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

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EXECUTIVE SUMMARY

BACKGROUND

Sugary drinks represent an important source of sugar consumption among Canadians. An increasing number of jurisdictions have enacted a tax on sugar-sweetened beverages (SSBs) as a fiscal measure to reduce excess sugar intake from beverages. To date, the evidence indicates that excise taxes are an effective measure for reducing SSB consumption, while also generating substantial government revenue.

METHODS

The current study consisted of three components:

1. An analysis of national data on sugary drink consumption among Canadians;
2. Estimates of the health and economic impacts of sugary drinks in Canada; and,
3. Estimates of any potential health and economic benefits of an excise tax on sugary drinks.

For each of these components, the findings are reported for SSBs and sugary drinks. *Sugar-sweetened beverages* are 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), and sugar-sweetened drinkable yogurt. *Sugary drinks* include the same beverage categories, plus 100% juices, consistent with the World Health Organization's definition of 'free sugars'.

FINDINGS

SUGARY DRINK SALES HAVE DECLINED, BUT REMAIN CLOSE TO HISTORIC HIGHS.

The total volume of SSBs and sugary drinks sold in Canada changed relatively little between 2004 and 2015 (-2.6% and -1.8%, respectively), although per capita sales have decreased due to increasing population (-13.2% and -12.6%, respectively). In 2015, Canadians purchased an average of 341 ml of SSBs per day, and an average of 444 ml of sugary drinks per day.

SALES OF TRADITIONAL SUGARY DRINKS HAVE DECREASED AND SALES OF NEWER PRODUCTS HAVE INCREASED.

Over the past 12 years (2004 to 2015), the per capita sales volume has decreased for regular soft drinks (-27%), fruit drinks (-22%), and 100% juice (-10%). In contrast, per capita sales volume increased for energy drinks (+638%), sweetened coffee (+579%), flavoured water (+527%), drinkable yogurt (+283%), sweetened tea (+36%), flavoured milk (+21%), and sports drinks (+4%). In 2004, sales of flavoured water, flavoured milk, drinkable yogurt, and energy drinks were negligible. However, by 2015, these categories accounted for approximately 18% of all sugary drink sales, and compensated for the 7% proportional reduction in sales of regular soft drinks since 2004.

SUGARY DRINK INTAKE IS HIGHEST AMONG YOUTH AND YOUNG ADULTS.

Sugary drink consumption was highest among youth and young adults. The average Canadian youth (age 9-18 years) reported consuming 578 ml of sugary drinks per day, with substantial levels of consumption even among young children.

SUGARY DRINKS ARE AN IMPORTANT SOURCE OF ENERGY INTAKE.

Based on projections from national dietary intake data and sales data, SSBs and sugary drinks account for a substantial proportion of energy intake among Canadians. For many age groups, the average caloric intake from these sugary drinks alone exceeds dietary recommendations to limit free sugar intake to less than 10% of total energy intake.

SUGARY DRINKS HAVE A SUBSTANTIAL NEGATIVE IMPACT ON CANADIANS' HEALTH.

The results from simulation modelling project that over the next 25 years, SSBs alone will be responsible for 2.7 million cases of overweight or obesity. The health burden from all sugary drinks is substantially higher: almost 4.1 million cases of overweight or obesity. Males will be more greatly affected, primarily due to their higher consumption of sugary drinks. Over the next 25 years, it is projected that Canadians' sugary drink consumption will contribute to 900,000 new cases of type 2 diabetes, 300,000 new cases of ischemic heart disease, 100,000 new cases of cancer, and 40,000 strokes. Canadians' sugary drink consumption is estimated to account for 63,000 deaths and almost 2.2 million disability adjusted life years (DALYs), which represent premature death or poor health.

THERE ARE SUBSTANTIAL HEALTH CARE COSTS FROM SUGARY DRINK CONSUMPTION.

The direct health care costs from SSB consumption are estimated at $33.7 billion over the following 25 years. Sugary drinks are projected to account for an estimated $50.7 billion in direct health care costs.

A 20% TAX ON SUGARY DRINKS WOULD REDUCE SUGARY DRINK CONSUMPTION AND ITS ADVERSE HEALTH IMPACTS.

The results from simulation modelling project that over the next 25 years, a 20% *ad valorem* excise tax on sugary drinks in Canada would prevent: over 700,000 cases of overweight and obesity, over 200,000 cases of type 2 diabetes, 60,000 cases of ischemic heart disease, 20,000 cancer cases, and 8,000 strokes. An estimated 13,000 deaths would be postponed, and almost 500,000 DALYs averted.

A 20% TAX ON SUGARY DRINKS WOULD REDUCE DIRECT HEALTH CARE COSTS AND GENERATE REVENUE.

The direct health care savings from a 20% tax on sugary drinks are estimated at almost $11.5 billion, even after accounting for health care costs due to unrelated diseases in added years of life. Projected annual sugary drink tax revenue is $1.7 billion, assuming an average price of $2.50 per litre. The 25-year total tax revenue is an estimated $43.6 billion, not adjusting for secular trends in beverage consumption or changes in population demographics.

HIGHER TAXES WOULD INCREASE ESTIMATED HEALTH AND ECONOMIC BENEFITS.

The impacts of 10% and 30% tax rates were modelled. A 10% tax would postpone and avert approximately 56% of the deaths and DALYs that a 20% tax would. A 30% tax would postpone or avert an additional 37% of deaths and DALYs, compared to a 20% tax.

CONCLUSIONS

The current study suggests that consumption of SSBs and sugary drinks have a substantial negative health and economic impact in Canada. At current levels of consumption, free sugar intake from beverages is an important risk factor for type 2 diabetes, cancers, cardiovascular disease and other conditions. In the coming years, these conditions will cost billions of dollars in health care. An excise tax on sugary drinks has the potential to substantially reduce the health and economic burden over the next 25 years.

BACKGROUND

Sugary drinks represent an important source of sugar consumption among Canadians.[1,2,3,4] Excess consumption of sugary drinks is associated with an increased risk of type 2 diabetes, metabolic syndrome, cardiovascular disease and cancer, primarily through its association with weight gain, as well as increased risk of dental caries.[5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20]

Sugar intake from beverages is commonly defined in one of two ways. The term 'sugar-sweetened beverage' (SSB) is based on criteria for 'added sugars', and typically includes non-diet carbonated soft drinks, ready-to-drink sweetened tea and coffee, energy drinks, sports drinks, flavoured bottled water, and 'fruit drinks' with less than 100% juice.[21] Most definitions of SSBs also include flavoured milk and drinkable yogurt with added sugars. The term 'sugary drinks' is based on the criteria for 'free sugars', which is broader than added sugars. Free sugars include monosaccharides and disaccharides added to foods and beverages, plus sugars naturally present in honey, syrups, fruit juices, and fruit juice concentrates. Therefore, 'sugary drinks' include SSBs but also beverages containing 100% juice on the basis that free sugars contribute to the overall energy density of beverages and are metabolized the same way as 'added sugars'.[22]

An increasing number of jurisdictions have enacted a tax on SSBs as a fiscal measure to reduce excess sugar intake from beverages. Countries including Mexico, France, Hungary, Finland, Norway, Belgium, Chile, Barbados, and a growing list of jurisdictions in the United States (e.g., Berkeley and Philadelphia) have implemented, or are in the process of implementing, excise taxes.[23,24,25,26,27,28,29] The United Kingdom (UK), Ireland and South Africa are among the countries that have proposed sugary drink taxes.[30,31,32]

The tax amount varies across these jurisdictions. For example, Mexico, Cook County (Illinois), and four Californian cities have enacted taxes of approximately 1 cent per ounce or 34 cents per litre, Philadelphia has implemented a tax of 1.5 cents per ounce or 51 cents per litre, while the Boulder (Colorado) tax is equivalent to 2 cents per ounce or 68 cents per litre.[28,29,33,34,35,36,37] The UK's proposed tax classifies beverages based on sugar content, with a lower tax rate for drinks with total sugar of 50 grams or more per litre, and a higher rate for those with 80 grams or more per litre. Proposed tax rates are 18 pence (~25 cents Canadian) and 24 pence (~34 cents Canadian) per litre, respectively.[30,38] To date, the evidence indicates that excise taxes are an effective measure for reducing SSB consumption, while also generating substantial government revenue.[39,40,41] The effect of a tax is influenced by the amount of the tax and the number of sugary drinks to which it applies.

The current study examined the health and economic impacts of sugary drinks in Canada, as well as the potential health and economic benefits of a sugary drink tax. The study consisted of three components: (1) an analysis of national data on sugary drink consumption among Canadians, (2) estimates of the health and economic impacts of sugary drinks in Canada, and (3) estimates of any potential health and economic benefits of an excise tax on sugary drinks.

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.[42] 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.[43] 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.[44]

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).[45] 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.[46] 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.[45] 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.[45] 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.[1]

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)[1,2] 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.[45,47] However, underreporting of food energies is a common limitation of dietary recall data, and no standard adjustment currently exists for correcting underreporting.[48] 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.[45]

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,[49,50,51] 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.

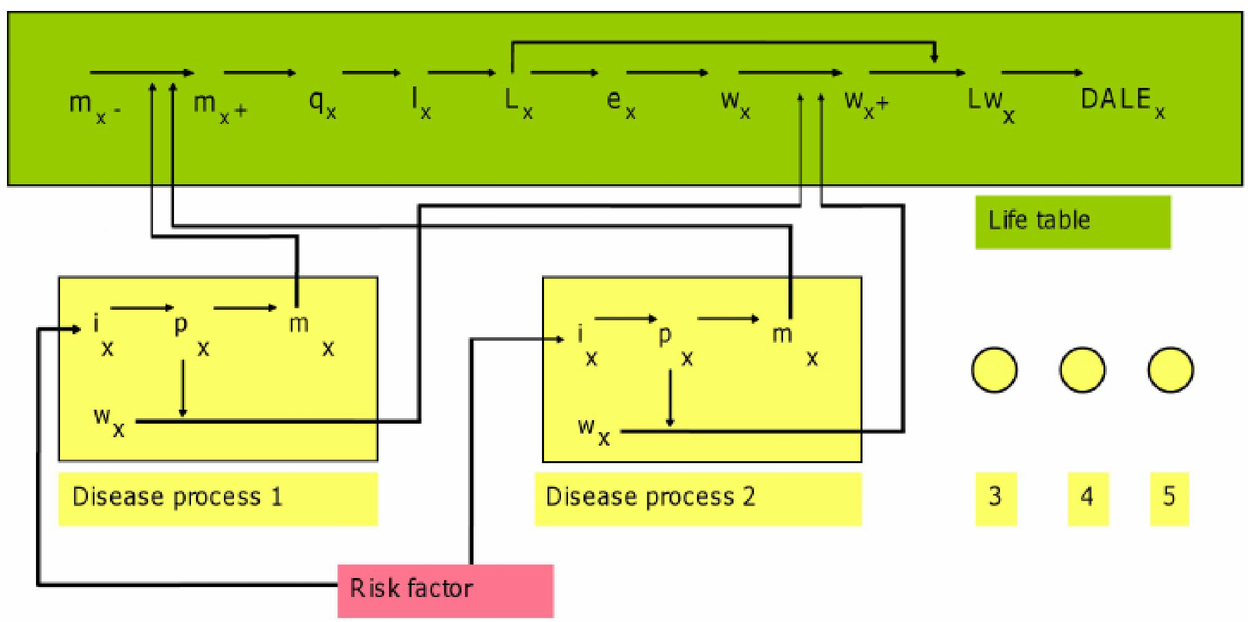
DISEASE MODELS

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).[52] 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

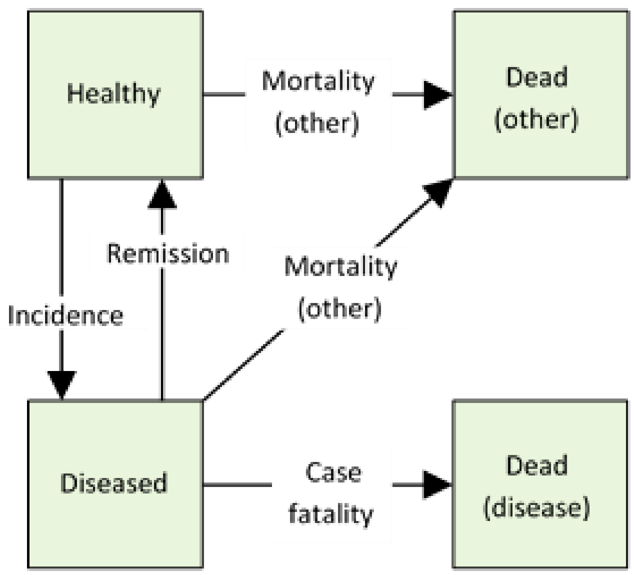
Esophageal cancer
Colon and rectum cancer
Liver cancer
Gallbladder and biliary tract cancer
Pancreatic cancer
Breast cancer (before menopause; after menopause)
Uterine cancer
Ovarian cancer
Kidney cancer
Thyroid cancer
Leukemia
Ischemic heart disease
Ischemic stroke
Hemorrhagic stroke
Hypertensive heart 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.[53] 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).[29,34,35,36,37] 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.[26]

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.[54] 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.[55]

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.[44] 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.[56,56] 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.[57]

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,52] 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,.[58] 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.[58] 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,[59] 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[60] derived from measured and self-reported BMI data in serial cross-sectional surveys: CCHS 2001-2010.[61,62,63,64,65,66,67] 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.[68] 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.[69,70] 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.[71] 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.[72,73,74]

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.,[75] 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.[57,76,77]

Lastly, health care costs were inflated to 2015 dollars using the Statistics Canada Consumer Price Index 'health care' sub-index.[55] 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.

FINDINGS

SUGARY DRINK SALES IN CANADA

In 2015, Canadians purchased an average of 341ml of SSBs per day, and an average of 444ml of sugary drinks per day when accounting for 100% juice.

The total volume of SSBs and sugary drinks sold in Canada did not change significantly between 2004 and 2015 (-2.6% and -1.8%, respectively); however, the per capita sales of SSBs and sugary drinks decreased (-13.2% and -12.6%, respectively) due to increasing population size (Figure 4).[54] While non-diet soft drink sales decreased over the 12–year period, the decrease was largely offset by the emergence of newer beverage categories, including flavoured waters, energy drinks and flavoured dairy products.

FIGURE 4
CHANGE IN SALES
EUROMONITOR

	TOTAL SALES VOLUME, 2004-2015	**PER CAPITA SALES** VOLUME, 2004-2015
	**-2.6%**	**-13.2%** -52ml PER DAY PER CAPITA
	**-1.8%**	**-12.6%** -64 ml PER DAY PER CAPITA

Between 2004 and 2015, the per capita sales volume decreased for three types of sugary drinks: regular soft drinks, fruit drinks, and 100% juice (Figure 5). In contrast, the per capita sales volume increased for energy drinks, sweetened coffee, flavoured water, drinkable yogurt, sweetened tea, flavoured milk, and sports drinks (Figure 6).

FIGURE 5
DECREASED SALES
VOLUME, PER CAPITA, 2004-2015

NON-DIET SOFT DRINKS
-27%

FRUIT DRINKS
-22%

100% JUICE
-10%

FIGURE 6

INCREASED SALES

VOLUME, PER CAPITA, 2004-2015

ENERGY DRINKS	SWEETENED COFFEE	FLAVOURED WATER	DRINKABLE YOGURT	SWEETENED TEAS	FLAVOURED MILK	SPORTS DRINKS
+638%	**+579%**	**+527%**	**+283%**	**+36%**	**+21%**	**+4%**

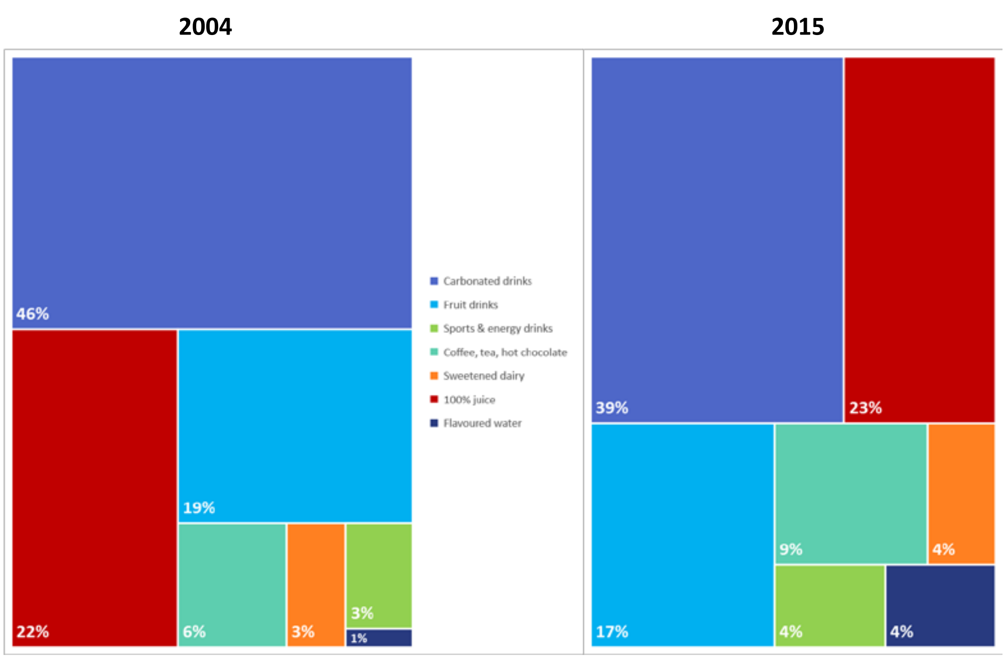
Overall, despite modest reductions over the preceding decade, SSB and sugar drink sales in 2015 remained near historic highs, with the emergence of new beverage categories helping to offset larger declines in soft drink sales.

