The Health and Financial Impacts of A Sugary Drink Tax Across Different Income Groups in Canada

by

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Abstract

Obesity remains a leading health issue and contributes to health inequality. Overconsumption of sugar-sweetened beverages (SSBs) contributes to both childhood and adult obesity, and also increases healthcare costs. Sugary drink taxes have been implemented to curb sugar intake in several countries. However, there is a concern that sugary drink taxes are regressive. This project assessed the health and financial impacts of a sugary drink tax by different income groups in Canada.

The current study extended Jones' Canadian sugary drink tax model to estimate the impact of a sugary drink tax on health and financial inequality. Sugary drinks consist of all types of beverages containing free sugar, including 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, flavoured milk, sugar-sweetened drinkable yogurt, and 100% juice. Income-specific parameters include: population demographics, cross- and own-price elasticities, mean BMI, sugary drink consumption, mortalities, and disease epidemiology.

Our result show that, overall, a 20% sugary drink tax was estimated to reduce the consumption of sugary drinks by an average of approximately 15%, with the lowest income quintile having a slightly greater reduction than other income quintiles.

The estimated mean reduction in BMI ranged from 0.21 to 0.33 depending on sex and income quintile. These reductions were greater among the lower income quintiles for both females and males, and lessened as income increased.

The 20% sugary drink tax was estimated to avert approximately 690,000 DALYs over a lifetime period among the 2016 Canadian adult population. The lowest income quintile had the most estimated DALYs averted per person.

Lifetime health care savings were estimated to be $2.27, $2.16, $2.17, $2.12, and $1.98 billion for quintile 1 to quintile 5, respectively. The lowest income quintile had the greatest estimated health care savings per person.

The estimated annual tax burden for the whole 2016 Canadian population (including children) was $1.4 billion. The average tax burden was estimated to be $39.00 to $44.30 per person, with the middle-income quintile bearing the heaviest burden. The lowest income quintile would pay the highest proportion of after-tax income in tax. A 20% sugary drink tax is regressive, but the estimated difference in annual tax burden was less than $6 per person.

In conclusion, the model predicts that low-income Canadians would gain the most health from a sugary drinks tax. While this income group would pay the largest proportion of their incomes in tax, the difference between income groups is small. If this regressivity is a concern, then policy makers may wish to consider investing the revenue raised from sugary drinks taxes in policies that address health or income inequalities.

Preface

The research is a contract project with the Heart and Stroke Foundation with professor Dr. Paulden being the principal investigator. The model was developed based on Dr. Jones' Canadian Sugary Drink Tax Model. This thesis is my original work, with assistance from Dr. Paulden, Dr. Jones, and Dr. Ohinmaa.

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Chapter 1. Background

Income-related health inequalities are growing worldwide. In Canada, the life expectancy of people in the lowest income quintile is two years shorter for females and five years shorter for males when compared to life expectancies for people in the highest income quintile (1). Health inequalities are also reflected in disease incidence. For example, Canadians in the lowest income quintile have approximately double the risk of having diabetes compared to those in the highest income quintile (2). The risk of hospitalized heart attack is approximately 1.3 times higher for those in the lowest income quintile compared to the highest income quintile (3). Furthermore, the Canadian Institute for Health Information (CIHI) has found that, in the past decade, health inequalities have worsened (4). The World Health Organization (WHO)'s Global Action Plan for the Prevention and Control of Noncommunicable Diseases 2013-2020 emphasized an equity-based approach and concern for the social determinants of health (5).

Health outcome is a result of a complex combination and interaction of many determinants, including personal, social, economic and environmental factors (6). It includes income and social status, employment and working conditions, education and literacy, childhood experiences, physical environments, social supports and coping skills, healthy behaviours, access to health services, biology and genetic endowment, gender, culture, and race (6). The relationship between different factors is complicated. Income, for example, is linked to education level and access to health services. Income inequality in Canada has also increased over the past 20 years (7). Policy makers need to consider the potential impact on health and financial inequalities when developing new policies or programs.

Obesity remains a leading health issue in Canada. Prevalence of obesity among the Canadian adult population ranks 7th among all the OECD countries. It is 6.3% higher than the OECD average and is predicted to continue to increase in the next decade (8). Obesity is a risk factor for numerous diseases, including ischemic heart disease, ischemic stroke, hemorrhagic stroke, hypertensive heart disease, type 2 diabetes mellitus, chronic kidney disease, esophageal cancer, colon and rectum cancer, liver cancer, gallbladder and biliary tract cancer, pancreatic cancer, breast cancer, uterine cancer, ovarian cancer, kidney cancer, thyroid cancer, leukemia, osteoarthritis, and low back pain (9). In Canada, the annual economic burden related to overweight and obesity is estimated to be $23.3 billion. It is 25 percent higher than that of smoking (10). The prevalence of obesity differs by income, sex and education, contributing to obesity-related inequalities. For the 2010-2013 Canadian population, obesity prevalence among the lowest income quintile was 1.2 times the prevalence of obesity among the highest income quintile (11). The inequality was more obvious among females (11). Obesity-related inequalities by education level are more pronounced than that by income (11).

Obesity results from a complex combination of determinants and contributing factors. Physical activity, sedentary behaviours and screen time, diet, and socioeconomic status are linked to the rising prevalence of obesity in Canada (12). Overconsumption of sugar-sweetened beverages (SSBs) is an important risk factor (13) that contributes to both childhood and adult obesity (14-16). SSBs have low satiety compared to solid foods. Many studies have shown that people do not reduce their consumption of solid food when their consumption of SSBs increases and, as a result, their total energy intake increases (14).

Sugar-sweetened beverages are defined as beverages containing added sugars, and include soft drinks, sports drinks, energy drinks, fruit drinks, and flavoured milk, but not 100% juice (17). Sugary drinks are defined as beverages with free sugars, including added sugar or sugar naturally existing in honey, fruit juice or fruit juice concentrate. The difference between SSBs and sugary drinks is that sugary drinks include 100% juice but SSBs do not (17). While it might be argued that 100% juice provides nutrition benefits such as vitamins, 100% juice nevertheless contains much free sugar and is metabolized in the same way as added sugar in SSBs, contributing to the obesity crisis (18). In 2019 Canada’s Food Guide, 100% juice is no longer a recommended source of fruits and it is recommended to replace sugary drinks with water (19).

