60-69	92.3 (4.8)	440.2	163.3 (5.7)	426.1
70-79	80.2 (5.8)	434.3	159.3 (6.8)	433.1
80-89	64.1 (4.6)	444.0	148.9 (6.1)	434.5
90+	40.2 (12.1)	449.9	138.0 (16.9)	437.1

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