Over the 12-year period between 2004 and 2015, new categories of sugary drinks emerged. In 2004, sales of flavoured water, flavoured milk, drinkable yogurt, and energy drinks were negligible. However, by 2015, these categories accounted for approximately 12% of all sugary drink sales, and offsetting the reduction in sales of regular soft drinks since 2004 (Figure 7).

FIGURE 7

SALES VOLUME BY PROPORTION OF SUGARY DRINK TYPE

EUROMONITOR



THE SIZE OF EACH SHAPE REPRESENTS THE PROPORTION OF TOTAL SUGARY DRINK SALES ACCOUNTED FOR BY EACH SUGARY DRINK TYPE. SALES VOLUME REFERS TO TOTAL VOLUME PER CATEGORY.

SUGARY DRINK INTAKE IN CANADA

Based on projections from CCHS 2004 dietary intake and Euromonitor sales estimates, Canadians consumed an average of 227ml (102 kcal) of SSBs per day in 2015. Including 100% juice, sugary drink intake was 334ml (148 kcal) each day. Consumption of sugary drinks was highest among young Canadians: for example, the average Canadian youth (aged 9-18) consumed an estimated 578ml of sugary drinks per day, whereas children up to age 8 consumed 326ml per day (Figure 8).

FIGURE 8

DAILY INTAKE

PROJECTED 2015, PER CAPITA*

	CHILDREN 0-8 YEARS	**YOUTH** 9-18 YEARS	**YOUNG ADULTS** 19-30 YEARS	**ADULTS** 31+ YEARS
	**236** ml **166** kcal	**430** ml **201** kcal	**371** ml **164** kcal	**169** ml **73** kcal
	**326** ml **207** kcal	**578** ml **266** kcal	**504** ml **221** kcal	**259** ml **110** kcal

Figure 9 shows the volume of intake by more specific age categories, with the highest level of intake among 14- to 18-year-olds.

FIGURE 9

VOLUME OF INTAKE

ML PER DAY, PER CAPITA, PROJECTED 2015

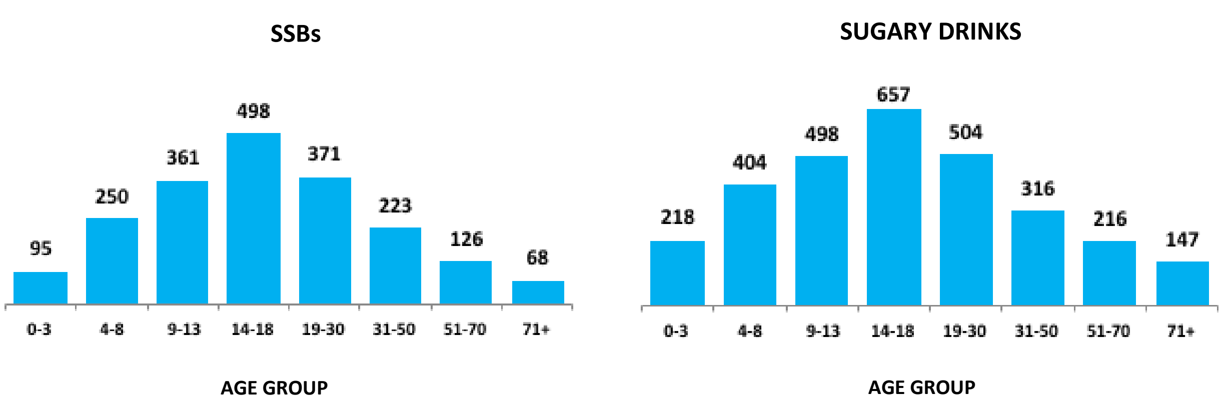


Figure 10 shows energy intake from SSBs and sugary drinks, by age categories. For many age groups, the mean caloric intake from these sugary drinks alone exceeds dietary recommendations to limit free sugar intake to less than 10% of total energy intake.

FIGURE 10

ENERGY INTAKE

KCAL PER DAY, PER CAPITA, PROJECTED 2015

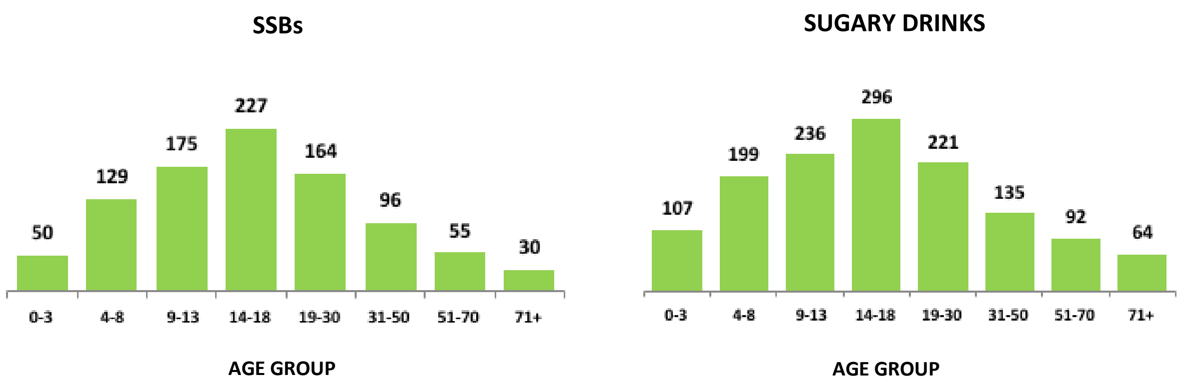
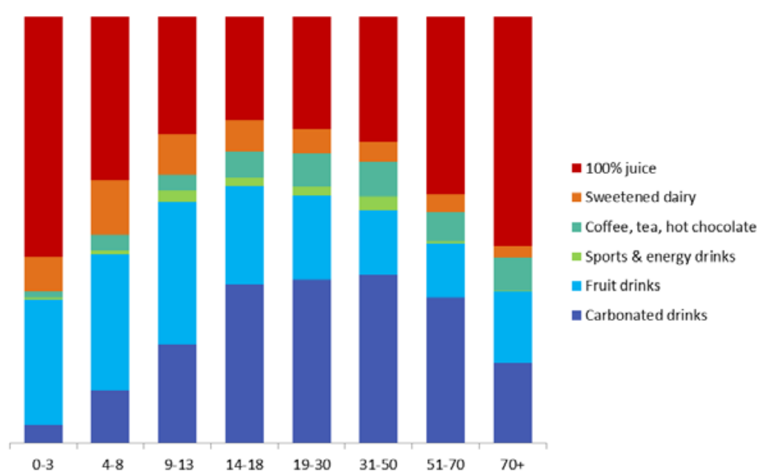


Figure 11 shows the contributions of individual beverage types (by volume) to overall sugary drink intake in 2004. Among children up to age 3 and adults age 70 and older, 100% juice accounted for more than half of sugary drink intake (56%). In contrast, carbonated beverages were the largest contributor among Canadians aged 14 to 50.

FIGURE 11

DISTRIBUTION OF TYPES OF SUGARY DRINKS CONSUMED

PROPORTION OF TOTAL VOLUME BY BEVERAGE CATEGORY, CCHS 2004



HEALTH CARE BURDEN AND ECONOMIC COSTS OF SUGARY DRINKS IN CANADA

BODY MASS INDEX

The avoidable health burden from SSB and sugary drink intake in Canada was estimated based on projected 2015 consumption levels. SSB intake is estimated to be responsible for an average per capita increase of 1.53 BMI units (95% uncertainty intervals [UI]: 1.43, 1.64) among males and 1.14 (1.06, 1.22) among females aged 20 and older. The BMI increases are projected to produce 650,488 additional cases of overweight and 2,101,399 additional cases of obesity over the next 25 years (Figure 12), of which 63% of cases would be among males. Males are projected to carry a greater burden of weight gain and disease cases, primarily due to their higher consumption of SSBs and sugary drinks.

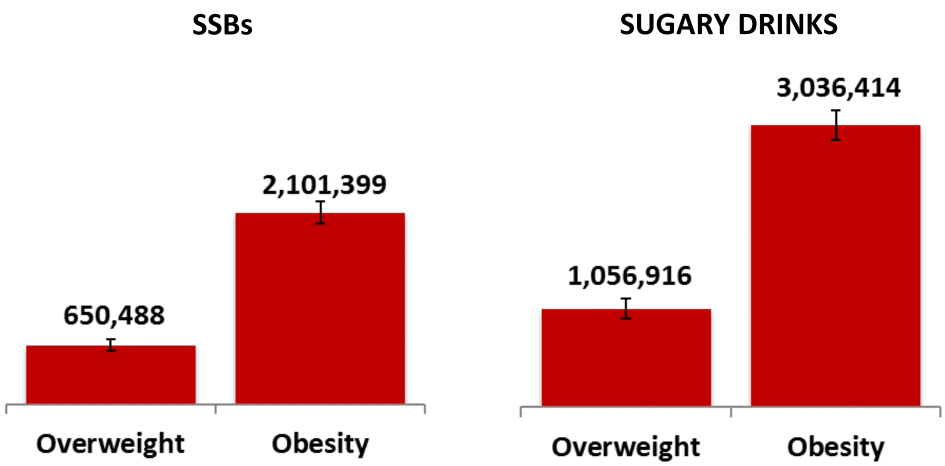
The health burden from sugary drinks is substantially higher than SSBs. Sugary drinks are projected to increase adult males' and females' average BMIs by 2.18 (2.05, 2.33) and 1.75 (1.65, 1.87) units, respectively. Over the next 25 years, sugary drink consumption is projected to be responsible for 1,056,916 cases of overweight and 3,036,414 cases of obesity.

Appendix B includes additional results on the avoidable burden of SSBs and sugary drinks.

FIGURE 12

CASES OF OBESTIY AND OVERWEIGHT DUE TO BEVERAGE CONSUMPTION

2016-2041



*ERROR BARS REPRESENT 95% UNCERTAINTY INTERVALS

SPECIFIC DISEASES

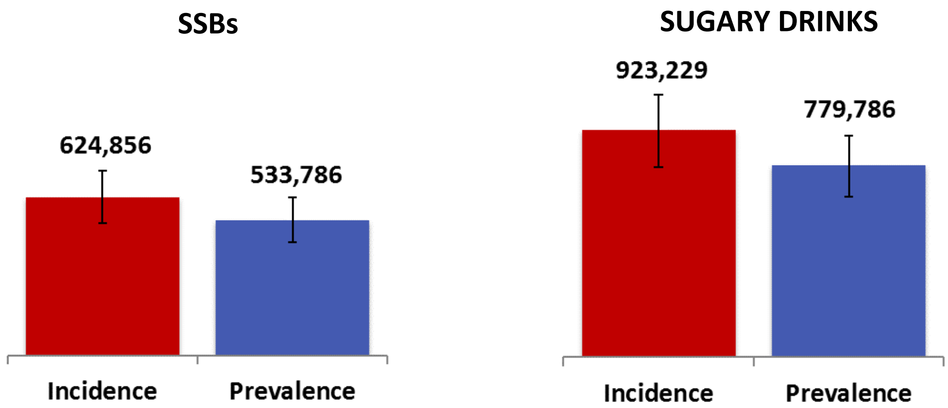
TYPE 2 DIABETES

Assuming current consumption levels hold, over the next 25 years, SSBs would contribute to an estimated 624,856 new cases of type 2 diabetes, averaging almost 25,000 cases annually. In the year 2041, the prevalence of type 2 diabetes is a projected to increase by 533,786 cases (Figure 13). Sugary drinks would contribute to an estimated 923,229 news cases of type 2 diabetes, averaging almost 37,000 new cases annually. In the year 2041, the prevalence of type 2 diabetes is projected to increase by an estimated 779,786 cases (Figure 13).

FIGURE 13

CASES OF TYPE 2 DIABETES DUE TO BEVERAGE CONSUMPTION

2016-2041

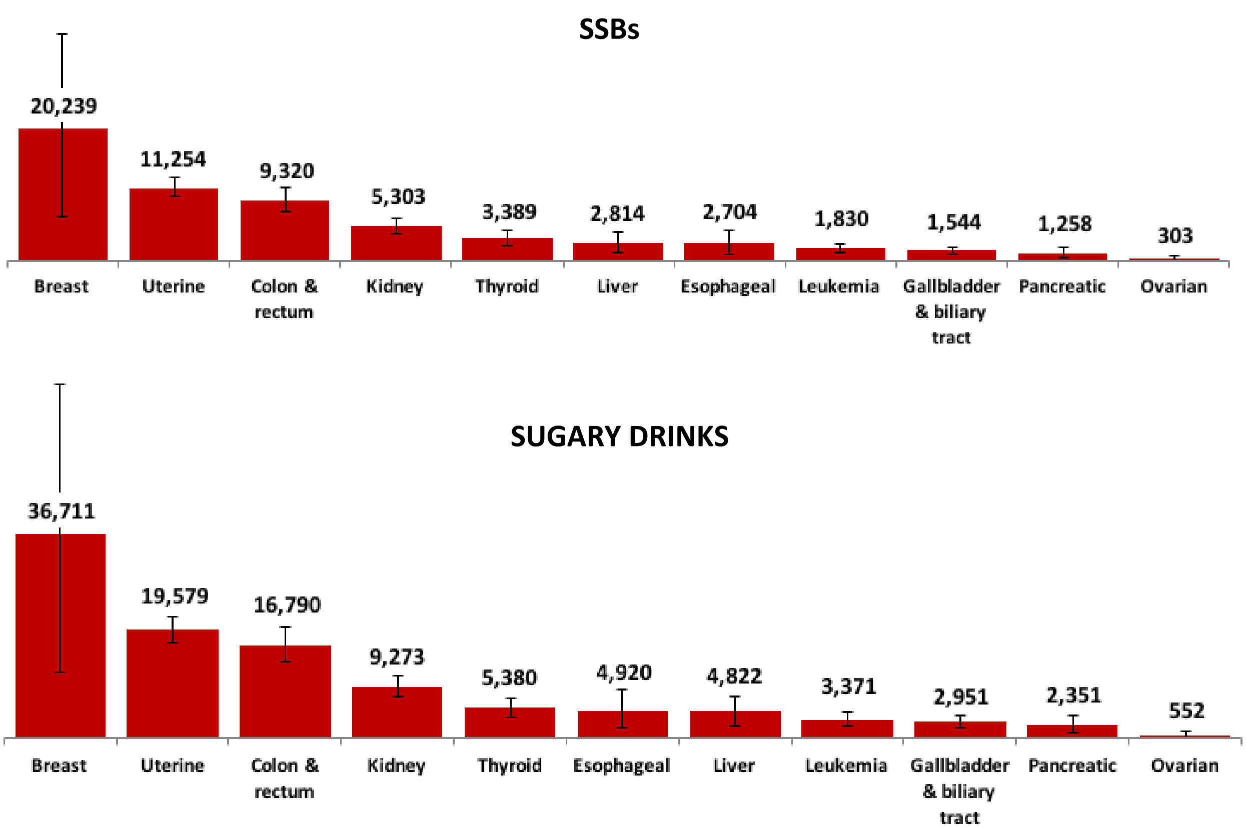


*ERROR BARS REPRESENT 95% UNCERTAINTY INTERVALS
*RED BARS REPRESENT NEW CASES IN 2016-2041 DUE TO SSBs OR SUGARY DRINKS
*BLUE BARS REPRESENT PREVALENT CASES IN 2041 DUE TO SSBs OR SUGARY DRINKS