Although consumption of sugary drinks has declined from 2004 to 2015, it remains the leading source of sugar for Canadians (20, 21). Canadians have been estimated to consume an average of 74 ml of 100% juice and 204 ml of SSBs every day, based on 2015 national data (20). This equates to 132 kcal, approximately 7% of a 2,000 calorie reference diet (22). This consumption of sugary drinks alone, without taking free sugar consumed from other food into account, exceeds WHO’s conditional recommendation that the consumption of free sugar should be limited to 5% of total energy intake (18). SSBs are estimated to account for direct health care costs of $383 million per year for Canadians (23).

To meet the goal of reducing sugar intake and the prevalence of obesity, the WHO recommends that the price of SSBs should be increased by at least 20% (17). Well-recognized health organizations in Canada have endorsed taxes on SSBs, including the Heart & Stroke Foundation, Dietitians of Canada, Canadian Diabetes Association, Childhood Obesity

Foundation, Chronic Disease Prevention Alliance of Canada (24). Taxes on SSBs have been implemented in at least 36 countries, including the UK, Ireland, Mexico, France, Hungary, Norway, and some US jurisdictions, such as Berkeley (California), Philadelphia (Pennsylvania), Seattle (Washington), and San Francisco (California) (25). Most of these countries exclude 100% juice and dairy products from such taxes, while some jurisdictions include beverages containing artificial sweeteners (26-28). A recent meta-analysis of studies that evaluated these real-world SSB taxes found that SSB taxes successfully reduced sales or consumption of SSBs equivalent to a rate of a 10% reduction in SSB volume for a 10% SSB tax (29).

While SSB taxes have shown positive outcomes and have been supported by many health organizations, the beverage industry has been strongly opposed to such taxes and has used various tactics to block them (30). In 2016 to 2017, the beverage industry spent $48.9 million on legislative lobbying and ballot campaigns in the U.S. to fight against SSB taxes while ‘public health’ (e.g. non-profit health organizations) spent only $27.6 million (31). One of the arguments made by the beverage industry in opposition to SSB taxes is that they are “regressive” and inequitable (32). That is, low-income consumers will be paying a larger percentage of their income towards the SSB tax than high-income consumers.

A recent systematic review (29) of real-world SSB tax evaluations identified eight studies, across four jurisdictions, that examined the impact of the tax on different socioeconomic groups: Mexico (n=4) (33-36), Chile (n=2) (37, 38), USA (n=1) (39), and Catalonia, Spain (n=1) (40). Of these, two studies from Mexico showed a significantly greater reduction in beverage consumption among lower-income households (33, 34). By contrast, one study from Chile showed a significantly greater reduction in beverage consumption among high-income groups (38). The other studies showed no or unclear statistical significance, including a Mexican study and the Spanish study that found a similar consumption decline across all income groups (36, 40), a Mexican study and the US study that showed a larger consumption decline in the low-income groups (35, 39), and a Chile study that showed a larger consumption decline in the high-income group. None of these studies examined financial regressivity.

Another systematic review identified seven SSB tax modelling studies that reported the change in energy intake reduction and/or beverage purchase by income group within the USA, UK, Ireland, and Australia (41). For these seven studies, two reported greater effect sizes for lower-income groups, and five reported similar effect sizes across all the income groups (41). Five studies reported financial regressivity, and all of these reported that the tax would be financially regressive (41). However, even though the tax was predicted to be regressive, the difference between the amount paid by low-income and high-income households was no more than US$5 per year according to these five studies (41).

Two modelling studies from the USA and the UK reported heart disease deaths prevented or postponed by socioeconomic group, in addition to weight change (42, 43). Both of them showed greater numbers of deaths prevented or postponed among the lower socioeconomic groups (42, 43). Three economic modelling studies reported disability- or quality-adjusted life years (DALYs or QALYs), and health care costs for different socioeconomic groups. The study from the UK developed microsimulation model (44), and the Australian and Indonesian studies adopted a life table approach (45, 46). Results from the UK and the Australian studies showed greater health benefits for the lower socioeconomic groups, while the Indonesian study showed greater health benefit for the higher socioeconomic groups (44-46). This is possibly because Indonesia is a developing country where SSB consumption is more concentrated among higher income groups. In terms of financial regressivity, an SSB tax was predicted to be regressive in the Australian context but progressive in the Indonesian context (45, 46).

It appears that the equity impact of an SSB tax would highly depend on the context. In Canada, an experimental study and an economic modelling study investigated the potential impact of SSB taxes (20, 47). However, the potential impact of a sugary drink tax on different income groups in a Canadian context remains unclear.

This purpose of the present study is to address this gap in the literature. Specifically, this study aimed to:

1. Predict the distribution of the financial impact of a simulated sugary drink tax by income group among Canadian adults, and assess whether such a tax is regressive.
2. Estimate the health impacts of a simulated sugary drink tax on different income groups among Canadian adults and the impact on health inequality.

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Chapter 2. Health and Financial Impacts of a Sugary Drink Tax across Different Income Groups in Canada

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2.1 BACKGROUND

Obesity remains a leading health issue for countries around the world. It is a risk factor for numerous chronic diseases, including heart disease, strokes, cancers, and type 2 diabetes. In Canada, the economic burden related to overweight and obesity is estimated to be 25 percent higher than that of smoking (10). The prevalence of obesity differs by income and sex, contributing to obesity-related inequalities. For the 2010-2013 Canadian population, obesity prevalence among the lowest income quintile was 1.2 times the prevalence of obesity among the highest income quintile (11). The inequality was more obvious among females (11). For diabetes, health inequalities are even more pronounced: Canadians in the lowest income quintile have approximately double the risk of having diabetes compared to those in the highest income quintile (2).

Nutrition and diet play a major role in obesity and related preventable diseases. Overconsumption of sugar-sweetened beverages (SSBs) contributes to both childhood and adult obesity (14), and has resulted in estimated direct health care costs of $383 million per year for Canadians (23). SSBs are defined as beverages containing added sugars, and include soft drinks, sports drinks, energy drinks, fruit drinks, and flavoured milk, but not 100% juice (17). Sugary drinks are defined as beverages with free sugars including added sugar or sugar naturally existed in honey, fruit juice or fruit juice concentrate. Sugary drinks include SSBs and 100% juice (17).