FIGURE 14

NEW CASES OF CANCER DUE TO BEVERAGE CONSUMPTION

2016-2041

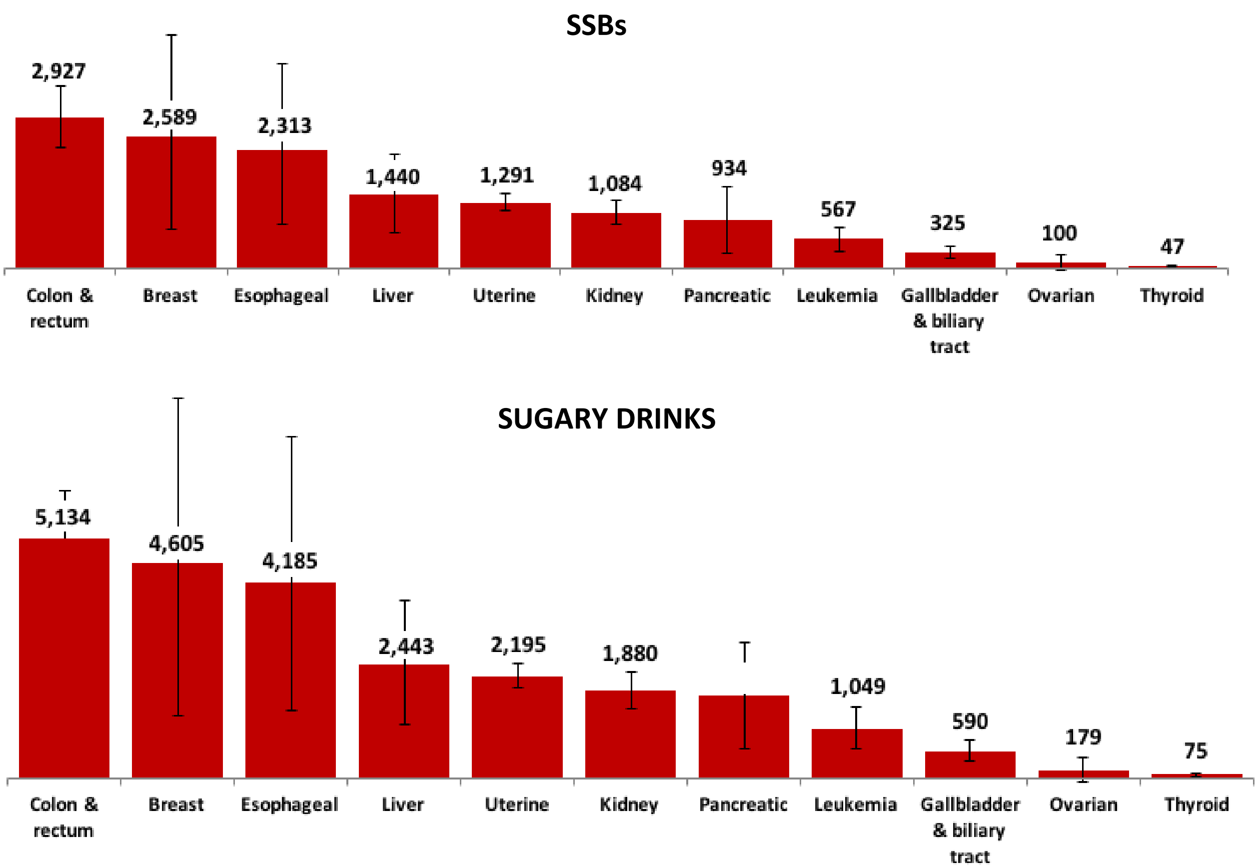


*ERROR BARS REPRESENT 95% UNCERTAINTY INTERVALS

FIGURE 15

CANCER DEATHS DUE TO BEVERAGE CONSUMPTION

2016-2041



*ERROR BARS REPRESENT 95% UNCERTAINTY INTERVALS

CANCERS

An estimated 59,956 new cancer cases over the next 25 years will be attributable to Canadians' consumption of SSBs. Figure 14 illustrates the number of new cases for 11 cancer types. Females will be more severely affected: the two most common incident cancers are specific to females (i.e., female breast and uterus) and constitute more than half of new cancer cases (53%). Four cancer types contribute three-quarters (77%) of new cancers: breast, uterine, colon and rectum, and kidney. Compared to SSBs alone, sugary drink consumption is associated with substantially more (80%) new cancer cases, a total of 106,701. Cases of specific cancers are found in Figure 14. Cancers due to sugary drink consumption follow similar patterns as those due to SSBs, but in greater numbers.

As shown in Figure 15, over the next 25 years, SSBs are estimated to contribute 13,617 cancer deaths from different types of cancer. Four cancers contribute to more than two-thirds (68%) of cancer deaths: colon and rectum (21% of deaths), breast (19%), esophageal (17%) and liver (11%). For sugary drinks, consumption of these beverages will cause a projected 24,087 cancer deaths (Figure 15), 77%

more than SSBs. Cancer deaths due to sugary drink consumption follow similar patterns as those due to SSBs, but in greater numbers.

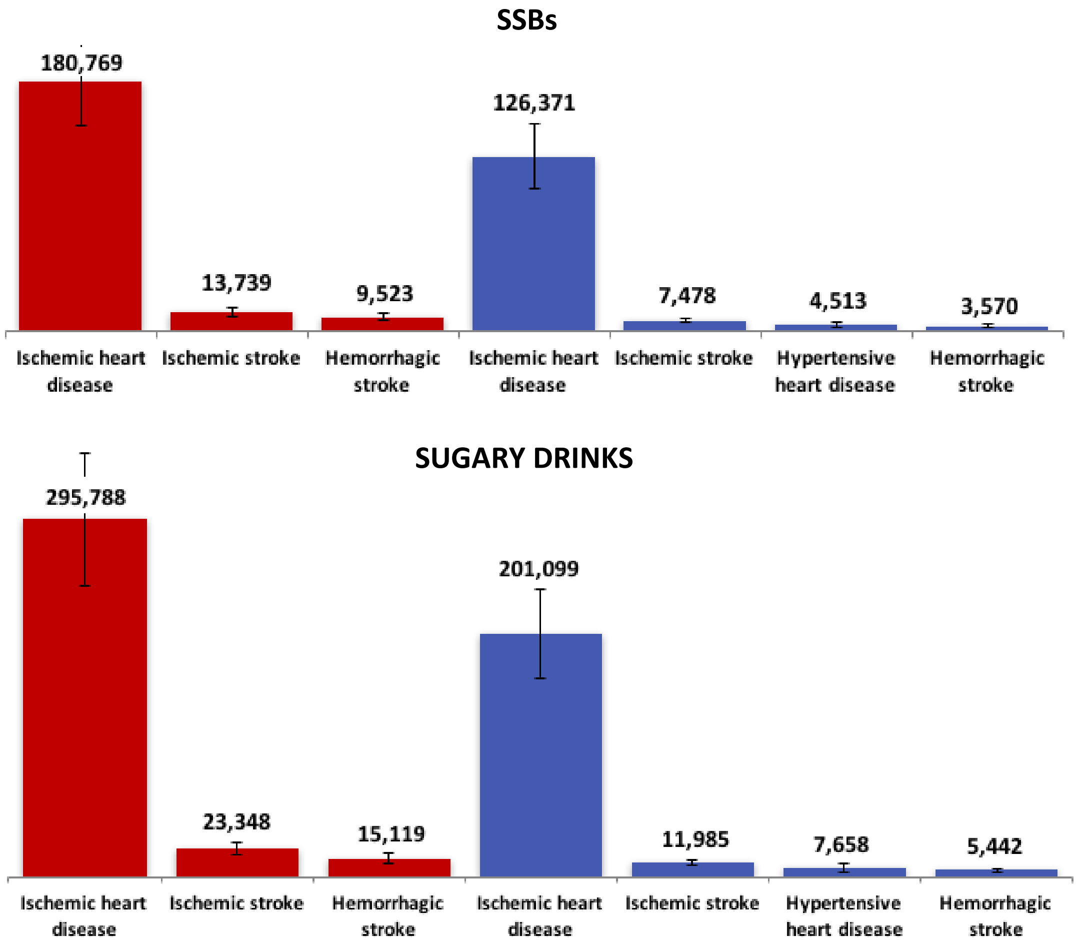
CARDIOVASCULAR DISEASE

Figure 16 illustrates projected new cases of ischemic heart disease (IHD), ischemic stroke and hemorrhagic stroke, and prevalent cases attributable to SSB consumption.[ii] Figure 16 also depicts the number of projected cardiovascular disease incident and prevalent cases due to sugary drink consumption, which are substantially higher than for SSB consumption. For example, new cases of IHD increase by 64%, equating to 115,019 additional cases.

FIGURE 16

CARDIOVASCULAR DISEASE CASES DUE TO BEVERAGE CONSUMPTION

2016-2041



*ERROR BARS REPRESENT 95% UNCERTAINTY INTERVALS

*RED BARS REPRESENT NEW CASES IN 2016-2041 DUE TO SWEET BEVERAGES

*BLUE BARS REPRESENT PREVALENT CASES IN 2041 DUE TO SWEET BEVERAGES

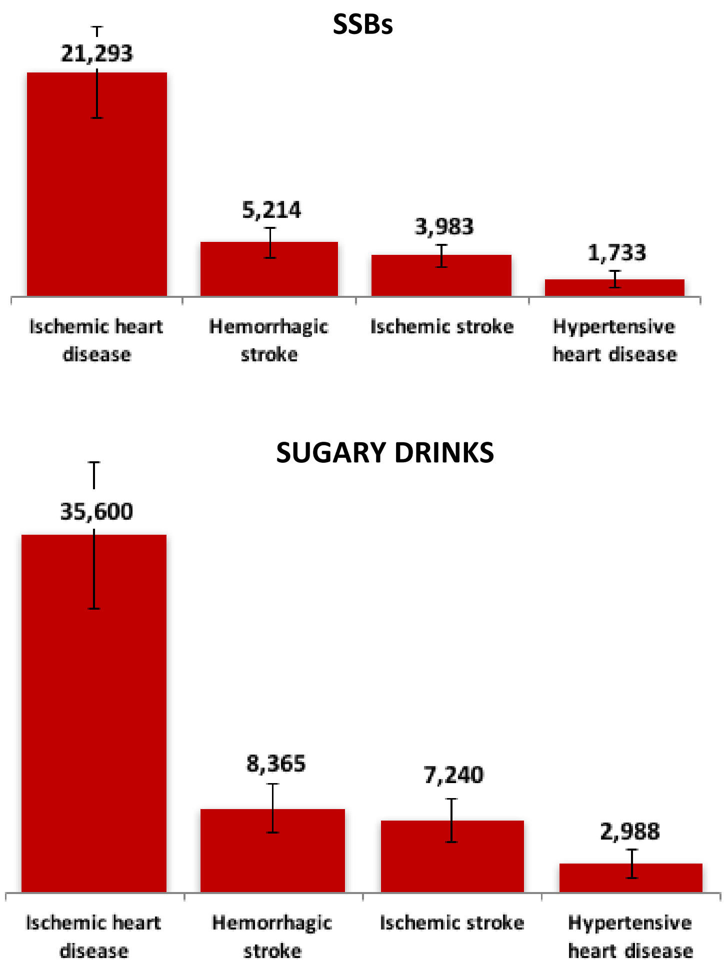
[ii]Data limitations necessitate that some of the model's disease output be reported by incident cases or prevalent cases only. For example, hypertensive heart disease prevalent cases are reportable, but not incident cases.

Over the next 25 years, an estimated 32,223 deaths from cardiovascular diseases will be due to Canadians' SSB intake. Cardiovascular disease deaths due to sugary drink consumption are estimated to total 54,193 over the next 25 years, 68% greater than for SSBs. As depicted in Figure 17, two-thirds (66%) of these deaths are from IHD.

FIGURE 17

CARDIOVASCULAR DISEASE DEATHS DUE TO BEVERAGE CONSUMPTION

2016-2041



*ERROR BARS REPRESENT 95% UNCERTAINTY INTERVALS

CHRONIC KIDNEY DISEASE, OSTEOARTHRITIS AND LOW BACK PAIN

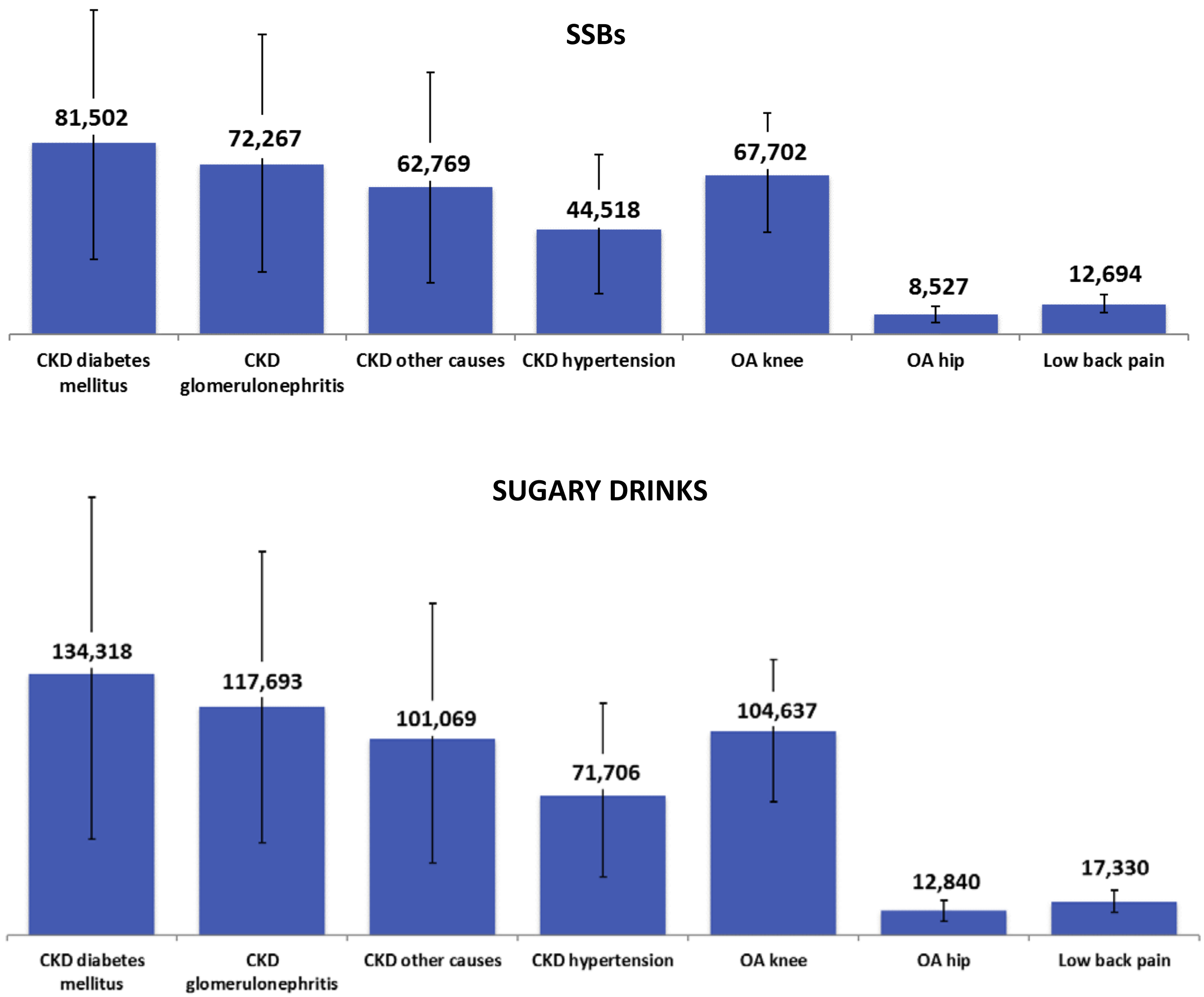
SSB consumption is predicted to increase the prevalence of other chronic conditions: chronic kidney disease (CKD), osteoarthritis (OA) and low back pain. Figure 18 depicts the estimated increase in the number of new cases during the year 2041. For 2041, the projected rise in the number of prevalent cases will total 261,056 for CKD, 76,229 for OA and 12,694 for low back pain.

Figure 18 shows the estimated increase in the number of new cases of CKD, OA and low back pain during the year 2041 due to sugary drink consumption. For 2041, the projected rise in the number of prevalent cases will total 424,786 for CKD, 117,477 for OA and 17,330 for low back pain.

FIGURE 18

PREVALENT CASES OF CHRONIC KIDNEY DISEASE, OSTEOARTHRITIS AND LOW BACK PAIN DUE TO BEVERAGE CONSUMPTION

2041



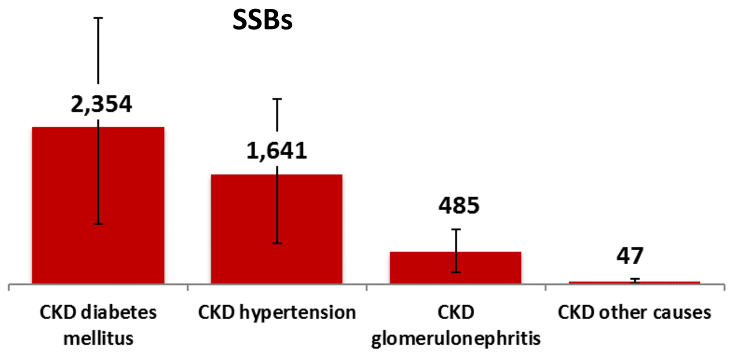
*ERROR BARS REPRESENT 95% UNCERTAINTY INTERVALS
*BLUE BARS REPRESENT PREVALENT CASES IN 2041 DUE TO SWEET BEVERAGES
*CKD NOTATION: E.G., 'CKD DIABETES MELLITUS' REFERS TO CHRONIC KIDNEY DISEASE DUE TO DIABETES MELLITUS
*OA NOTATION: E.G., 'OA KNEE' REFERS TO OSTEOARTHRITIS OF THE KNEE

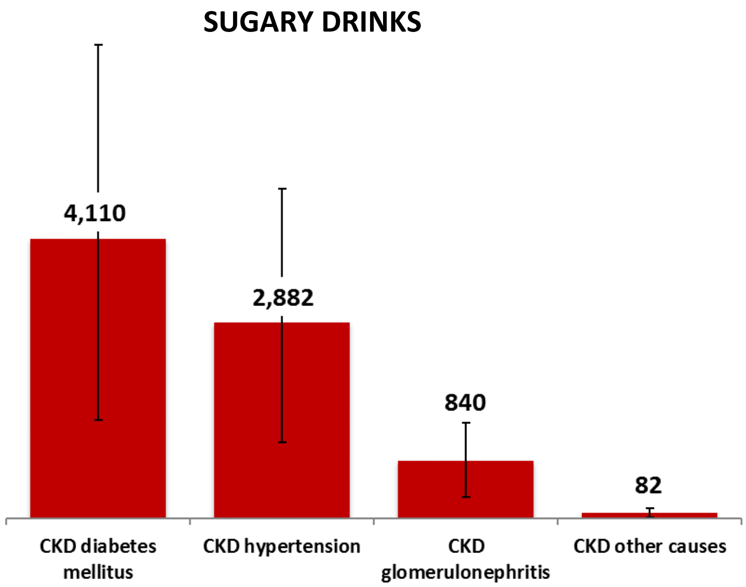
Deaths from CKD due to SSB consumption were estimated to total 4,528 over the next 25 years; CKD deaths due to sugary drink consumption totalled 7,915 (Figure 19). CKD due to diabetes mellitus contributed the highest proportion (52%) of CKD deaths.