To help curb sugar intake and the obesity crisis, taxes on SSBs have been implemented in at least 36 countries, including the UK, Ireland, Mexico, France, Hungary, Norway, and some US jurisdictions, such as Berkeley (California), Philadelphia (Pennsylvania), Seattle (Washington), and San Francisco (California) (25). Most of the countries exclude 100% juice and dairy products, and some jurisdictions include beverages containing artificial sweeteners (26-28). A recent meta-analysis of studies that evaluated these real-world SSB taxes found that SSB taxes successfully reduced sales or consumption of SSBs equivalent to a rate of a 10% reduction in SSB volume for a 10% SSB tax (29).

Critics of SSB taxes argue that such a tax is "regressive". That is, low-income consumers will be paying a larger percentage of their income towards the SSB tax than high-income consumers. A systematic review identified five modelling studies that examined SSB taxes by income group; each study reported that a SSB tax would be financially regressive (41). However, even though the tax was predicted to be regressive, the difference between the amount paid by low-income and high-income households was no more than US$5 per year (41). While income differences contribute to possible regressivity, few differences have been observed in sugary drink consumption by income (48-52).

Other than the concern about financial regressivity, it is also critical to evaluate whether a potential SSB tax would increase or decrease health inequalities. Health inequalities are growing worldwide. In Canada, the life expectancy of people in the lowest income quintile is two years shorter for females and five years shorter for males when compared to life expectancies for people in the highest income quintile (1). Thus, it is important for the policy makers to consider the potential impact on health inequalities when developing new policies or programs.

2.2 OBJECTIVES

The potential impact of a sugary drink tax on different income groups in a Canadian context is currently unclear. This study aimed to:

1. Predict the distribution of the financial impact of a simulated sugary drink tax by income group among Canadian adults and assess whether such a tax is regressive.
2. Estimate the health impacts of a simulated sugary drink tax on different income groups among Canadian adults and the impact on health inequality.

2.3 METHODS

The study used simulation modelling to predict health and financial impacts across five income quintiles in the 2016 Canadian adult population. Concentration indices were used to evaluate the health equality impact under different model assumptions and in various policy scenarios. The study used literature data and datasets accessed through the Research Data Centre (RDC). Ethics approval was not required to access these data sources.

2.3.1 INTERVENTION

A 20% *ad valorem* excise tax on sugary drinks was modelled in the base case analysis. Excise tax is paid by manufacturers, distributors, or retailers and may be passed on to consumers. An excise tax was chosen because the price increase shows on the price tag, in comparison to a sales tax which is a tax on consumers and, in Canada, is applied at the point of purchase. Thus, an excise tax has a greater impact on consumer purchasing behaviour (53). *Ad valorem* tax is based on the value of the product and so can better reflect inflation over time compared to a volumetric tax (53). A 20% tax rate was chosen based on World Health Organization (WHO)'s recommendation that the price of SSBs needs to be increased by at least 20% to create a meaningful health effect (17). Tax rates of 10% and 30% were modelled in sensitivity analyses.

The model assumed an average pre-tax price of $2.52 per litre. This was based on previous modelling by Jones et al. (54), inflated to 2016 dollars using the Statistics Canada Consumer Price Index for 'Other food products and non-alcoholic beverages' (55).

In the base case analysis, the pass-on rate was assumed to be 100%. This means that the post-tax price is assumed to increase by exactly the amount of the tax. Note that a pass-on rate below 100% would imply that manufacturers, distributors, or retailers absorb some of the cost of the tax, while a pass-on rate above 100% would imply that the price is increased by more than the amount of the tax. Sensitivity analyses modelled pass-on rates from observational data of the Berkeley and Seattle SSB taxes (56, 57). The Seattle City Auditor found a pass-on rate of 101% (95% CI: 89%, 112%) six months after implementation of an SSB tax in Seattle (56). Meanwhile, Falbe et al. assessed the price change three months after implementation of an SSB tax in Berkeley, and found a pass-on rate of 47% (95% CI: 25%, 69%) (57).

Taxed beverages were sugary drinks, which consist of all types of beverages containing free sugar, including 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, flavoured milk, sugar-sweetened drinkable yogurt, and 100% juice. The definition is consistent with Jones et al. (54) and WHO's definition of sugary drinks (58). In our study, 100% juice was included following the 2019 Canada's Food Guide, which excludes juice as a recommended source of fruits and recommends replacing sugary drinks with water (19).

2.3.2 MODEL STRUCTURE

MODEL OVERVIEW

The model used in the current study was based on Jones et al.'s 'Canadian Sugary Drinks Tax' model (54). We extended this to consider the impact of the sugary drink taxes on the Canadian population, stratified across five income quintiles.

Jones' model was based on Vos et al.'s 'Assessing Cost-Effectiveness' (ACE) model (59). This is a multi-state, multiple cohort life table model used to evaluate the cost-effectiveness of interventions for preventing non-communicable diseases such as obesity (60-62).

The general methods of the model used in the current study are summarized in Table 2.1.

Table 2.1 Summary of general methods of the model

Type of Analysis	Evaluation of the impacts on health and finance
Type of Model	A multi-state, multiple cohort life table model built in Microsoft Excel with two add-ins: EpiGear XL and Ersatz (Version 1.3)
Population Modelled	2016 Canadian population was divided by five income quintiles depending on the rank of household income adjusted by Low-Income Cut-Offs (LICO)
Intervention	*Ad valorem* excise taxes on sugary drinks
Comparator	"Business as usual" scenario
Outcomes (Age 20 and above)	• Changes in beverage consumption, energy intake, and BMI • Changes in relative risks, incidence, and prevalence of 19 obesity-related diseases • Disability-adjusted life years (DALYs) averted
Costs	• Health care costs from a healthcare system perspective (age 20 and above) • Tax burden (all ages)
Monetary Unit of Measurement	Canadian dollars (CAD)
Base Year	2016
Time Horizon	Lifetime
Discount Rate	1.5%

CONSUMER BEHAVIOUR

As in Jones' study (20), the model simulates consumer behavior through 'price elasticities'. Price elasticities reflect the change in the demand for a product in relation to its price change. After the implementation of a sugary drinks tax, the retail price of sugary drinks generally increases. Consumers reduce their consumption of sugary drinks according to the own-price elasticities of demand and baseline consumption of sugary drinks. Price change in sugary drinks might also affect consumers' consumption of other beverages.

To model potential substitution or complementarity, cross-price elasticities of demand for plain milk and diet beverages were used. The mean reduction in net energy intake was calculated based on the change in mean beverage consumption by sex and age group, as well as sex- and age-specific mean beverage energy densities that reflected the type of beverages consumed within each group. The model assumed that there was a one-time reduction in energy intake and that the reduced beverage intake was maintained over time. In the current study, each income quintile had different mean baseline beverage consumption and mean beverage energy density. Price elasticities used in this study were also different for each income quintile as each quintile reacts to the price increase differently.