FIGURE 19

CHRONIC KIDNEY DISEASE DEATHS DUE TO BEVERAGE CONSUMPTION

2016-2041





*ERROR BARS REPRESENT 95% UNCERTAINTY INTERVALS

*CKD NOTATION: E.G., 'CKD DIABETES MELLITUS' REFERS TO CHRONIC KIDNEY DISEASE DUE TO DIABETES MELLITUS

SUMMARY OF DISEASE MORBIDITY

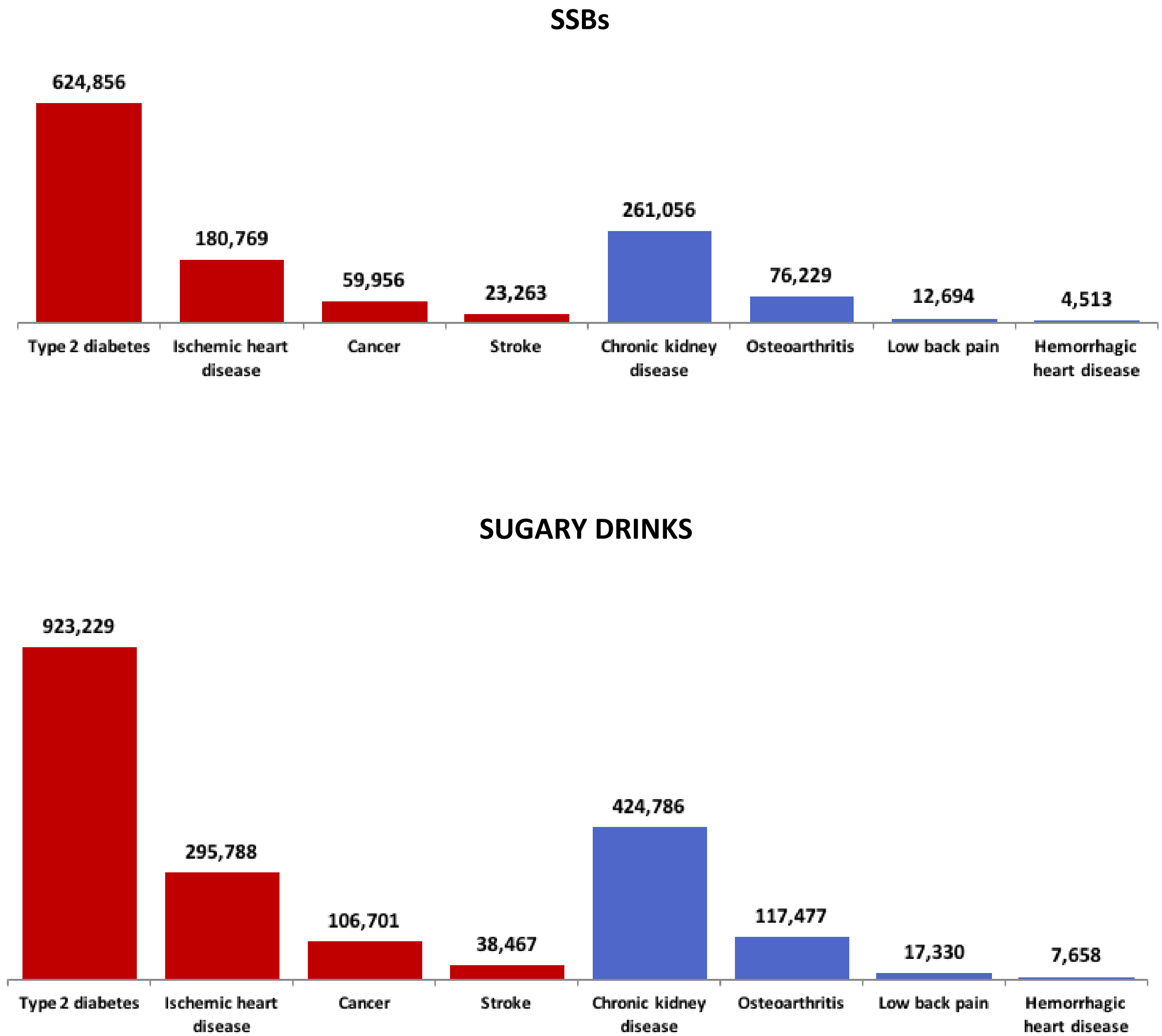
Overall, the diseases attributable to SSBs over the next 25 years are projected at 624,856 new cases of type 2 diabetes, 180,769 ischemic heart disease cases, 59,956 cancer cases and 23,263 strokes. In year 2041, prevalent cases of other conditions attributable to SSBs are estimated to increase by 261,056 CKD cases, 76,229 OA cases, 12,694 low back pain cases, and 4,513 hemorrhagic heart disease cases, as summarized in Figure 20.

The estimated health impact of Canadians' sugary drink consumption is even greater. Over the next 25 years, new disease cases are estimated at 923,229 cases of type 2 diabetes, 295,788 ischemic heart disease cases, 106,701 cancer cases and 38,467 strokes. In 2041, sugary drink consumption is projected to have increased the prevalence of chronic conditions, by 424,786 CKD cases, 117,477 OA cases, 17,330 low back pain cases, and 7,658 hemorrhagic heart disease cases (Figure 20).

FIGURE 20

DISEASE CASES ATTRIBUTABLE TO BEVERAGE CONSUMPTION

2016-2041



*RED BARS REPRESENT NEW CASES IN 2016-2041 DUE TO SSBs OR SUGARY DRINKS

*BLUE BARS REPRESENT PREVALENT CASES IN 2041 DUE TO SSBs OR SUGARY DRINKS

OVERALL DEATHS AND DALYs

For a 25-year period (2016-2041), among the 2015 Canadian adult population, SSBs are projected to account for an additional 38,385 (95% UI: 33,911, 43,103) deaths and nearly 1,433,485 (1,279,138, 1,584,753) disability adjusted life years (DALYs)[iii] in Canada. The majority of these deaths will be due ischemic heart disease or cancer. In comparison, sugary drinks will account for an additional 63,321 (56,160, 70,871) deaths and 2,185,549 (1,969,310, 2,406,124) DALYs—a 52% increase in DALYs compared to SSBs. Figure 21 summarizes these projections.

ECONOMIC BURDEN

The direct health care costs from SSB consumption are estimated at $33.7 billion ($30.0 billion, $37.5 billion) over the following 25 years. Sugary drinks will account for an estimated $50.7 billion ($45.4 billion, $55.7 billion) in direct health care costs, 50% greater than the health care costs for SSB consumption (Figure 21).

FIGURE 21

AVOIDABLE HEALTH BURDEN AND ECONOMIC COSTS

2016-2041

	DALYs	DEATHS	DIRECT HEALTH CARE COSTS
SSBs 	1,433,485	38,385	$33,735,536,562
Sugary drinks 	2,185,549	63,321	$50,657,213,642

[iii] Disability-adjusted life years (DALYs) are a population health 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).

HEALTH AND ECONOMIC BENEFITS FROM A TAX ON SUGARY DRINKS IN CANADA

ENERGY INTAKE AND BODY MASS INDEX

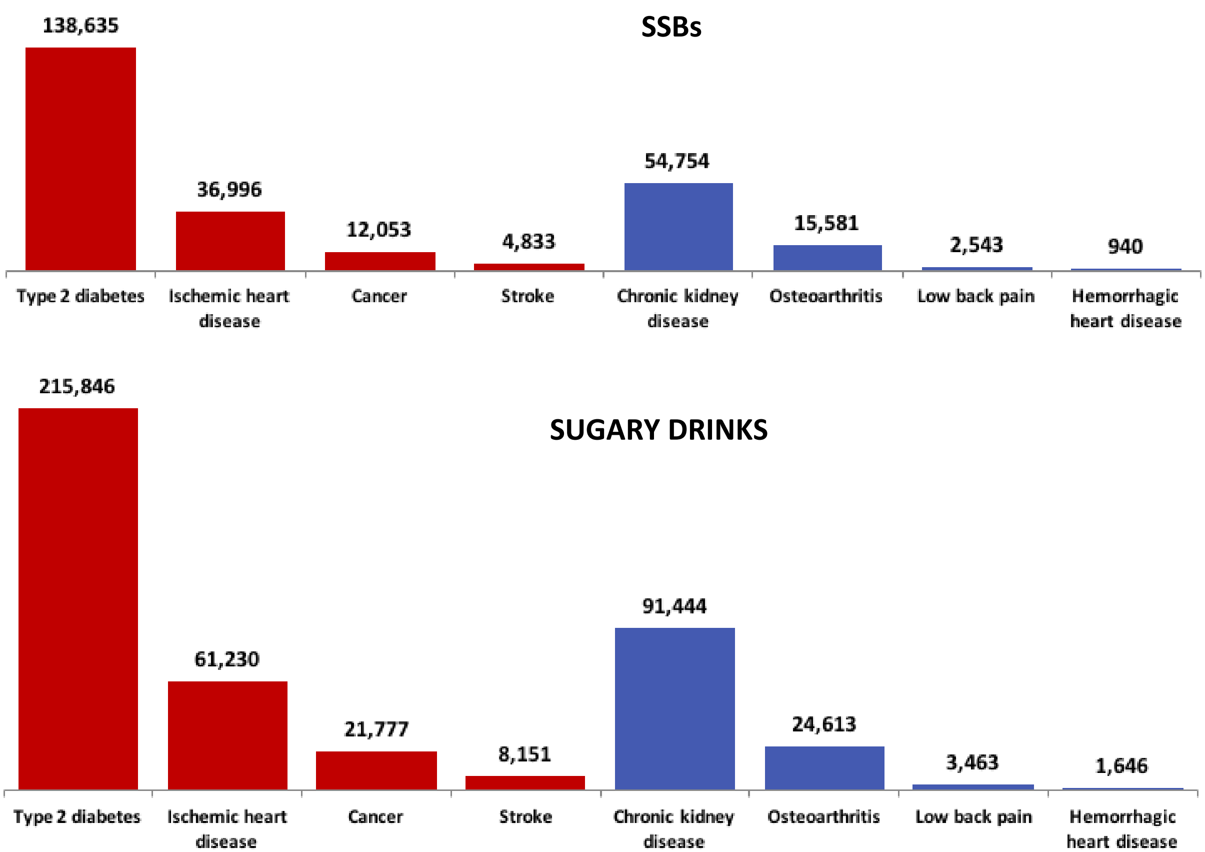
Over the next 25 years, a 20% tax on SSBs is projected to decrease the per capita daily energy intake of Canadian adult males and females by 21 kcal (95% UI: 19, 23) and 13 kcal, respectively (12, 15). The overall effect on adults' BMI would be a mean reduction in BMI of 0.30 (0.26, 0.34) for males and 0.22 (0.20, 0.25) for females. These seemingly modest reductions would translate into considerable health benefits: the prevention of 69,560 (59,172, 80,781) cases of overweight and 449,732 (395,623, 506,843) cases of obesity.

The potential health benefits are greater for a sugary drinks tax than a SSB tax. A 20% tax on sugary drinks is estimated to decrease the per capita daily energy intake of males and females by 30 kcal (27, 33) and 20 kcal (18, 22), respectively. The lower energy intake would produce a mean reduction in BMI of 0.43 (0.38, 0.48) for males and 0.34 (0.30, 0.39) for females. These reductions would translate into the prevention of 96,807 (81,441, 114,162) cases of overweight and 667,431 (587,371, 751,010) cases

FIGURE 22

DISEASE CASES PREVENTED BY 20% BEVERAGE TAXES

2016-2041



*RED BARS REPRESENT NEW CASES IN 2016-2041 DUE TO SWEET BEVERAGES

*BLUE BARS REPRESENT PREVALENT CASES IN 2041 DUE TO SWEET BEVERAGES of obesity among Canadian adults in the next 25 years. See Appendix B for additional results on the projected effects of a 20% beverage taxes.

DISEASE REDUCTIONS

By reducing obesity and overweight, a 20% tax on SSBs is estimated to prevent 12,053 cancer cases, 36,996 cases of ischemic heart disease, 4,833 strokes, and 138,635 cases of type 2 diabetes. Prevented incident and prevalent disease cases are illustrated in Figure 22. For a 20% sugary drink tax, prevented diseases would include 21,777 cancer cases, 61,230 cases of ischemic heart disease, 8,151 strokes, and 215,846 cases of type 2 diabetes (Figure 22).

OVERALL DEATHS AND DALYs PREVENTED

Overall, a 20% SSB tax is estimated to postpone 7,874 (6,630, 9,118) deaths and avert 309,441 (260,634, 358,948) DALYs in Canada over 25 years. In comparison, a greater number of deaths would be postponed and DALYs averted by a 20% sugary drinks tax: 13,206 (11,184, 15,456) deaths and 488,778 (415,999, 567,478) DALYs. The majority of postponed deaths would be due to reductions in ischemic heart disease or cancer mortality. Table 2 outlines the projected health and economic impact from 20% beverage taxes.

TABLE 2

SUMMARY OF HEALTH AND ECONOMIC BENEFITS FROM 20% BEVERAGE TAXES

2016-2041

	20% SSB tax	20% sugary drink tax
Deaths postponed	7,874	13,206
DALYs averted	309,441	488,778
Cases of overweight & obesity prevented	519,292	764,238
New type 2 diabetes cases prevented	138,635	215,846
New ischemic heart disease cases prevented	36,996	61,230
New cancer cases prevented	12,053	21,777
New stroke cases prevented	4,833	8,151
Health care costs savings	$7,350,664,242	$11,456,596,995
Tax revenue	$29,647,578,056	$43,610,950,060
Health care costs savings & revenue	$36,998,242,299	$55,067,547,055

*SEE APPENDIX BFOR 95% UNCERTAINTY INTERVALS

HEALTH CARE COSTS SAVINGS AND TAX REVENUE

The direct health care savings from a 20% SSB tax are estimated at almost $7.4 billion ($6.2 billion, $8.6 billion) across 25 years. These savings account for health care costs due to unrelated diseases that would occur in additional years of life. Annual SSB tax revenue is projected to be almost $1.2 billion ($1,185,903,122; 95% UI: $1,152,933,049, $1,222,583,183), assuming an average price of $2.50 per litre. The 25-year total tax revenue is an estimated $29.6 billion, not adjusting for secular trends in beverage consumption or changes in population demographics. The combined health care savings and revenue from a 20% SSB tax over this period would be nearly $37 billion.

The health care savings from a 20% sugary drinks tax are estimated at almost $11.5 billion ($9.7 billion, $13.3 billion). Using the same average price, sugary drink tax revenue is estimated to be $1.7 billion ($1,744,438,002; 95% UI: $1,698,682,393, $1,794,706,087) per year, and $43.6 billion over 25 years. The combined health care savings and revenue from a 20% sugary drinks tax is estimated at $55.1 billion (Table 2).

SENSITIVITY ANALYSES

Tables 3 and 4 present the results of univariate sensitivity analyses for a 20% SSB tax and a 20% sugary drink tax over a 25-year period, with comparisons to each beverage tax's base case. Patterns were similar for both beverage taxes. Scenario 1 examined the impact of removing the underlying upward trend in the population's BMI. Compared to the base case, the health benefits and health care savings would decline minimally. Revenue would be unaffected. When the tax intervention was modelled to be effective at reducing BMI for only the first 10 years (Scenario 2), the tax intervention maintained a sizable, though substantially reduced, projected effect on health benefits and economic savings. In Scenario 3, a more conservative own-price elasticity of demand would minimally reduce health outcomes and economic savings, and revenue would increase slightly.

Scenarios 4a and 4b examined the assumed 100% tax pass-on rate. If the entire cost of the tax was not passed on to consumers (Scenario 4a), the intervention's effectiveness would be diminished. Health improvements and health care savings would be slightly lower; however, revenue would increase, since beverage consumption would not decrease to the same degree as the base case. If more than the tax's value was passed on to consumers (tax 'overshifting') using a 120% pass-on, health benefits and health care savings would increase and revenue would decrease.

Varying the pre-tax beverage price would have little impact on health outcomes and health care savings (Scenarios 5a and 5b) since the model used an *ad valorem* excise tax that corresponded to the beverage price. However, as expected with an *ad valorem* excise tax, a lower pre-tax beverage price would reduce tax revenue and a higher price would increase revenue. Discounting health gain, costs and revenue by 3% annually (Scenario 6) would lower all outcomes except deaths, which were not linked to discounting.