WEIGHT CHANGE

Following Jones' study (20), a constant reduction in daily energy intake was translated to a weight loss and reduction in BMI through Swinburn's energy equation for adults (63, 64). This equation specifies that a constant reduction of 94 kJ of daily energy intake for 10 years is required for a 1 kg weight loss for adults. According to Hall et al.'s study (65), 50% of the maximum weight loss happens during the first year and 95% of the maximum weight loss happens within the first three years. However, to simplify the model structure, weight loss was assumed to happen during the first year in Jones' model and in our model.

EFFECT OF RISK FACTOR EXPOSURE

As with Jones' study (20), the model used two physiological mechanisms to link the reduction in consumption of sugary drinks to health gains (e.g. disability-adjusted life years [DALYs] averted).

The first was a BMI-mediated effect. BMI is a risk factor for obesity-related diseases. The model used relative risks reported by the GBD 2015 Risk Factors Collaborators, which were based on international data (9). It assumed that relative risks were uniform across countries. Modelled

BMI-related diseases included 11 cancers, 4 cardiovascular conditions, chronic kidney disease (CKD), osteoarthritis, and low back pain. The relative risk for each obesity-related disease were reported elsewhere [Appendix B, Table 2 in PhD dissertation by Jones (20)].

The second physiological mechanism was a direct non-BMI-mediated effect. A reduction in sugary drink consumption directly reduced the incidence of type 2 diabetes. The model used a relative risk from Imamura et al.'s meta-analysis, which concluded that the incidence of type 2 diabetes increased by 18% (95% CI: 8.8%, 28%) per serving (250 ml/day) (66). Changes in BMI and consumption of sugary drinks led to changes in the incidence of modelled diseases and further changes in prevalence, case-fatality, life expectancy, DALYs and health care costs. Due to data limitations, the model only simulated health outcomes in the Canadian adult population age 20 and over. A complete list of modelled diseases is presented in Table 3.2.

Table 2.2 Modelled diseases

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
CKD due to diabetes mellitus
CKD due to hypertension
CKD due to glomerulonephritis
CKD due to other causes
Osteoarthritis - hip
Osteoarthritis - knee
Low back pain

LIFE TABLE ANALYSIS

In each income quintile-specific model, there was one life table and 23 disease-specific structures. The life table was populated with a cohort that replicated the 2016 Canadian adult population, aging over time without newborns adding to the model. The population was disaggregated by sex, 5-year age groups, and income quintiles.

The life table integrates all-cause mortality rates and the prevalent years lived with disability (pYLDs) by sex and age. 'Mortality rate from all other causes' was calculated by subtracting the sum of disease-specific, pre-intervention mortality rates from the all-cause mortality rate (67). Within the model, disease-specific post-intervention mortality rates generated from each disease-specific structure were used to update the 'mortality from all other causes' and result in post-intervention all-cause mortality rates. In the same way, pYLDs for all other causes were updated on the sum of revised disease-specific pYLDs and result in post-intervention pYLDs. Disease-specific pYLDs were disability weights of the disease multiplied by disease prevalence.

Changes in all-cause mortality rates and pYLDs led to changes in disability-adjusted life expectancy, allowing 'DALYs averted' to be calculated. Figure 2.1 illustrates this process (68).

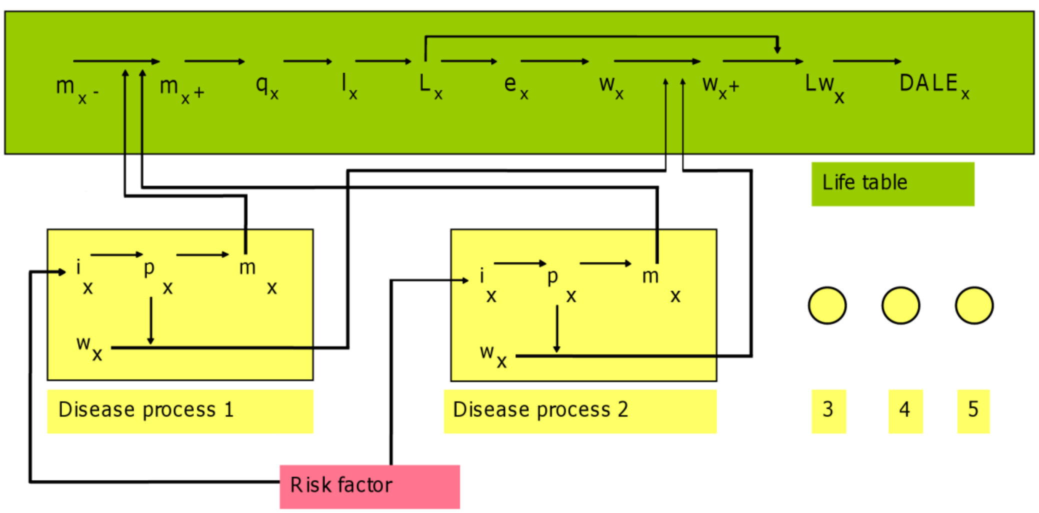


Figure 2.1 'Schematic of a proportional, multi-state life table showing the interaction between disease parameters and life table parameters' (68)

In this figure: x is age; i is incidence; p is prevalence; m is mortality; w is pYLD; q is probability of dying; l is number of survivors; L is life years; Lw is disability-adjusted life years; e is life expectancy 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).' (68)

Each disease-specific structure integrated incidence, prevalence, case-fatality, remission, and mortality rate from all other causes. As the risk factors change (e.g., BMI and sugary drinks consumption), the incidence was assumed to change. Post-intervention incidence was calculated using Potential Impact Fractions (PIFs). According to Barendregt et al. (69, 70), 'the potential impact fraction (PIF) is an epidemiological measure of effect that calculates the proportional change in average disease incidence (or prevalence or mortality) after a change in the exposure of a related risk factor.' The PIFs were calculated using a Microsoft Excel Add-in called EpiGearXL 5.0 from EpiGear.com (Brisbane, Australia).

Post-intervention disease-specific mortality rates were then calculated using post-intervention incidence, remission, case-fatality, and mortality rate from all other causes. In addition to being used to update the life table, disease-specific structures were also used to report disease outcomes including health care costs, incidence, and prevalence.

TAX BURDEN

The annual tax burden was calculated by multiplying the sugary drinks consumption a year after the implementation of the tax by a unit price of $2.52 per litre, and then multiplying this by the modelled tax rate. The tax burden was calculated based on the whole 2016 Canadian population, including children and adults, and is reported by income quintile in 2016 CAD (55).

2.3.3 INPUT PARAMETERS

POPULATION

The model replicated the 2016 Canadian population through the inclusion of three parameters: population size, mortality rate, and pYLD for all causes. The model's population size, demographics, and income were obtained from the 2016 Census data (71). Mortality rates were based on the rates used in Jones' study and adjusted to be income-specific using data from Canadian Census Health and Environment Cohort (CanCHEC) 2001 (72). The rate of 'all-cause' pYLD by sex and 5-year age group was from the GBD Results Tool (73), as in Jones' study, and was not income-specific (54).

The 2016 Census data was accessed through Statistics Canada Public Use Microdata Files (PUMF). Through analysis, the population was divided into income quintiles, which consisted of sex and 5-year age groups. Income quintiles were obtained from aggregating the variable 'EFDECILE' (national economic family after-tax income decile for all persons) to quintiles.

‘EFDECILE’ was calculated by Statistics Canada based on the adjusted ratio of respondent’s after-tax family income to the square root of the respondent’s household size and included only private households (71).

The income quintile-specific all-cause mortality rates were adjusted versions of the rates used in Jones’ study (54). Sex, age, and income quintile-specific adjustment mortality rate ratios were calculated from CanCHEC 2001 (72). CanCHEC 2001 is a cohort that was sampled to represent the Canadian population and it consists of data from the 2001 Census of Population and is linked to Canadian Mortality Database and Canadian Cancer Registry. Sex, age, and income quintile-specific mortality rate and mortality rate for each sex, age group were calculated. The adjustment ratios were then calculated by dividing each income quintile-specific mortality rate by the overall mortality rate for the sex, age subgroup. These adjustment ratios were applied to the rates used in Jones’ study to get adjusted mortality rates by sex, 5-year age group, and income quintile. For age 15 and below, it was assumed that the mortality rates were uniform across the income quintiles due to data limitations. Variable ‘D_ LICORatio _QN’ was used to divide the CanCHEC 2001 cohort into five income quintiles. It was generated by Statistics Canada by sorting the cohort according to the low income cut-off (LICO) ratios and dividing the cohort into five equal quintiles (72). LICO ratios were calculated by dividing household incomes by Statistics Canada LICO for the applicable family size and community size group (74). The income used was from the 2001 Census, and it was assumed that respondents’ income quintile would not change during the follow-up time (72).

PRICE ELASTICITIES OF DEMAND

Suitable price elasticities of demand were sourced through a focused literature search. The aim was to obtain own-price and cross-price elasticities for SSBs specific to three or more income groups and that would be reasonably applicable to the Canadian context. For own-price elasticities, the most suitable options were a UK study, an Australian study, and a Canadian thesis by Lundy that reported price elasticities by three income groups (75-77). The own-price elasticities of SSB from Lundy’s thesis were chosen because they fit the Canadian context well, although it should be noted that these data were collected in 2001. The definition of SSBs in Lundy’s study consisted of food drink powders, fruit drinks, and carbonated beverages.
The main difference between Lundy’s definition of SSBs and definition of sugary drinks used in the current study is that Lundy’s definition did not include sugar-sweetened coffee and tea, flavoured milk, sugar-sweetened drinkable yogurt, and 100% juice. For the cross-price

elasticities, the most suitable data were those of SSBs with diet soft drinks and milk from an Australian study by Sharma et al. (75).

Additional steps were required to prepare the own- and cross-price elasticities for modelling. For cross-price elasticities of milk, the Australian Sharma study reported separate elasticities for high-fat milk and low-fat milk. These beverage categories were combined by weighting the elasticities according to the volume consumed by the examined Australian population. Both Lundy and Sharma et al. reported elasticities for three income populations, whereas the current model examines five income populations. To address this, the elasticities were extrapolated and interpolated to get elasticities for 5 quintiles. Both studies used different definitions of low/middle/high-income group and the size of each income group was not equal. The proportion of each income group in each study was identified and used for interpolation and extrapolation. Linearity between the 0^{th} and 100^{th} income percentile was assumed.

The modelled own- and cross-price elasticities are reported in Table 2.3. Two cross-price elasticities were modelled: milk and diet beverages. Sensitivity analysis tested a pooled own-price elasticity, based on a meta-analysis that assumed no difference in elasticity across income quintiles (78).

Table 2.3 Own- and cross-price elasticities of demand by income quintile

	Sugary Drinks	Milk	Diet beverages
Quintile 1 (Mean ± SD)	-0.9178±0.0551	0.0227±0.0071	-0.0695±0.0377
Quintile 2 (Mean ± SD)	-0.8946±0.0537	0.0513±0.0160	0.2165±0.1174
Quintile 3 (Mean ± SD)	-0.8715±0.0524	0.0799±0.0249	0.5025±0.2724
Quintile 4 (Mean ± SD)	-0.8763±0.0526	0.0584±0.0182	0.3173±0.1720
Quintile 5 (Mean ± SD)	-0.8919±0.0536	0.0368±0.0115	0.1320±0.0716

BEVERAGE CONSUMPTION

The mean consumption (volume and energy density) of sugary drinks, plain milk, and diet beverages by sex and 10-year age groups were obtained from Jones' study (54), which included analyses of the 2015 'Canadian Community Health Survey (CCHS) – Nutrition' (79).

To obtain the mean beverage consumption by sex, age, and income quintile, it was first assumed that any trend of the mean beverage consumption across income quintiles was consistent across all sex and age groups. Scalars of the mean beverage volumes by income quintile were generated from existing analysis of income-specific beverage consumption based on data from the 2015 ‘CCHS–Nutrition’. The methods for this income-specific analysis are previously reported (20). The scalars were then applied to the mean beverage volumes by sex and 10-year age groups to obtain estimates of mean beverage volumes by sex, age, and income quintile.

The formula used for the scalars was:

$$S_{gai} = \frac{C_i}{\sum_{i=1}^{5}(C_i \times W_{gai})} \qquad [1]$$

where g=sex (male or female); a=age group index (5-year age groups); i=quintile (1-5); S_{gai}=scalar for sex g, age group a, quintile i; C_i=national average beverage consumption for quintile i; W_{gai}=percentage of quintile i in sex g, age group a group.