TABLE 3

SENSITIVITY ANALYSES FOR 20% SSB TAX

2016-2041

SCENARIO	DEATHS		DALYS		HEALTH CARE COSTS SAVINGS		TAX REVENUE	
Base case	7,874		309,441		$7,350,664,242		$29,647,578,056	
1) BMI remains at 2015 levels	7,423	*-6%*	289,270	*-7%*	$6,793,382,892	*-8%*	$29,649,871,425	*0.0%*
2) Effect of tax on BMI capped at 10 years	3,865	*-51%*	193,908	*-37%*	$4,081,455,145	*-44%*	$29,664,266,425	*0.1%*
3) Upper boundary of own-price elasticity of demand	7,033	*-11%*	276,657	*-11%*	$6,571,646,625	*-11%*	$30,427,937,903	*3%*
4a) Tax pass-on 80%	6,539	*-17%*	257,953	*-17%*	$6,131,162,375	*-17%*	$30,903,869,450	*4%*
4b) Tax pass-on 120%	9,088	*15%*	357,700	*16%*	$8,490,757,802	*16%*	$28,505,049,650	*-4%*
5a) Pre-tax beverage price 25% lower	7,878	*0.1%*	309,957	*0.2%*	$7,363,429,733	*0.2%*	$22,056,880,000	*-26%*
5b) Pre-tax beverage price 25% higher	7,854	*-0.3%*	309,139	*-0.1%*	$7,348,628,581	*0.0%*	$37,133,771,625	*25%*
6) Health gain, costs and revenue discounted by 3%	7,863	*-0.1%*	195,272	*-37%*	$4,786,301,406	*-35%*	$21,279,053,572	*-28%*

*SEE APPENDIX BFOR 95% UNCERTAINTY INTERVALS

TABLE 4

SENSITIVITY ANALYSES FOR 20% SUGARY DRINK TAX

2016-2041

SCENARIO	DEATHS		DALYS		HEALTH CARE COSTS SAVINGS		TAX REVENUE	
Base case	13,206		488,778		$11,456,596,995		$43,610,950,060	
1) BMI remains at 2015 levels	12,467	*-6%*	456,129	*-7%*	$10,563,817,772	*-8%*	$43,598,375,744	*0.0%*
2) Effect of tax on BMI capped at 10 years	6,259	*-53%*	303,752	*-38%*	$6,231,834,130	*-46%*	$43,596,691,875	*0.0%*
3) Upper boundary of own-price elasticity of demand	11,876	*-10%*	438,710	*-10%*	$10,296,504,417	*-10%*	$44,722,909,487	*3%*
4a) Tax pass-on 80%	11,040	*-16%*	408,627	*-16%*	$9,588,434,812	*16%*	$45,417,184,185	*4%*
4b) Tax pass-on 120%	15,279	*16%*	563,589	*15%*	$13,205,861,326	*15%*	$41,914,177,191	*-4%*
5a) Pre-tax beverage price 25% lower	13,251	*0.3%*	490,901	*0.4%*	$11,506,856,037	*0.4%*	$32,417,799,796	*-26%*
5b) Pre-tax beverage price 25% higher	13,303	*0.7%*	490,936	*0.4%*	$11,512,591,689	*0.5%*	$54,567,291,370	*25%*
6) Health gain, costs and revenue discounted by 3%	13,223	*0.1%*	308,849	*-37%*	$7,488,312,743	*-35%*	$31,292,439,942	*-28%*

*SEE APPENDIX BFOR 95% UNCERTAINTY INTERVALS

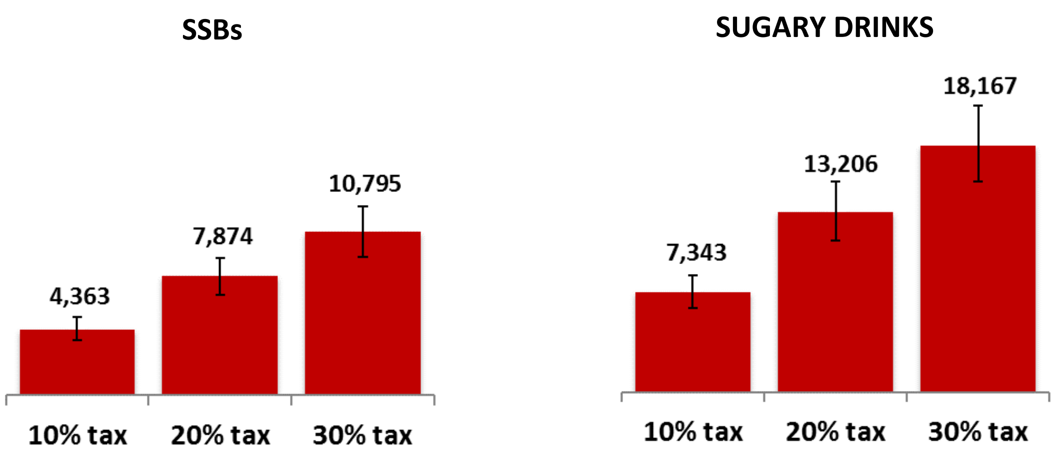
HEALTH AND ECONOMIC IMPACT OF DIFFERENT TAXATION LEVELS

In addition to a 20% tax rate, the impacts of 10% and 30% tax rates were modelled for SSBs and sugary drinks. As illustrated in Figure 23, for each beverage classification, a 10% tax would postpone and avert approximately 56% of the deaths and DALYs that a 20% tax would. A 30% tax would postpone or avert an additional 37% of deaths and DALYs, compared to a 20% tax. The absolute difference varies by beverage classification. For example, compared to a 20% tax, a 30% SSB tax would postpone 2,920 deaths, while a 30% sugary drinks tax would postpone 4,961 deaths.

FIGURE 23

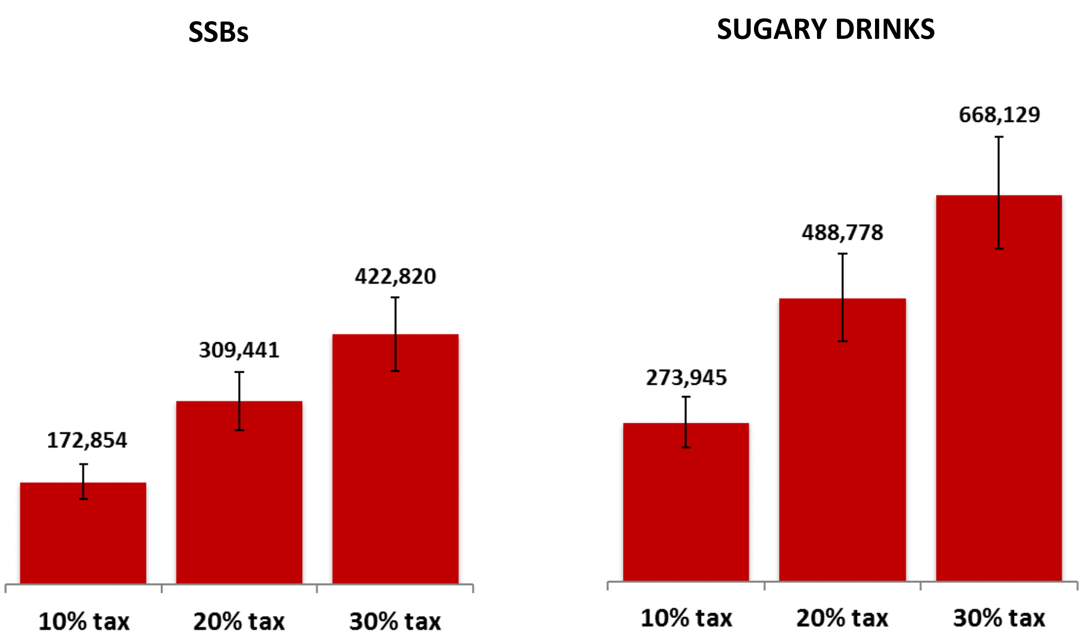
TOTAL POSTPONED DEATHS BY TAX LEVEL

2016-2041



TOTAL DALYS AVERTED BY TAX LEVEL

2016-2041

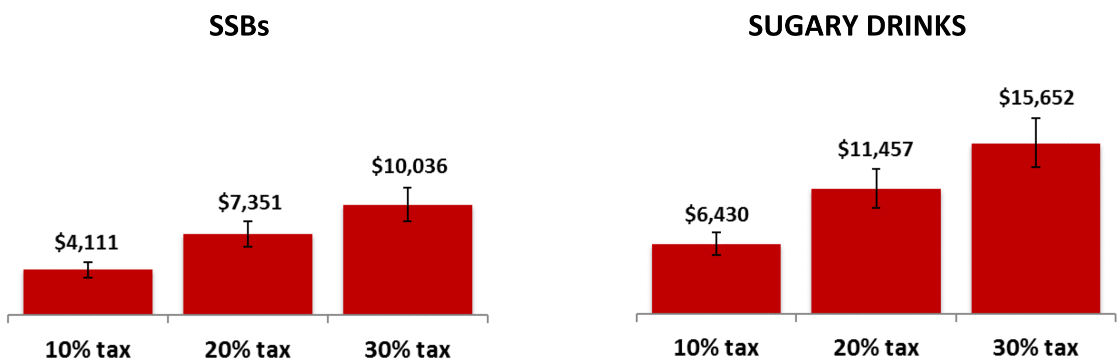


The projected changes in health care savings and revenue generated by the different tax levels are shown in Figure 24. For a SSB tax, the combined savings and revenue from a 10% tax are estimated at $20.6 billion, and for a 30% tax at $50.5 billion. For a sugary drinks tax, the combined savings and revenue from a 10% tax would be $30.6 billion, and $75.1 billion for a 30% tax.

FIGURE 24

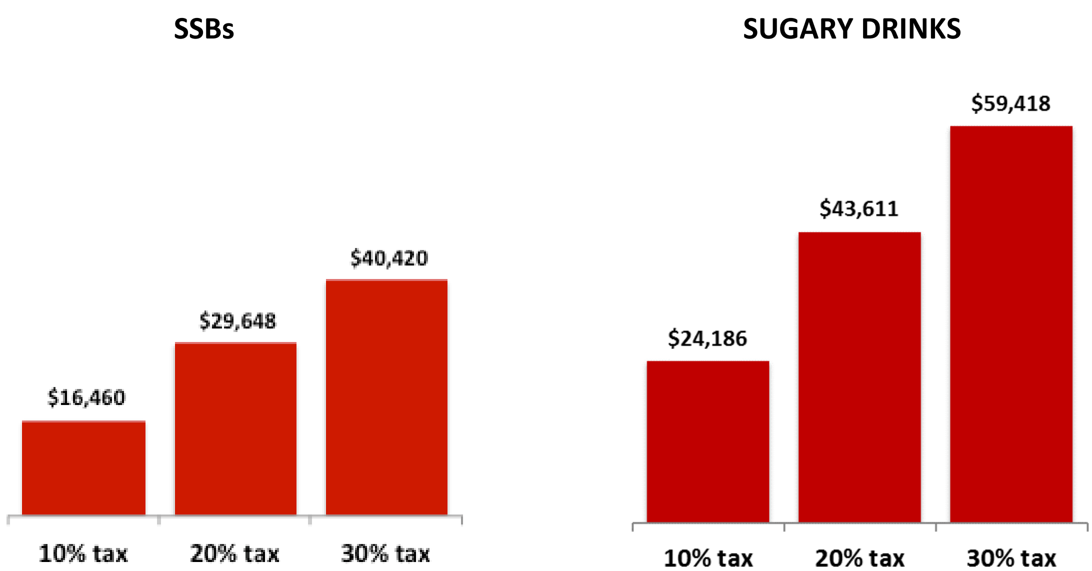
TOTAL HEALTH CARE SAVINGS BY TAX LEVEL

2016-2041 (CAD, MILLIONS)



TOTAL REVENUE BY TAX LEVEL

2016-2041 (CAD, MILLIONS)



SUMMARY OF HEALTH AND ECONOMIC BENEFITS

The projected health and economic impacts from 10% and 30% beverage taxes are summarized in Table 5 and Table 6.

TABLE 5

SUMMARY OF HEALTH AND ECONOMIC BENEFITS FROM 10% BEVERAGE TAXES

2016-2041

	10% SSB tax	10% sugary drink tax
Deaths postponed	4,363	7,343
DALYs averted	172,854	273,945
Cases of overweight & obesity prevented	284,202	417,919
New type 2 diabetes cases prevented	77,893	121,793
New ischemic heart disease cases prevented	20,431	34,043
New cancer cases prevented	6,650	12,068
New stroke cases prevented	2,682	4,513
Health care costs savings	$4,111,197,705	$6,430,291,304
Tax revenue	$16,460,060,744	$24,185,715,306
Health care costs savings & revenue	$20,571,258,449	$30,616,006,609

*SEE APPENDIX BFOR 95% UNCERTAINTY INTERVALS

TABLE 6

SUMMARY OF HEALTH AND ECONOMIC BENEFITS FROM 30% BEVERAGE TAXES

2016-2041

	30% SSB tax	30% sugary drink tax
Deaths postponed	10,795	18,167
DALYs averted	422,820	668,129
Cases of overweight & obesity prevented	717,938	1,062,420
New type 2 diabetes cases prevented	189,308	294,162
New ischemic heart disease cases prevented	50,603	84,334
New cancer cases prevented	16,542	30,091
New stroke cases prevented	6,621	11,154
Health care costs savings	$10,035,638,427	$15,652,297,745
Tax revenue	$40,420,455,014	$59,417,690,195
Health care costs savings & revenue	$50,456,093,442	$75,069,987,939

*SEE APPENDIX BFOR 95% UNCERTAINTY INTERVALS

DISCUSSION

The current study represents the most comprehensive analysis of the health and economic impact of sugary drink consumption in Canada to date. The findings indicate that sugary drink sales volumes in Canada have declined from 2004 to 2015, but remained close to historically high levels. Per capita sales of traditional sugary drinks have decreased (i.e., regular carbonated soft drinks, fruit drinks and 100% juice), whereas sales of newer products have increased (energy drinks, sweetened coffee, flavoured water, drinkable yogurt, sweetened tea, flavoured milk and sports drinks). While decreases in soft drink sales have been previously reported in data originating from the Canadian Beverage Association,[78,79] the current study identifies substantial growth among emergent beverage categories, which have offset declines in carbonated soft drink sales and shifted the profile of Canadians' sugary drink purchases.

Sugary drinks account for a substantial proportion of energy intake among Canadians, particularly among youth and young adults. The inclusion of beverages containing free sugars significantly increased intake estimates. Indeed, 100% fruit juice was the largest contributor to sugary drink intake among children under 9 years old and adults aged 51 and older. For many age groups, the average caloric intake from sugary drinks alone exceeded dietary recommendations to limit free sugar intake to less than 10% of total energy intake. This is consistent with data on the food supply showing that the vast majority of pre-packaged non-dairy beverage products in Canada contain added sugars and free sugars.[80,81] Among non-dairy beverages, 70% of calories are from free sugars.[81]

Due to a lack of recent date, intake estimates from 2004 were adjusted using trends in sales data between 2004 and 2015. It should be noted that the correspondence between Euromonitor International sales data and population dietary intake data is unknown. For 2004—the only year for which both sales estimates and intake data were both available—the per capita daily sales volume was higher than the per capita intake estimates from the 2004 CCHS 24-hour dietary recall data. This difference was expected given that sales data may overestimate actual intake because it does not account for any 'waste', in terms of beverages sold but not consumed. In addition, dietary recalls are known to underestimate sugary drink consumption, by as much as 30-40% according to some estimates.[82] It should also be noted that the CCHS sampling frame has poor coverage of certain sub-populations with higher than average SSB consumption, including Indigenous peoples in Canada.[83,84] While low calorie and no calorie beverages were distinguished from 'regular' beverages in the CCHS dataset, for the Euromonitor data it was assumed that all beverages in some sub-categories contained added sugar or free sugar. Since CCHS dietary recall values were used as model inputs, the study's findings may underestimate actual sugary drink intake, and the associated negative health effects and the benefits of a sugary drink tax may also be underestimated. Though it does not address under-coverage of key sub-populations, the CCHS Nutrition 2015 data to be released in 2017 will provide updated estimates of national beverage intake, including trends since 2004.[85]

The current study represents the first systematic effort to quantify the health and economic impact of SSBs and sugary drinks in Canada. The avoidable burden represents the future disease and economic costs that could be eliminated if a risk factor were eliminated today. The GBD 2010 Study published estimates of the deaths and DALYs attributable to SSB consumption for Canada.[86] Disease and economic burdens attributable to excess weight in the Canadian population are reported elsewhere.[87,88] However, in these studies the health effects are for a single year, they are not forecasted into the future, nor do they account for the risk factor's lagged effects. Apart from the direct effects of sugary drinks on type 2 diabetes, the model did not account for other non-BMI-mediated health effects. However, the model could be considered the most comprehensive sugary drink tax simulation model available due to its inclusion of an extensive set of BMI-related diseases, as well as type 2 diabetes direct effects. Previous models examining the effects of weight gain have excluded any direct effects, including those associated with type 2 diabetes.[89,90,91] Future work could extend the model to account for additional direct effects and to include ages 0-19 years. Both efforts require data and parameters that may not exist or may not be accessible at present.