The mean energy densities (kilojoules per litre) by sex, age and income quintile were calculated in a similar way. Due to data limitations, mean beverage consumption for the population under age 20 was assumed to be uniform across income quintiles. To calculate the standard errors of mean beverage consumption and energy density for each sex, age and quintile group, it was assumed that the relative standard errors by income quintiles were the same in each age and sex group. The resulting beverage volumes and energy density are reported in Appendix Tables A.1 to A.4.

Two one-way sensitivity analyses related to beverage consumption were conducted. The first assumed that beverage consumption did not differ by income quintiles, using data from Jones’ study (54). In the second analysis, the effect of any secular trends in per person beverage volume was examined. A year-to-year trend in beverage volume was calculated from 17 years of sugary drink sales data (1999 to 2015) obtained from a proprietary source called GlobalData. The methods for calculating yearly sugary drink sales volume are detailed elsewhere (80).
A polynominal trend line was fitted to per person per day beverage volume in litres, with year as a variable, which showed a trend of declining beverage sales volume. The resulting coefficients were incorporated into the simulation model and the trend was applied for a 10-year period.

BODY WEIGHT

Population estimates of BMI were calculated using CCHS 2013/14 PUMF data. CCHS is a national cross-sectional survey that is collected annually. It is designed to represent the Canadian population age 12 and above, living in the ten provinces and the three territories, excluding persons living on reserves and other Aboriginal settlements in the provinces, full-time members of the Canadian Forces, the institutionalized population, and persons living in the Quebec health regions of Région du Nunavik and Région des Terres-Cries-de-la-Baie-James. CCHS 2013/14 PUMF contains two years of data (81). A total of 119,099 respondents (after excluding persons under 20, pregnant, or without stated BMI) were included in the analysis.

Mean BMI and the standard deviation were calculated for each sex, 5-year age group, and income quintile group for the Canadian adult population. Variable INCDRCA ('distribution of household income – national level') was used to generate income quintiles. INCDRCA reports income deciles based on respondents' ratio of the total household income to the LICO ratio. Standard deviation was used to model the uncertainty for prevalence of overweight and obesity. BMI was deterministic in the other parts of the model. Outcomes including disease reduction, DALYs averted, health care cost savings, and tax burden did not consider the uncertainty of BMI.

Since weight and height from CCHS 2013/14 were self-reported and prone to bias, BMI was adjusted using Shields et al.'s correction equation for adults (82). Proportional survey weights were applied to reflect the entire Canadian adult population. A detailed description of the proportional survey weight method can be found in Jones' study (54).

To adjust for the difference between data year 2013/14 and model base year 2016, predicted BMI trends for each sex and each 5-year age group were applied. The trend was generated from CCHS 2001-2010 by Lau et al. (83). Following Jones' study (54), the trend was applied for 25 years into the future from the model base year to account for the current secular trend in BMI.

DISEASE EPIDEMIOLOGY

In each disease structure, age- and sex-specific incidence, prevalence, case fatality, remission, and disability weight were used. Remission was assumed to be zero in the model for simplicity. For esophageal cancer, liver cancer, gallbladder and biliary tract cancer, pancreatic cancer, breast cancer, uterine cancer, ovarian cancer, kidney cancer, thyroid cancer, leukemia, osteoarthritis, and low back pain, data from Jones' study (20) were used and were assumed to be the same for all income quintiles. In Jones' study, data were obtained from various sources including the Canadian Chronic Disease Surveillance System (84), CANSIM tables (85-90), and GBD Results Tool (91). Dismod II (version 1.04) from EpiGear.com was used to generate an epidemiologically- and mathematically-coherent set of parameters for each disease.

Among 19 modelled diseases, the seven diseases associated with the highest SSB-related health care costs were chosen for income-specific analysis: colon and rectum cancer, ischemic heart disease, ischemic stroke, hemorrhagic stroke, hypertensive heart disease, type 2 diabetes mellitus, and chronic kidney disease. For disease epidemiology data for these conditions, income quintile-specific adjustment ratios were generated using data from CCHS 2017 (92), Canadian Health Measures Survey (CHMS) cycles 3 and 4 (93), and CanCHEC 2001 (72). These ratios were calculated by dividing the disease rate of an income quintile by the disease rate of the disease's population average. The adjustment ratios were applied to sex- and age-specific population average disease rates from Jones' study (20) to produce income quintile-specific disease rates that were also sex- and age-specific. Where Canadian data were not available, literature from other jurisdictions were used. Results were smoothed using Dismod.

A detailed description of data sources for each disease can be found in Appendix Table A.5. Briefly, CCHS is a national survey that collects information on health status, health care use and determinants of health annually. Self-reported type 2 diabetes, heart diseases, and stroke were used to generate prevalence rate ratios by income quintiles. It should be noted that the survey questions did not distinguish different types of strokes or heart diseases. Thus, it was assumed that the adjustment ratios were the same for ischemic and hemorrhagic strokes, and also the same for ischemic heart disease and hypertensive heart diseases. CHMS was used to estimate adjustment ratios of prevalence of chronic kidney disease. CHMS is a national survey that collects both lifestyle information through interview and direct physical measurements.

Serum creatinine data from CHMS was used to estimate glomerular filtration rate (eGFR) according to an equation from Levey et al.'s study (94). CKD case in the current study was defined as eGFR smaller than 60 ml/min per 1.73 m^2. CanCHEC 2001 is a large population cohort that links census, Canadian Mortality Database, and Canadian Cancer Registry data together. It was used to generate disease-specific mortalities rate ratios and colon and rectum cancer incidence rate ratios by income quintiles. GBD ICD-10 codes for causes of death were used. Point estimates and 95% confidence intervals for the incidence rate ratios were calculated using STATA. All data were accessed through the Alberta Research Data Centre.

Canada-specific disability weights for diseases were used in each disease-specific structure. The disability weights were obtained from Jones' study and are specific to each age and sex group. As detailed in Jones et al. (20), using 2015 GBD data (95) and DisMod output for each disease, the total number of years lived with disability was divided by the number of prevalent cases and then adjusted using the all other causes pYLD to fix artificially low weights for older ages. For a small number of weights, final adjustments leveled incongruent peaks.