The simulated tax on sugary drinks had a considerable impact on reducing the adverse health impacts of sugary drink consumption, reducing direct health care costs and generating tax revenue in Canada. This is consistent with other tax simulation studies, including those using variations of the ACE model in Australia, the United States, South Africa, and the East Asia Pacific Region.[51,54,89,92,93,94,95,96] The primary modelled scenario was a 20% tax on SSBs or sugary drinks, with comparisons to 10% and 30% tax levels. Due to the model design and data limitations, the type of tax modelled was an *ad valorem* excise tax on sugary drinks. However, the type of tax most commonly proposed and implemented in 'real world' settings is a specific excise tax based on beverage volume or sugar content.[23,28,29,30,31,33,34,35,36,37] Chriqui and colleagues have summarized the advantages of a specific tax over an *ad valorem* tax: specific excise taxes reduce relative price gaps, making it less likely that consumers will switch to cheaper beverages per volume; specific excise taxes are not subject to the same price manipulation by industry of *ad valorem* taxes; revenue is more predictable, and the tax is easier to administer. A disadvantage is that specific taxes need to keep pace with inflation and may require adjustment over time.[53] To ensure that specific taxes provide the necessary degree of price increase to achieve meaningful impacts on overall consumption and weight, the WHO advises a minimum of 20% of the beverage price as best practice.[26] In the current model, it was assumed that changes in consumption and weight would occur equally across population sex and age groups. In actuality, not all Canadians consume sugary drinks and, among consumers, some drink significantly less or more than the average.[1,2,3,4] Based on the simulation framework, high consumers stand to benefit the most as their consumption can decline more in response to a tax intervention. This also applies to low-income groups shown to have poorer diets,[97] and who may disproportionately benefit from the intervention. Additionally, tax revenue may be allocated toward programs to assist low-income families with health and education.[98]

The inclusion of 100% fruit juice within the definition of 'sugary drinks', represents an important extension of previous work given that the current study is the first modelling study to apply this definition to a beverage tax. The inclusion of 100% juice was based on the fact that free sugars contribute to the overall energy density of beverages and are metabolized the same way as 'added' sugars.[22] The model assumed that 100% fruit juice and other sugary drinks had the same BMI-mediated health effects as SSBs; however, it remains unclear whether macronutrients other than sugar in 100% fruit juice may alter the disease-specific risks attributable to SSBs. For this reason, all primary health and economic outcomes were reported separately for SSBs and sugary drinks. In addition, when estimating the non-BMI-mediated effects of SSBs and sugary drinks on type 2 diabetes cases, it was assumed that 100% juice would have the same effects as SSBs. However, a recent meta-analysis suggests that the effect of 100% fruit juice on type 2 diabetes may be slightly lower than for SSBs; therefore, the current analysis may have overestimated the direct of effect of 100% fruit juice on type 2 diabetes.[58] This may have produced a slight overestimation of type 2 diabetes cases for the burden of sugary drinks and the impact of a sugary drink tax. Future work should explore possible differences in the BMI and non-BMI mediated health effects between SSBs and sugary drinks in greater detail.

The study contains other limitations and assumptions. Given the broad definition of sugary drinks, the model did not incorporate caloric compensation from switching to non-taxed beverages and foods, and assumed no caloric substitution. Sugary drink consumption was assumed to have no secular change. The primary scenarios also used a 100% pass-on rate, although the sensitivity analysis illustrated the implications of a lower or higher pass-on rate. If beverage manufacturers and distributors choose to absorb some of the tax, a lower pass-on rate occurs (e.g. 80%), translating to smaller price increases and ultimately a less effective tax intervention as consumers do not reduce their consumption as much. An over-shifting (e.g. 120% pass-on rate) achieves an even greater change in consumer behaviour than the 100% pass through. Evidence from France and Mexico, settings with an excise tax on SSBs, show pass-on rates equal to or almost equal to 100%, with some heterogeneity by product, outlet and region.[99,100] In Berkeley, California, the tax was passed on but not at a 100% rate: 69% for carbonated soft drinks, 47% for fruit-flavoured beverages, and 47% for SSBs overall.[101] However, the pass-on rate may have been affected the localized nature of the tax. In France and Mexico the taxes were applied to all SSBs within the countries, making it more challenging for manufacturers to absorb the cost or shift some of the cost to other non-SSB products.

CONCLUSIONS

The current study suggests that consumption of SSBs and sugary drinks have a substantial negative health and economic impact in Canada. At current levels of consumption, free sugar intake from beverages is an important risk factor for type 2 diabetes, cancers, cardiovascular disease and other conditions. In the coming years, these conditions will cost billions of dollars in health care. An excise tax on sugary drinks has the potential to substantially reduce the health and economic burden over the next 25 years.

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)[77] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[102] **Prevalent cases:** GBD Results Tool (2015)[57] **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)[77] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[102] **Prevalent cases:** GBD Results Tool (2015)[57] **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)[57] **Disease-specific deaths:** GBD Results Tool (2015)[57] **Prevalent cases:** GBD Results Tool (2015)[57] **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)[57] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[102] **Prevalent cases:** GBD Results Tool (2015)[57] **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)[77] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[102] **Prevalent cases:** GBD Results Tool (2015)[57] **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)[77] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[102] **Prevalent cases:** GBD Results Tool (2015)[57] **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)[77] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[102] **Prevalent cases:** GBD Results Tool (2015)[57] **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)[77] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[102] **Prevalent cases:** GBD Results Tool (2015)[57] **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)[77] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[102] **Prevalent cases:** GBD Results Tool (2015)[57] **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)[77] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[102] **Prevalent cases:** GBD Results Tool (2015)[57] **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)[77] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[102] **Prevalent cases:** GBD Results Tool (2015)[57] **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)[76] **Disease-specific deaths:** CANSIM Table 102-0529 (2012)[103] **Prevalent cases:** CCDSS (2011)[76] **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)[57] **Disease-specific deaths:** GBD Results Tool (2015)[57] **Prevalent cases:** GBD Results Tool (2015)[57] **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)[57] **Disease-specific deaths:** GBD Results Tool (2015)[57] **Prevalent cases:** GBD Results Tool (2015)[57] **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)[76] **Disease-specific deaths:** CANSIM Table 102-0529 (2012)[103] **Prevalent cases:** GBD Results Tool (2015)[57] **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)[57] **Disease-specific deaths:** CANSIM Tables: 102-0524, 102-0536 & 102-0538 (2012)[104,105,106] **Prevalent cases:** GBD Results Tool (2015)[57] **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)[57] **Disease-specific deaths:** GBD Results Tool (2015)[57] **Prevalent cases:** GBD Results Tool (2015)[57] **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)[57] **Disease-specific deaths:** GBD Results Tool (2015)[57] **Prevalent cases:** GBD Results Tool (2015)[57] **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)[57] **Disease-specific deaths:** GBD Results Tool (2015)[57] **Prevalent cases:** GBD Results Tool (2015)[57] **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)[57] **Disease-specific deaths:** GBD Results Tool (2015)[57] **Prevalent cases:** GBD Results Tool (2015)[57] **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)[57] **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.[107] 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)[57] **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.[107] 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)[57] **Disease-specific mortality:** Inputted as 0 **Prevalent cases:** GBD Results Tool (2015)[57] **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

APPENDIX B: ADDITIONAL RESULTS

HEALTH CARE BURDEN AND ECONOMIC COSTS OF SUGARY DRINKS IN CANADA

BODY MASS INDEX

TABLE B1

AVERAGE CHANGE IN BMI DUE TO BEVERAGE CONSUMPTION

	SSBs Mean change in BMI (kg/m^2) (95% UI)		Sugary drinks Mean change in BMI (kg/m^2) (95% UI)	
Age group	**Males**	**Females**	**Males**	**Females**
20-24	2.87 (2.62, 3.13)	1.98 (1.81, 2.17)	3.78 (3.49, 4.09)	2.82 (2.59, 3.05)
25-29	2.87 (2.61, 3.13)	1.99 (1.81, 2.17)	3.78 (3.48, 4.08)	2.82 (2.59, 3.06)
30-34	2.14 (1.93, 2.37)	1.54 (1.38, 1.72)	2.83 (2.58, 3.08)	2.13 (1.94, 2.34)
35-39	2.14 (1.92, 2.37)	1.54 (1.37, 1.74)	2.83 (2.58, 3.09)	2.13 (1.93, 2.34)
40-44	1.45 (1.30, 1.61)	1.10 (0.99, 1.23)	2.04 (1.86, 2.23)	1.69 (1.55, 1.85)
45-49	1.45 (1.30, 1.60)	1.11 (1.00, 1.23)	2.04 (1.87, 2.23)	1.69 (1.54, 1.84)
50-54	1.00 (0.89, 1.11)	0.82 (0.72, 0.92)	1.58 (1.44, 1.72)	1.38 (1.26, 1.51)
55-59	1.00 (0.90, 1.11)	0.82 (0.73, 0.92)	1.58 (1.45, 1.72)	1.38 (1.26, 1.51)
60-64	0.80 (0.70, 0.91)	0.72 (0.64, 0.81)	1.45 (1.30, 1.60)	1.23 (1.12, 1.34)
65-69	0.80 (0.70, 0.91)	0.72 (0.64, 0.81)	1.44 (1.30, 1.60)	1.23 (1.12, 1.35)
70-74	0.51 (0.43, 0.59)	0.62 (0.52, 0.72)	0.95 (0.85, 1.06)	1.22 (1.09, 1.35)
75-79	0.51 (0.43, 0.58)	0.62 (0.52, 0.72)	0.95 (0.85, 1.06)	1.22 (1.1, 1.35)
80+	0.43 (0.37, 0.49)	0.46 (0.40, 0.53)	0.92 (0.82, 1.04)	1.13 (1.03, 1.23)
All ages	1.53 (1.43, 1.64)	1.14 (1.06, 1.22)	2.18 (2.05, 2.33)	1.75 (1.65, 1.87)

TABLE B2

CASES OF OVERWEIGHT AND OBESITY DUE TO BEVERAGE CONSUMPTION

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Cases of overweight (2016-2041)		
Males	471,224 (422,184, 525,985)	730,901 (658,633, 808,884)
Females	179,263 (162,792, 197,243)	326,015 (295,852, 357,912)
Total	650,488 (587,770, 721,228)	1,056,916 (956,452, 1,164,409)
Cases of obesity (2016-2041)		
Males	1,273,180 (1,202,440, 1,350,007)	1,766,877 (1,678,156, 1,855,708)
Females	828,219 (776,964, 885,383)	1,269,537 (1,196,785, 1,344,003)
Total	2,101,399 (1,986,063, 2,231,360)	3,036,414 (2,877,753, 3,194,817)

DISEASES

TYPE 2 DIABETES

TABLE B3

INCIDENT CASES OF TYPE 2 DIABETES DUE TO BEVERAGE CONSUMPTION

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Type 2 diabetes mellitus		
Males	366,254 (291,904, 439,055)	525,794 (422,633, 626,871)
Females	258,602 (208,197, 309,249)	397,434 (315,918, 475,108)
Total	624,856 (521,264, 731,043)	923,229 (771,466, 1,069,627)

TABLE B4

PREVALENT CASES OF TYPE 2 DIABETES DUE TO BEVERAGE CONSUMPTION

2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Type 2 diabetes mellitus		
Males	308,761 (246,314, 370,989)	437,290 (351,437, 520,884)
Females	225,025 (181,327, 268,559)	342,496 (273,158, 408,663)
Total	533,786 (44,6051, 623,945)	779,786 (651,793, 903,133)

TABLE B5

INCIDENT CASES OF CANCER DUE TO BEVERAGE CONSUMPTION

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Esophageal cancer		
Males	2,140 (504, 4,000)	3,837 (821, 7,203)
Females	564 (52, 1,168)	1,083 (15, 2,250)
Total	2,704 (1,008, 4,673)	4,920 (1,708, 8,582)
Colon and rectum cancer		
Males	7,566 (6,005, 9,179)	13,472 (10,857, 16,207)
Females	1,753 (837, 2,686)	3,318 (1,565, 5,016)
Total	9,320 (7,552, 11,198)	16,790 (13,718, 19,972)
Liver cancer		
Males	2,263 (845, 3,747)	3,795 (1,416, 6,282)
Females	551 (89, 1,050)	1027 (126, 2,039)
Total	2,814 (1,356, 4,409)	4,822 (2,283, 7,591)
Gallbladder and biliary tract cancer		
Males	443 (62, 826)	813 (114, 1541)
Females	1,101 (712, 1,519)	2,138 (1,326, 2,950)
Total	1,544 (966, 2,103)	2,951 (1,899, 4,052)
Pancreatic cancer		
Males	591 (125, 1,380)	1,050 (226, 2,392)
Females	667 (247, 1,111)	1,301 (496, 2,134)
Total	1,258 (412, 2,128)	2,351 (855, 3,905)
Breast cancer		
Males	--	--
Females	20,239 (6,705, 34,972)	36,711 (11,989, 63,416)
Total	20,239 (6,705, 34,972)	36,711 (11,989, 63,416)
Uterine cancer		
Males	--	--
Females	11,254 (9,927, 12,743)	19,579 (17,279, 21,862)
Total	11,254 (9,927, 12,743)	19,579 (17,279, 21,862)
Ovarian cancer		
Males	--	--
Females	303 (57, 695)	552 (103, 1,223)
Total	303 (57, 695)	552 (103, 1,223)
Kidney cancer		
Males	3,134 (2,211, 4,146)	5,332 (3,768, 6,964)
Females	2,168 (1,678, 2,658)	3,942 (3,101, 4,811)
Total	5,303 (4,284, 6,433)	9,273 (7,467, 11,121)
Thyroid cancer		
Males	1,328 (406, 2,283)	2,057 (654, 3,480)
Females	2,061 (1,374, 2,753)	3,322 (2,257, 4,371)
Total	3,389 (2,207, 4,595)	5,380 (3,617, 7,125)
Leukemia		
Males	933 (525, 1,331)	1,662 (965, 2,366)
Females	896 (364, 1,457)	1,709 (712, 2,731)
Total	1,830 (1,134, 2,529)	3,371 (2,128, 4,693)

TABLE B6

CANCER DEATHS DUE TO BEVERAGE CONSUMPTION

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Esophageal cancer		
Males	1,847 (433, 3,450)	3,298 (701, 6,194)
Females	466 (42, 968)	887 (9, 1,841)
Total	2,313 (849, 3,989)	4,185 (1,439, 7,329)
Colon and rectum cancer		
Males	2,464 (1,937, 3,008)	4,289 (3,450, 5,214)
Females	463 (181, 744)	845 (312, 1,360)
Total	2,927 (2,353, 3,542)	5,134 (4,154, 6,161)
Liver cancer		
Males	1,127 (412, 1,872)	1,869 (680, 3,107)
Females	313 (47, 602)	573 (60, 1,150)
Total	1,440 (691, 2,243)	2,443 (1,143, 3,821)
Gallbladder and biliary tract cancer		
Males	94 (10, 178)	166 (17, 319)
Females	232 (149, 321)	425 (262, 587)
Total	325 (201, 445)	590 (371, 818)
Pancreatic cancer		
Males	409 (112, 986)	726 (204, 1,702)
Females	525 (188, 882)	1,026 (376, 1,699)
Total	934 (302, 1,585)	1,752 (619, 2,918)
Breast cancer		
Males	--	--
Females	2,589 (772, 4,552)	4,605 (1,345, 8,129)
Total	2,589 (772, 4,552)	4,605 (1,345, 8,129)
Uterine cancer		
Males	--	--
Females	1,291 (1,140, 1,463)	2,195 (1,937, 2,450)
Total	1,291 (1,140, 1,463)	2,195 (1,937, 2,450)
Ovarian cancer		
Males	--	--
Females	100 (45, 260)	179 (89, 454)
Total	100 (45, 260)	179 (89, 454)
Kidney cancer		
Males	693 (481, 921)	1,163 (807, 1,535)
Females	391 (301, 484)	717 (559, 880)
Total	1,084 (861, 1,329)	1,880 (1,489, 2,285)
Thyroid cancer		
Males	38 (9, 69)	61 (14, 108)
Females	8 (5, 12)	14 (8, 20)
Total	47 (17, 78)	75 (29, 121)
Leukemia		
Males	248 (121, 371)	448 (226, 669)
Females	318 (118, 527)	601 (228, 977)
Total	567 (322, 805)	1,049 (611, 1,519)

CARDIOVASCULAR DISEASE

TABLE B7

INCIDENT CASES OF CARDIOVASCULAR DISEASE DUE TO BEVERAGE CONSUMPTION

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Ischemic heart disease		
Males	112,785 (86,495, 141,532)	178,887 (136,772, 219,274)
Females	67,985 (50,341, 87,234)	116,901 (86,241, 149,104)
Total	180,769 (148,283, 215,292)	295,788 (241,045, 350,198)
Ischemic stroke		
Males	7,912 (5,684, 10,210)	13,144 (9,398, 17,058)
Females	5,827 (3,841, 7,862)	10,203 (6,432, 14,100)
Total	13,739 (10,714, 16,756)	23,348 (17,983, 28,955)
Hemorrhagic stroke		
Males	5,148 (3,302, 7,174)	7,964 (5,190, 11,093)
Females	4,376 (2,703, 6,163)	7,155 (4,272, 10,456)
Total	9,523 (7,058, 12,229)	15,119 (10,802, 19,761)