HEALTH CARE COSTS

Health care costs were derived from those used within Jones' study (20). The only modification was to inflate the costs to 2016 dollars using the Statistics Canada Consumer Price Index 'health care' sub-index (96). Costs increased by 1.30% from 2015 to 2016 (Appendix Table A.6).

These health care costs included direct health care costs. They did not account for indirect costs such as productivity loss. For cancers, the cost per incident case was used. For ischemic heart disease, ischemic stroke, hemorrhagic stroke, hemorrhagic heart disease, type 2 diabetes, chronic kidney disease, osteoarthritis, and low back pain, the cost per prevalent case was used.

In Jones' study, the cost per disease case was calculated using cost data from *Economic Burden of Illness in Canada* (EBIC) 2005-2008, the Canadian Institute for Health Information (CIHI)'s *National Health Expenditure Database*, and the epidemiology data described earlier. The direct health care cost per disease case included both attributable cost (e.g. hospital care, physician care, and drug), and unattributable costs (e.g. other institutions, other professions, capital, public health, administration and other health spending). Details on the calculation process can be found in Jones' study (20).

2.3.4 UNCERTAINTY ANALYSIS

The impact of uncertainty around input parameters was estimated using probabilistic sensitivity analysis. An Excel add-in, Ersatz (Version 1.34) from EpiGear.com (Brisbane, Australia), was used to conduct Monte Carlo simulations with 2,000 iterations. 95% credible intervals were reported for the main outcomes to reflect the uncertainties around price elasticity of demand, beverage consumption, effect of change in energy intake on weight, and relative risks. Five income-quintile models were run independently.

Several one-way sensitivity analyses were conducted. The following departures from the base-case assumptions were made in each respective analysis:

1) It was assumed that price elasticities of demand did not differ by income quintiles. For this, pooled own- and cross-price elasticities from a meta-analysis were used (78).
2) Disease epidemiology was assumed to be the same across income quintiles including incidence, prevalence, and case fatality. Results from Jones' study were used (20).
3) Pass-on rates from observational studies were used instead of 100% pass-on rate. Two studies were selected and examined separately.
4) It was assumed that BMI remained at 2016 levels instead of increasing for 25 years.
5) It was assumed that beverage consumption had a decreasing trend for 10 years.
6) Beverage consumption was assumed to be the same across income quintiles.

Scenario analyses of 10% and 30% tax levels were also conducted, as compared to the 20% tax rate in the base case analysis.

2.3.5 HEALTH AND FINANCIAL EQUALITY ANALYSIS

Concentration indices were used to quantify inequality in health over the distribution of income. The concentration index is a relative measure of inequality and is frequently used to measure socioeconomic-related inequality in health (97). Concentration indices in the current study represent the degree to which disability-adjusted life years lived (Lw) are concentrated in the high-income quintiles. The index is bounded between -1 to 1. A positive concentration index means that the high-income groups are healthier than the low-income groups. A negative concentration index means that low-income groups are healthier than high-income groups. A zero concentration index means that the health is equally distributed across all income groups. A concentration index that is closer to zero indicates a smaller health inequality.

The formula used to calculate concentration indices was (98):

$$C = \frac{2}{u}\sum_{t-1}^{T} f_t u_t R_t - 1 \qquad [2]$$

where u_t is the mean number of Lw of the tth quintile group, f_t is its population share, and R_t is the fractional rank of quintile t.

Concentration indices were calculated for “business as usual” scenario, each tax intervention scenario, and each one-way sensitivity analysis in order to compare the change in health equality under different assumptions.

Financial equality was assessed through annual tax burden per person (or per household) per year, and sugary drink tax as percentage of after-tax income. Tax burden per person (or per household) was calculated by dividing the annual tax burden in each quintile by the population size (or the number of households) of each quintile including children and adults. Sugary drink tax as percentage of after-tax income was calculated by dividing the tax burden per person of each quintile by after-tax income of each quintile. Average adjusted after-tax income in 2016 of each decile from Statistics Canada was used to obtain quintile-specific after-tax income (99). The income was adjusted for economies of scale by dividing the household income by the square root of the household size by Statistics Canada (100). The incomes of pairs of deciles were combined and averaged to obtain quintile-specific estimates. Sugary drink tax as percentage of after-tax household income was calculated by dividing the tax burden per household of each quintile by average after-tax household income of each quintile. Quintile-specific average household income was the weighted average of the income of pairs of deciles obtained from the 2016 Census Data Table (101).

2.4 FINDINGS

The following section reports the findings of the base case analysis, followed by the scenario and sensitivity analyses.

All comparisons between income quintiles were made based on the reported point estimates.

2.4.1 POPULATION CHARACTERISTICS

We analyzed 2016 Census data and divided the total 2016 Canadian population into five equally sized income quintiles, depending on the rank of household income adjusted by the household size. Note that the population aged 20 and above differed for each income quintile because higher income quintiles had greater proportions of individuals aged 20 and above (Table 2.4).

Overall, both the proportion of males and the average age of males increased with income.

The age-sex structure of the population also differed across income quintiles: the population pyramids of the higher income quintiles were each wider at older ages (Figure 2.2).

Among females aged 20 and above, the highest two income quintiles had lower mean BMIs. However, the opposite was observed for males age 20 and above (Table 2.4).

Table 2.4 Characteristics of 2016 Census population in private households by income quintiles

		Q1 (Lowest income)	**Q2**	**Q3**	**Q4**	**Q5**
Population Size (20 and above)	*Female*	2,726,107 (53%)	2,684,541 (52%)	2,646,704 (50%)	2,653,036 (50%)	2,738,598 (49%)
	Male	2,264,796 (47%)	2,371,091 (48%)	2,557,593 (50%)	2,673,846 (50%)	2,859,445 (51%)
	Total	4,990,903	5,055,632	5,204,297	5,326,882	5,598,043
Mean Age (20 and above)	*Female*	40.47	41.16	40.34	40.04	41.09
	Male	37.05	38.92	39.04	39.46	41.07
BMI (Mean ± SD) (20 and above)	*Female*	27.00±6.14	27.07±5.44	26.93±5.59	26.77±5.61	26.31±5.18
	Male	27.35±6.19	27.56±5.41	28.10±5.48	28.25±5.26	28.29±4.95