TABLE B8

PREVALENT CASES OF CARDIOVASCULAR DISEASE DUE TO BEVERAGE CONSUMPTION

2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Ischemic heart disease		
Males	77,893 (59,613, 97,996)	120,383 (91,821, 147,834)
Females	48,478 (35,926, 62,301)	80,716 (59,949, 102,503)
Total	126,371 (103,513, 150,439)	201,099 (164,127, 237,863)
Ischemic stroke		
Males	4,251 (3,155, 5,371)	6,692 (5,027, 8,424)
Females	3,227 (2,307, 4,153)	5,293 (3,761, 6,864)
Total	7,478 (6,066, 8,882)	11,985 (9,700, 14,372)
Hemorrhagic stroke		
Males	1,854 (1,200, 2,557)	2,761 (1,836, 3,766)
Females	1,715 (1,109, 2,326)	2,682 (1,710, 3,710)
Total	3,570 (2,701, 4,507)	5,442 (4,023, 6,924)
Hypertensive heart disease		
Males	2,134 (925, 3,559)	3,300 (1,385, 5,573)
Females	2,379 (811, 4,354)	4,358 (1,514, 7,682)
Total	4,513 (2,436, 6,873)	7,658 (4,192, 11,609)

TABLE B9

CARDIOVASCULAR DISEASE DEATHS DUE TO BEVERAGE CONSUMPTION

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Ischemic heart disease		
Males	14,907 (11,284, 18,860)	24,011 (17,972, 29,769)
Females	6,386 (4,537, 8,401)	11,589 (8,152, 15,242)
Total	21,293 (17,098, 25,657)	35,600 (28,223, 42,824)
Ischemic stroke		
Males	2,270 (1,512, 3,067)	3,998 (2,617, 5,440)
Females	1,714 (960, 2,508)	3,242 (1,661, 4,927)
Total	3,983 (2,873, 5,082)	7,240 (5,151, 9,448)
Hemorrhagic stroke		
Males	2,845 (1,827, 3,935)	4,435 (2,887, 6,151)
Females	2,369 (1,451, 3,361)	3,930 (2,310, 5,791)
Total	5,214 (3,853, 6,704)	8,365 (5,957, 10,932)

CHRONIC KIDNEY DISEASE

TABLE B10

PREVALENT CASES OF CHRONIC KIDNEY DISEASE DUE TO BEVERAGE CONSUMPTION

2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Chronic kidney disease due to diabetes mellitus		
Males	32,589 (6,437, 63,718)	53,063 (9,115, 101,558)
Females	48,913 (6,501, 99,376)	81,255 (15,186, 163,237)
Total	81,502 (31,917, 137,994)	134,318 (49,404, 224,889)
Chronic kidney disease due to hypertension		
Males	17,970 (3,845, 34,764)	28,032 (5,988, 54,961)
Females	26,548 (4,390, 53,050)	43,674 (9,283, 88,897)
Total	44,518 (17,294, 76,401)	71,706 (30,139, 119,453)
Chronic kidney disease due to glomerulonephritis		
Males	28,299 (5,346, 56,729)	45,511 (6,171, 89,793)
Females	43,968 (5,981, 90,962)	72,183 (12,732, 140,808)
Total	72,267 (26,502, 127,616)	117,693 (47,773, 197,226)
Chronic kidney disease due to other causes		
Males	24,657 (3,671, 49,519)	39,384 (5,160, 78,491)
Females	38,112 (5,211, 78,543)	61,685 (9,268, 123,197)
Total	62,769 (21,923, 111,515)	101,069 (37,589, 170,335)

TABLE B11

CHRONIC KIDNEY DISEASE DEATHS DUE TO BEVERAGE CONSUMPTION

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Chronic kidney disease due to diabetes mellitus		
Males	1,527 (295, 2,990)	2,662 (415, 5,158)
Females	828 (109, 1,669)	1,449 (245, 2,912)
Total	2,354 (900, 3,991)	4,110 (1,448, 6,946)
Chronic kidney disease due to hypertension		
Males	944 (174, 1,847)	1,607 (276, 3,216)
Females	697 (83, 1,443)	1,275 (191, 2,723)
Total	1,641 (616, 2,771)	2,882 (1,122, 4,840)
Chronic kidney disease due to glomerulonephritis		
Males	273 (50, 535)	464 (57, 906)
Females	213 (28, 432)	376 (57, 729)
Total	485 (177, 823)	840 (320, 1,408)
Chronic kidney disease due to other causes		
Males	24 (0, 50)	39 (3, 84)
Females	24 (1, 53)	43 (0, 94)
Total	47 (13, 87)	82 (21, 148)

OSTEOARTHRITIS

TABLE B12

PREVALENT CASES OF OSTEOARTHRITIS DUE TO BEVERAGE CONSUMPTION

2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Osteoarthritis of the hip		
Males	4,388 (1,940, 6,840)	6,320 (2,655, 10,292)
Females	4,139 (1,779, 6,535)	6,520 (2,805, 10,302)
Total	8,527 (4,958, 11,870)	12,840 (7,462, 18,309)
Osteoarthritis of the knee		
Males	31,181 (16,394, 46,918)	46,357 (24,168, 69,294)
Females	36,521 (17,774, 56,702)	58,280 (30,536, 89,737)
Total	67,702 (43,391, 94,203)	104,637 (68,812, 141,633)

LOW BACK PAIN

TABLE B13

PREVALENT CASES OF LOW BACK PAIN DUE TO BEVERAGE CONSUMPTION

2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Low back pain		
Males	6,404 (3,674, 9,114)	8,332 (4,377, 12,495)
Females	6,290 (3,763, 8,984)	8,998 (5,167, 12,862)
Total	12,694 (8,935, 16,683)	17,330 (11,919, 23,118)

DEATHS

TABLE B14

AVOIDABLE DEATHS DUE TO BEVERAGE CONSUMPTION

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Avoidable deaths		
Males	23,857 (20,198, 27,592)	38,301 (32,713, 43,918)
Females	14,528 (12,265, 16,949)	25,020 (21,114, 29,097)
Total	38,385 (33,911, 43,103)	63,321 (56,160, 70,871)

DISABILITY ADJUSTED LIFE YEARS (DALYs)

TABLE B15

AVOIDABLE DALYs DUE TO BEVERAGE CONSUMPTION

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Avoidable DALYs		
Males	818,035 (715,340, 922,018)	1,211,590 (1,072,780, 1,351,773)
Females	615,450 (538,759, 694,246)	973,959 (852,313, 1,092,882)
Total	1,433,485 (1,279,138, 1,584,753)	2,185,549 (1,969,310, 2,406,124)

ECONOMIC BURDEN

TABLE B16

HEALTH CARE COSTS DUE TO BEVERAGE CONSUMPTION

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Health care costs		
Males	$20,244,635,749 ($17,651,954,111, $22,948,876,848)	$29,349,111,609 ($25,863,205,496, $32,876,956,785)
Females	$13,490,900,813 ($11,739,914,968, $15,303,263,125)	$21,308,102,034 ($18,513,450,419, $24,040,367,100)
Total	$33,735,536,562 ($30,064,710,938, $37,530,398,564)	$50,657,213,642 ($45,397,898,875, $55,736,669,189)

*2015 Canadian dollars

BODY MASS INDEX

TABLE B17

PER CAPITA DAILY CHANGE IN ENERGY INTAKE DUE TO 20% BEVERAGE TAXES

2016-2041

	SSBs Mean change (per person, per day; kcal) (95% UI)		Sugary drinks Mean change (per person; per day; kcal) (95% UI)	
Age group	**Males**	**Females**	**Males**	**Females**
20-24	-40 (-45, -35)	-23 (-27, -21)	-52 (-59, -46)	-33 (-37, -29)
25-29	-40 (-45, -35)	-23 (-26, -21)	-52 (-58, -46)	-33 (-37, -29)
30-34	-30 (-34, -26)	-18 (-21, -16)	-39 (-44, -34)	-25 (-29, -22)
35-39	-30 (-34, -26)	-18 (-21, -16)	-39 (-44, -34)	-25 (-29, -22)
40-44	-20 (-23, -17)	-13 (-15, -11)	-28 (-31, -24)	-19 (-22, -17)
45-49	-20 (-23, -17)	-13 (-15, -11)	-28 (-32, -24)	-19 (-22, -17)
50-54	-14 (-16, -12)	-9 (-11, -8)	-22 (-24, -19)	-16 (-18, -14)
55-59	-14 (-16, -12)	-9 (-11, -8)	-22 (-24, -19)	-16 (-18, -14)
60-64	-11 (-12, -9)	-8 (-9, -7)	-19 (-22, -17)	-14 (-15, -12)
65-69	-11 (-12, -9)	-8 (-9, -7)	-19 (-22, -17)	-14 (-15, -12)
70-74	-7 (-8, -6)	-7 (-8, -6)	-13 (-14, -11)	-14 (-15, -12)
75-79	-7 (-8, -6)	-7 (-8, -6)	-13 (-14, -11)	-14 (-15, -12)
80+	-6 (-7, -5)	-5 (-6, -4)	-12 (-14, -10)	-12 (-14, -11)
All ages	-21 (-23, -19)	-13 (-15, -12)	-30 (-33, -27)	-20 (-22, -18)

TABLE B18

CHANGE IN BMI DUE TO 20% BEVERAGE TAXES

2016-2041

	SSBs Mean change (kg/m^2) (95% UI)		Sugary drinks Mean change (kg/m^2) (95% UI)	
Age group	**Males**	**Females**	**Males**	**Females**
20-24	-0.56 (-0.64, -0.49)	-0.39 (-0.45, -0.34)	-0.74 (-0.84, -0.64)	-0.55 (-0.63, -0.48)
25-29	-0.56 (-0.64, -0.49)	-0.39 (-0.45, -0.34)	-0.74 (-0.84, -0.65)	-0.55 (-0.63, -0.48)
30-34	-0.42 (-0.48, -0.36)	-0.30 (-0.35, -0.26)	-0.55 (-0.64, -0.48)	-0.42 (-0.48, -0.36)
35-39	-0.42 (-0.49, -0.36)	-0.30 (-0.35, -0.26)	-0.56 (-0.64, -0.48)	-0.42 (-0.48, -0.36)
40-44	-0.28 (-0.33, -0.24)	-0.22 (-0.25, -0.19)	-0.40 (-0.46, -0.34)	-0.33 (-0.38, -0.29)
45-49	-0.28 (-0.33, -0.24)	-0.22 (-0.25, -0.18)	-0.40 (-0.46, -0.35)	-0.33 (-0.38, -0.29)
50-54	-0.20 (-0.23, -0.17)	-0.16 (-0.19, -0.14)	-0.31 (-0.35, -0.27)	-0.27 (-0.31, -0.23)
55-59	-0.20 (-0.23, -0.17)	-0.16 (-0.19, -0.14)	-0.31 (-0.36, -0.27)	-0.27 (-0.31, -0.23)
60-64	-0.16 (-0.19, -0.13)	-0.14 (-0.17, -0.12)	-0.28 (-0.33, -0.24)	-0.24 (-0.28, -0.21)
65-69	-0.16 (-0.19, -0.13)	-0.14 (-0.16, -0.12)	-0.28 (-0.33, -0.24)	-0.24 (-0.28, -0.21)
70-74	-0.10 (-0.12, -0.08)	-0.12 (-0.15, -0.10)	-0.19 (-0.22, -0.16)	-0.24 (-0.28, -0.21)
75-79	-0.10 (-0.12, -0.08)	-0.12 (-0.15, -0.10)	-0.19 (-0.22, -0.16)	-0.24 (-0.28, -0.20)
80+	-0.08 (-0.10, -0.07)	-0.09 (-0.11, -0.08)	-0.18 (-0.21, -0.15)	-0.22 (-0.25, -0.19)
All ages	-0.30 (-0.34, -0.26)	-0.22 (-0.25, -0.20)	-0.43 (-0.48, -0.38)	-0.34 (-0.39, -0.30)

TABLE B19

PREVENTED CASES OF OVERWEIGHT AND OBESITY DUE TO 20% BEVERAGE TAXES

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Overweight		
Males	45,638 (38,322, 53,719)	59,356 (49,248, 70,781)
Females	23,922 (20,721, 27,529)	37,450 (32,112, 43,485)
Total	69,560 (59,172, 80,781)	96,807 (81,441, 114,162)
Obesity		
Males	281,087 (247,238, 316,353)	404,113 (355,953, 454,700)
Females	168,645 (148,308, 190,456)	263,318 (230,935, 297,447)
Total	449,732 (395,623, 506,843)	667,431 (587,371, 751,010)

DISEASES

TYPE 2 DIABETES

TABLE B20

PREVENTED INCIDENT CASES OF TYPE 2 DIABETES DUE TO 20% BEVERAGE TAXES

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Type 2 diabetes mellitus		
Males	82,721 (63,191, 103,955)	125,482 (95,952, 157,244)
Females	55,914 (42,979, 70,316)	90,364 (70,043, 113,495)
Total	138,635 (110,130, 169,061)	215,846 (172,290, 262,006)

TABLE B21

PREVENTED PREVALENT CASES OF TYPE 2 DIABETES DUE TO 20% BEVERAGE TAXES

2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Type 2 diabetes mellitus		
Males	70,192 (53,643, 88,308)	105,142 (80,356, 131,733)
Females	48,791 (37,526, 61,271)	78,153 (60,729, 98,045)
Total	118,983 (94,506, 145,129)	183,295 (146,328, 222,477)

TABLE B22

PREVENTED INCIDENT CASES OF CANCER DUE TO 20% BEVERAGE TAXES

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Esophageal cancer		
Males	435 (80, 828)	783 (158, 1,525)
Females	114 (5, 245)	225 (8, 479)
Total	549 (199, 975)	1,008 (349, 1,779)
Colon and rectum cancer		
Males	1,507 (1,174, 1,873)	2,708 (2,111, 3,336)
Females	341 (164, 526)	664 (300, 1,044)
Total	1,848 (1,458, 2,276)	3,372 (2,689, 4,174)
Liver cancer		
Males	446 (163, 745)	780 (285, 1,322)
Females	111 (17, 223)	208 (29, 398)
Total	556 (259, 890)	988 (463, 1,571)
Gallbladder and biliary tract cancer		
Males	89 (13, 168)	166 (28, 315)
Females	219 (134, 310)	438 (274, 627)
Total	308 (191, 432)	604 (387, 843)
Pancreatic cancer		
Males	114 (24, 267)	203 (44, 467)
Females	132 (43, 224)	261 (105, 436)
Total	246 (88, 435)	465 (182, 788)
Breast cancer		
Males	--	--
Females	4,088 (1,442, 7,311)	7,494 (2,422, 13,365)
Total	4,088 (1,442, 7,311)	7,494 (2,422, 13,365)
Uterine cancer		
Males	--	--
Females	2,293 (1,925, 2,698)	4,087 (3,429, 4,809)
Total	2,293 (1,925, 2,698)	4,087 (3,429, 4,809)
Ovarian cancer		
Males	--	--
Females	60 (13, 142)	109 (23, 256)
Total	60 (13, 142)	109 (23, 256)
Kidney cancer		
Males	626 (438, 834)	1,076 (747, 1,429)
Females	437 (328, 551)	802 (609, 1,019)
Total	1,063 (819, 1,320)	1,878 (1,472, 2,317)
Thyroid cancer		
Males	267 (81, 470)	422 (130, 746)
Females	412 (283, 561)	675 (454, 916)
Total	679 (446, 928)	1,097 (727, 1,514)
Leukemia		
Males	183 (102, 274)	326 (182, 487)
Females	181 (75, 295)	349 (149, 566)
Total	364 (232, 513)	674 (421, 945)

TABLE B23

PREVENTED CANCER DEATHS DUE TO 20% BEVERAGE TAXES

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Esophageal cancer		
Males	375 (69, 713)	673 (134, 1,310)
Females	94 (4, 203)	185 (5, 393)
Total	470 (169, 837)	858 (292, 1,517)
Colon and rectum cancer		
Males	491 (381, 614)	864 (668, 1,070)
Females	90 (36, 146)	169 (61, 281)
Total	581 (453, 721)	1,032 (812, 1,287)
Liver cancer		
Males	222 (79, 373)	385 (136, 656)
Females	63 (9, 128)	116 (14, 224)
Total	285 (133, 456)	501 (233, 793)
Gallbladder and biliary tract cancer		
Males	19 (2, 36)	34 (4, 66)
Females	46 (28, 65)	87 (54, 125)
Total	65 (40, 92)	121 (76, 170)
Pancreatic cancer		
Males	79 (22, 189)	140 (40, 334)
Females	104 (33, 178)	206 (80, 345)
Total	182 (63, 325)	346 (134, 589)
Breast cancer		
Males	--	--
Females	525 (167, 954)	944 (268, 1,717)
Total	525 (167, 954)	944 (268, 1,717)
Uterine cancer		
Males	--	--
Females	263 (221, 310)	459 (386, 541)
Total	263 (221, 310)	459 (386, 541)
Ovarian cancer		
Males	--	--
Females	20 (10, 53)	35 (19, 94)
Total	20 (10, 53)	35 (19, 94)
Kidney cancer		
Males	138 (96, 186)	235 (160, 315)
Females	79 (59, 100)	146 (110, 186)
Total	217 (165, 273)	381 (293, 473)
Thyroid cancer		
Males	8 (2, 14)	12 (3, 23)
Females	17 (12, 24)	3 (2, 4)
Total	9 (3, 16)	15 (6, 26)
Leukemia		
Males	48 (23, 77)	87 (42, 137)
Females	64 (25, 107)	123 (49, 203)
Total	113 (67, 164)	210 (120, 305)

TABLE B24

PREVENTED INCIDENT CASES OF CARDIOVASCULAR DISEASE DUE TO 20% BEVERAGE TAXES

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Ischemic heart disease		
Males	23,161 (17,175, 29,358)	37,230 (27,405, 47,905)
Females	13,835 (10,083, 17,990)	24,000 (17,278, 31,206)
Total	36,996 (29,359, 44,993)	61,230 (48,054, 75,885)
Ischemic stroke		
Males	1,634 (1,151, 2,152)	2,740 (1,917, 3,652)
Females	1,185 (778, 1,640)	2,131 (1,314, 3,063)
Total	2,819 (2,130, 3,575)	4,871 (3,650, 6,232)
Hemorrhagic stroke		
Males	1,096 (685, 1,549)	1,736 (1,088, 2,518)
Females	40 (29, 52)	1,544 (913, 2,330)
Total	2,014 (1,450, 2,669)	3,281 (2,296, 4,419)

TABLE B25

PREVENTED PREVALENT CASES OF CARDIOVASCULAR DISEASE DUE TO 20% BEVERAGE TAXES

2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Ischemic heart disease		
Males	16,059 (11,807, 20,423)	25,154 (18,415, 32,533)
Females	9,888 (7,186, 12,894)	16,609 (11,981, 21,579)
Total	25,948 (20,522, 31,645)	41,764 (32,727, 51,803)
Ischemic stroke		
Males	888 (641, 1,152)	1,415 (1,033, 1,846)
Females	661 (466, 877)	1,114 (765, 1,499)
Total	1,549 (1,199, 1,930)	2,529 (1,981, 3,149)
Hemorrhagic stroke		
Males	399 (251, 562)	611 (386, 875)
Females	363 (227, 513)	585 (366, 840)
Total	762 (560, 999)	1,196 (858, 1,580)
Hypertensive heart		
Males	440 (172, 786)	735 (277, 1,299)
Females	500 (170, 901)	911 (276, 1,768)
Total	940 (504, 1,500)	1,646 (852, 2,577)

TABLE B26

PREVENTED CARDIOVASCULAR DISEASE DEATHS DUE TO 20% BEVERAGE TAXES

2016-2041

	SSBs	Sugary drinks
	Mean (95% UI)	Mean (95% UI)
Ischemic heart disease		
Males	3,056 (2,225, 3,886)	4,987 (3,609, 6,483)
Females	1,292 (911, 1,720)	2,362 (1,628, 3,161)
Total	4,348 (3,375, 5,350)	7,349 (5,636, 9,221)
Ischemic stroke		
Males	462 (304, 630)	818 (530, 1,138)
Females	344 (192, 512)	670 (341, 1,052)
Total	807 (568, 1,073)	1,488 (1,038, 1,992)
Hemorrhagic stroke		
Males	604 (381, 853)	964 (604, 1,392)
Females	496 (296, 726)	845 (493, 1,281)
Total	1,100 (791, 1,458)	1,808 (1,265, 2,435)

CHRONIC KIDNEY DISEASE

TABLE B27

PREVENTED PREVALENT CASES OF CHRONIC KIDNEY DISEASE DUE TO 20% BEVERAGE TAXES

2041

	SSBs	Sugary drinks
	Mean (95% UI)	Mean (95% UI)
Chronic kidney disease due to diabetes mellitus		
Males	6,975 (1,274, 14,649)	11,467 (2,048, 23,303)
Females	10,312 (1,866, 21,361)	17,209 (3,343, 34,938)
Total	17,287 (6,744, 31,094)	28,676 (10,743, 49,193)
Chronic kidney disease due to hypertension		
Males	3,697 (610, 7,554)	6,098 (1,116, 12,809)
Females	5,594 (939, 11,806)	9,142 (1,419, 18,936)
Total	9,291 (3,563, 16,296)	15,240 (5,658, 26,578)
Chronic kidney disease due to glomerulonephritis		
Males	5,857 (812, 12,517)	10,160 (1,771, 21,637)
Females	9,194 (1,218, 19,512)	15,506 (2,729, 31,851)
Total	15,051 (5,194, 26,959)	25,666 (9,488, 45,453)
Chronic kidney disease due to other causes		
Males	5,243 (674, 11,036)	8,500 (1,338, 17,951)
Females	7,882 (1,350, 16,931)	13,363 (1,711, 28,237)
Total	13,126 (5,110, 23,468)	21,863 (7,759, 38,667)

TABLE B28

PREVENTED CHRONIC KIDNEY DISEASE DEATHS DUE TO 20% BEVERAGE TAXES

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Chronic kidney disease due to diabetes mellitus		
Males	322 (58, 670)	567 (97, 1,143)
Females	174 (31, 354)	306 (55, 621)
Total	496 (188, 910)	873 (295, 1,493)
Chronic kidney disease due to hypertension		
Males	191 (27, 390)	342 (52, 724)
Females	145 (19, 312)	264 (26, 566)
Total	336 (125, 600)	606 (213, 1,069)
Chronic kidney disease due to glomerulonephritis		
Males	56 (7, 115)	102 (16, 212)
Females	44 (6, 93)	80 (12, 164)
Total	100 (35, 174)	182 (67, 320)
Chronic kidney disease due to other causes		
Males	5 (0, 11)	8 (0, 19)
Females	5 (0, 11)	9 (0, 21)
Total	10 (3, 18)	18 (5, 33)

OSTEOARTHRITIS

TABLE B29

PREVENTED PREVALENT CASES OF OSTEOARTHRITIS DUE TO 20% BEVERAGE TAXES

2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Osteoarthritis of the hip		
Males	877 (409, 1,412)	1,288 (521, 2,109)
Females	825 (364, 1,336)	1,314 (511, 2,131)
Total	1,703 (1,056, 2,434)	2,602 (1,506, 3,783)
Osteoarthritis of the knee		
Males	6,491 (3,352, 9,721)	9,918 (5,373, 15,017)
Females	7,387 (3,451, 11,751)	12,093 (6,065, 19,138)
Total	13,878 (8,540, 19,398)	22,012 (14,418, 30,731)

LOW BACK PAIN

TABLE B30

PREVENTED PREVALENT CASES OF LOW BACK PAIN DUE TO 20% BEVERAGE TAXES

2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Low back pain		
Males	1,309 (736, 1,896)	1,694 (869, 2,575)
Females	1,234 (711, 1,796)	1,769 (931, 2,630)
Total	2,543 (1,782, 3,359)	3,463 (2,291, 4,757)

DEATHS

TABLE B31

POSTPONED DEATHS DUE TO 20% BEVERAGE TAXES

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Postponed deaths		
Males	4,906 (3,985, 5,849)	8,020 (6,614, 9,622)
Females	2,968 (2,410, 3,579)	5,186 (4,227, 6,312)
Total	7,874 (6,639, 9,118)	13,206 (11,184, 15,456)

DISABILITY ADJUSTED LIFE YEARS (DALYs)

TABLE B32

PREVENTED DALYs DUE TO 20% BEVERAGE TAXES

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Prevented DALYs		
Males	179,155 (146,718, 210,828)	275,557 (230,375, 325,188)
Females	130,286 (108,214, 154,159)	213,222 (179,218, 250,405)
Total	309,441 (260,634, 358,948)	488,778 (415,999, 567,478)

HEALTH CARE COSTS SAVINGS

TABLE B33

HEALTH CARE COSTS SAVINGS DUE TO 20% BEVERAGE TAXES

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Health care costs savings		
Males	$4,486,719,433 ($3,680,754,718, $5,345,248,352)	$6,784,949,824 ($5,646,661,919, $8,030,510,332)
Females	$2,863,944,809 ($2,364,171,351, $3,404,478,069)	$4,671,647,171 ($3,888,174,870, $5,502,046,641)
Total	$7,350,664,242 ($6,192,984,454, $8,559,506,169)	$11,456,596,995 ($9,737,428,240, $13,344,880,964)

*2015 Canadian dollars

TAX REVENUE

TABLE B34

TAX REVENUE DUE TO 20% BEVERAGE TAXES

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Tax revenue		
Annual (2016)	$1,185,903,122 ($1,152,933,049, $1,222,583,183)	$1,744,438,002 ($1,698,682,393, $1,794,706,087)
25-year total	$29,647,578,056	$43,610,950,060

*2015 Canadian dollars

SENSITIVITY ANALYSES

TABLE B35

SENSITIVITY ANALYSES FOR 20% BEVERAGE TAXES

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
1) BMI remains at 2015 levels		
Deaths	7,423 (6,315, 8,617)	12,467 (10,598, 14,531)
DALYs	289,270 (247,690, 333,148)	456,129 (388,235, 528,376)
Health care costs savings	$6,793,382,892 ($5,759,110,222, $7,860,010,855)	$10,563,817,772 ($8,958,790,890, $12,199,040,204)
Tax revenue (annual)	$1,185,994,857 ($1,152,441,291, $1,219,706,8190)	$1,743,935,030 ($1,696,462,495, $1,790,813,322)
Tax revenue	$29,649,871,425	$43,598,375,744
2) Effect of tax on BMI capped at 10 years		
Deaths	3,865 (3,261, 4,524)	6,259 (5,337, 7,273)
DALYs	193,908 (163,784, 225,317)	303,752 (262,203, 349,691)
Health care costs savings	$4,081,455,145 ($3,441,635,656, $4,771,962,044)	$6,231,834,130 ($5,335,344,250, $7,208,300,824)
Tax revenue (annual)	$1,186,570,657 ($1,151,427,701, $1,220,163,439)	$1,743,867,675 ($1,695,822,838, $1,793,166,639)
Tax revenue	$29,664,266,425	$43,596,691,875
3) Lower boundary of own-price elasticity of demand		
Deaths	7,033 (6,176, 7,895)	11,876 (10,479, 13,390)
DALYs	276,657 (244,301, 309,903)	438,710 (388,055, 491,441)
Health care costs savings	$6,571,646,625 ($5,816,640,068, $7,402,690,831)	$10,296,504,417 ($9,041,832,670, $11,538,602,145)
Tax revenue (annual)	$1,271,117,516 ($1,200,863,213, $1,234,211,281)	$1,788,916,379 ($1,700,060,775, $1,807,288,651)
Tax revenue	$30,427,937,903	$44,722,909,487
4a) Tax pass-on 80%		
Deaths	6,539 (5,533, 7,645)	11,040 (9,325, 13,010)
DALYs	257,953 (216,572, 299,092)	408,627 (347,433, 476,135)
Health care costs savings	$6,131,162,375 ($5,167,848,511, $7,129,362,664)	$9,588,434,812 ($8,107,706,462, $11,194,242,322)
Tax revenue (annual)	$1,236,154,778 ($1,205,664,215, $1,267,481,653)	$1,816,687,367 ($1,774,855,159, $1,858,604,623)
Tax revenue	$30,903,869,450	$45,417,184,185
4b) Tax pass-on 120%		
Deaths	9,088 (7,651, 10,614)	15,279 (12,953, 17,870)
DALYs	357,700 (305,342, 416,877)	563,589 (480,949, 650,359)
Health care costs savings	$8,490,757,802 ($7,235,402,332, $9,904,274,848)	$13,205,861,326 ($11,230,729,655, $15,261,511,479)
Tax revenue (annual)	$1,140,201,986 ($1,101,842,950, $1,179,842,860)	$1,676,567,088 ($1,624,868,762, $1,730,419,654)
Tax revenue	$28,505,049,650	$41,914,177,191
5a) Pre-tax beverage price 25% lower		
Deaths	7,878 (6,634, 9,165)	13,251 (11,231, 15,657)
DALYs	309,957 (263,698, 360,673)	490,901 (416,951, 570,923)
Health care costs savings	$7,363,429,733 ($6,233,684,293, $8,614,905,847)	$11,506,856,037 ($9,764,227,778, $13,449,863,245)

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Tax revenue (annual)	$882,275,200 ($855,733,880, $907,839,252)	$$1,296,711,992 ($1,260,826,497, $1,335,389,849)
Tax revenue	$22,056,880,000	$32,417,799,796
5b) Pre-tax beverage price 25% higher		
Deaths	7,854 (6,567, 9,254)	13,303 (11,272, 15,526)
DALYs	309,139 (260,665, 358,469)	490,936 (421,243, 567,117)
Health care costs savings	$7,348,628,581 ($6,197,611,262, $8,514,403,631)	$11,512,591,689 ($9,858,899,031, $13,346,728,599)
Tax revenue (annual)	$1,485,350,865 ($1,411,011,629, $1,531,203,515)	$2,182,691,655 ($2,122,394,855, $2,243,077,405)
Tax revenue	$37,133,771,625	$54,567,291,370
6) Health gain, costs and revenue discounted by 3%		
Deaths	7,863 (6,630, 9,246)	13,223 (11,135, 15,505)
DALYs	195,272 (165,987, 226,626)	308,849 (261,516, 356,745)
Health care costs savings	$4,786,301,406 ($4,074,729,958, $5,534,701,283)	$7,488,312,743 ($6,336,202,556, $8,677,074,171)
Tax revenue (2016)*	$1,186,418,198 ($1,152,702,178, $1,221,384,906)	$1,744,716,704 ($1,697,325,840, $1,794,548,915)
Tax revenue*	$21,279,053,572	$31,292,439,942

*TAX REVENUE CALCULATED BY DISCOUNTING 2016 REVENUE AT RATE OF 3% ANNUALLY

TABLE B36

SUMMARY OF HEALTH AND ECONOMIC BENEFITS FROM 10% BEVERAGE TAXES

2016-2041

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Deaths	4,363 (3,677, 5,150)	7,343 (6,174, 8,585)
DALYs	172,854 (144,973, 203,221)	273,945 (232,425, 319,030)
Overweight & obesity	249,788 (218,547, 284,214)	417,919 (364,258, 473,380)
Type 2 diabetes	77,893 (60,779, 96,803)	121,793 (96,507, 148,866)
Ischemic heart disease	20,431 (16,240, 25,256)	34,043 (26,811, 41,940)
Cancer (total)	6,616	12,068
Esophageal	307 (101, 541)	566 (210, 966)
Colon and rectum	1,025 (802, 1,266)	1,865 (1,472, 2,308)
Liver	308 (135, 484)	544 (257, 864)
Gallbladder & biliary tract	171 (109, 240)	334 (206, 466)
Pancreas	139 (45, 242)	264 (98, 433)
Breast	2,233 (715, 3,957)	4,134 (1,353, 7,210)
Uterine	1,269 (1,058, 1,514)	2,275 (1901, 2,681)
Ovarian	34 (7, 77)	60 (13, 142)
Kidney	588 (456, 733)	1,047 (800, 1,297)
Thyroid	376 (249, 527)	609 (401, 829)
Leukemia	200 (123, 283)	371 (228, 527)
Stroke (total)	2,682	4,513
Ischemic	1,565 (1,170, 1,989)	2,697 (2,007, 3,479)
Hemorrhagic	1,117 (794, 1,506)	1,816 (1,288, 2,456)
Health care costs savings	$4,111,197,705 ($3,444,842,339, $4,852,129,437)	$6,430,291,304 ($5,420,281,955, $7,508,435,906)
Tax revenue (annual)	$658,402,430 ($645,701,512, $671,639,059)	$967,428,612 ($951,149,601, $983,274,731)
Tax revenue	$16,460,060,744	$24,185,715,306

*FOR DISEASE CONDITIONS, CASES ARE PREVENTED CASES

TABLE B37

SUMMARY OF HEALTH AND ECONOMIC BENEFITS FROM 30% BEVERAGE TAXES

2016-2041*

	SSBs Mean (95% UI)	Sugary drinks Mean (95% UI)
Deaths	10,795 (9,144, 12,530)	18,167 (15,519, 21,095)
DALYs	422,820 (360,147, 485,167)	668,129 (575,489, 767,851)
Overweight & obesity	717,938 (632,933, 805,505)	1,062,420 (940,869, 1,194,973)
Type 2 diabetes	189,308 (152,730, 229,317)	294,162 (234,878, 359,452)
Ischemic heart disease	50,603 (40,035, 62,145)	84,334 (67,860, 103,508)
Cancer (total)	16,542	30,091
Esophageal	757 (258, 1,323)	1,383 (494, 2,423)
Colon and rectum	2,550 (2,029, 3,098)	4,642 (3,700, 5,680)
Liver	765 (364, 1,222)	1,356 (630, 2,137)
Gallbladder & biliary tract	424 (262, 595)	827 (540, 1,149)
Pancreas	346 (112, 599)	650 (239, 1,102)
Breast	5,585 (1,811, 9,646)	10,454 (3467, 18,237)
Uterine	3,134 (2,662, 3,677)	5,605 (4710, 6,587)
Ovarian	82 (17, 188)	156 (31, 353)
Kidney	1,463 (1,139, 1,821)	2,587 (2,019, 3,167)
Thyroid	934 (611, 1,286)	1,500 (976, 2,023)
Leukemia	503 (310, 706)	931 (581, 1,307)
Stroke (total)	6,621	11,154
Ischemic	3,883 (2,948, 4,897)	6,677 (5,009, 8,494)
Hemorrhagic	2,738 (1,984, 3,616)	4,477 (3,158, 5,925)
Health care costs savings	$10,035,638,427 ($8,544,562,655, $11,579,303,594)	$15,652,297,745 ($13,452,374,164, $17,987,758,112)
Tax revenue (annual)	$1,616,818,201 ($1,554,867,098, $1,681,620,494)	$2,376,707,608 ($2,286,590,010, $2,469,203,801)
Tax revenue	$40,420,455,014	$59,417,690,195

*FOR DISEASE CONDITIONS, CASES ARE PREVENTED CASES

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