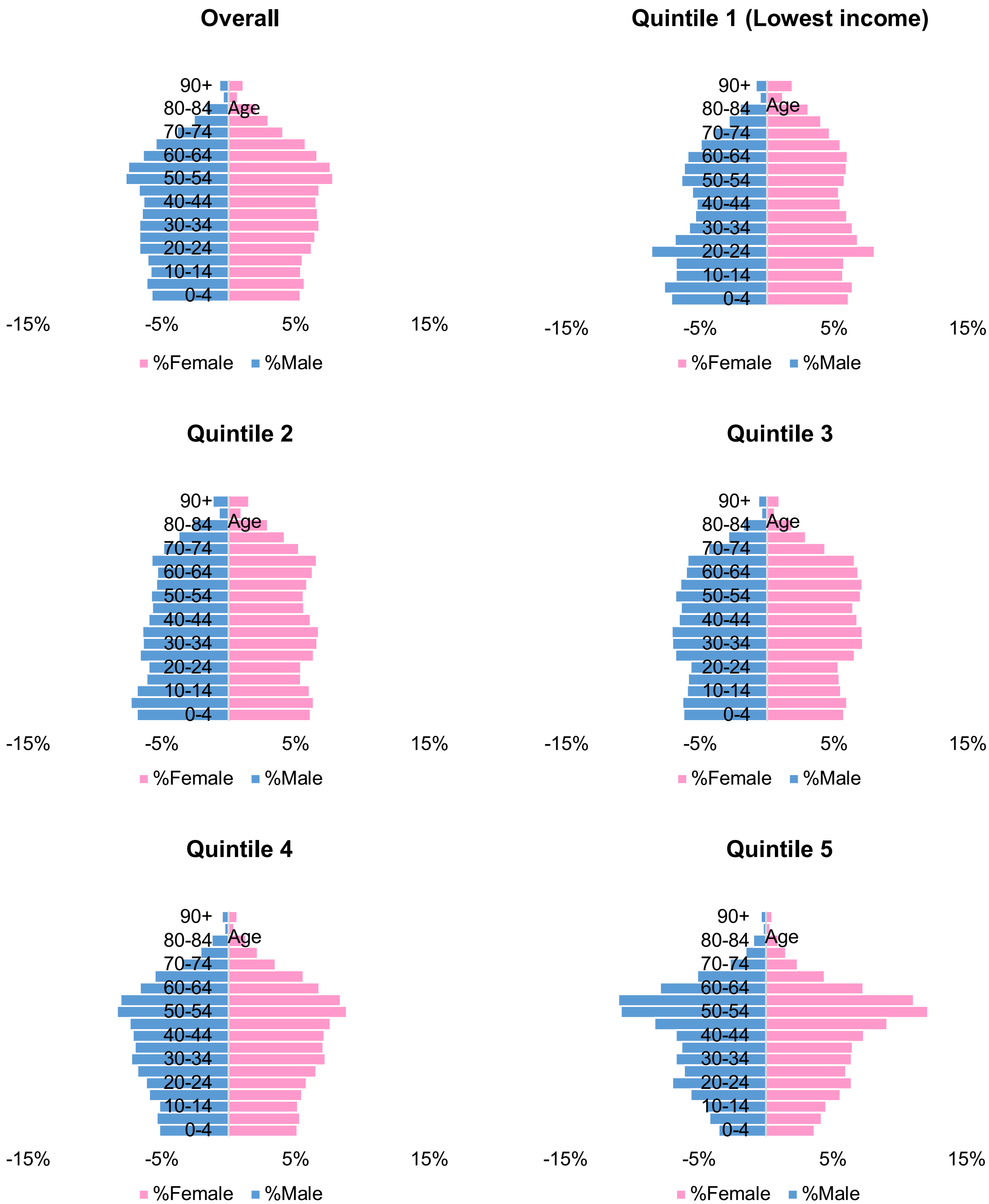


Figure 2.2 Population pyramid overall and by income quintile

2.4.2 HEALTH BENEFITS

ENERGY INTAKE

The model simulated a one-time reduction of sugary drinks consumption and assumed that the effect would last for a lifetime. Overall, the 20% sugary drink tax was estimated to reduce the consumed volume of sugary drinks by an average of approximately 15%, with the lowest income quintile having a reduction that was slightly greater than that for the other income quintiles (Figure 4.2).

In addition, from the analysis of 'CCHS 2015 Nutrition', the mean daily energy intake from sugary drinks of the lowest income quintile was also larger than that of the highest income quintile (Appendix Table A.1). As a result, the lowest income quintile was estimated to have the greatest mean reduction in daily energy intake compared to all other income quintiles for both females and males (15.36 kcal [-17.04, -13.70] for females and 23.51 kcal [26.13, 21.01] for males) (Appendix Tables B.1 and B.2).

The model estimated the daily energy intake change due to consumption change in plain milk (between 0.2 kcal to 0.82 kcal, depending on the sex and quintile group) and diet beverages (between -0.01 kcal to 0.07 kcal, depending on the sex and quintile group), but the change is not significant (Appendix Tables B.3 to B.6).

The net reduction in total daily energy intake among the lowest income quintile remained greater compared to all other income quintiles (Appendix Tables B.7 and B.8).

BODY MASS INDEX

The estimated reduction in net daily energy intake generated a reduction in BMI over time.

The model assumed the effect of the tax would be fully achieved one year after the implementation of the tax. Thus, a year after the implementation of the sugary drink tax, the estimated mean reduction in BMI ranged from 0.21 to 0.33 depending on the sex and income quintile (Figure 2.4). These estimates were highest among the lower income quintiles for both females and males and decreased as income increased (Figure 2.4).

The trend remained the same across all sex-age groups with the greatest reduction found in Q1 males aged 20-24 (0.51 kg/m^2 [-0.60, -0.44]) (Appendix Tables B.9 and B.10).

The prevalence of overweight and obesity was estimated to decrease by 1.66% among the overall Canadian adult population.

Among females, the lower income quintiles had greater reductions in the prevalence of obesity but smaller reductions in the prevalence of overweight (Figure 2.5). When overweight and obesity were combined together, the largest reduction was in the highest quintile and the second-largest reduction was in the lowest quintile (Appendix Table B.11).

Among males, the reduction in the prevalence of overweight was greater among the lower income quintiles while the reduction in the prevalence of obesity was greater among the higher income quintiles (Figure 2.6). When overweight and obesity were combined together, the reduction was the largest among the lowest income quintile and it decreased as income increased (Appendix Table B.11).

Overall, over 30,000 cases of overweight and approximately 400,000 cases of obesity were estimated to be prevented one year after implementation of a 20% sugary drink tax (Table 4.2)

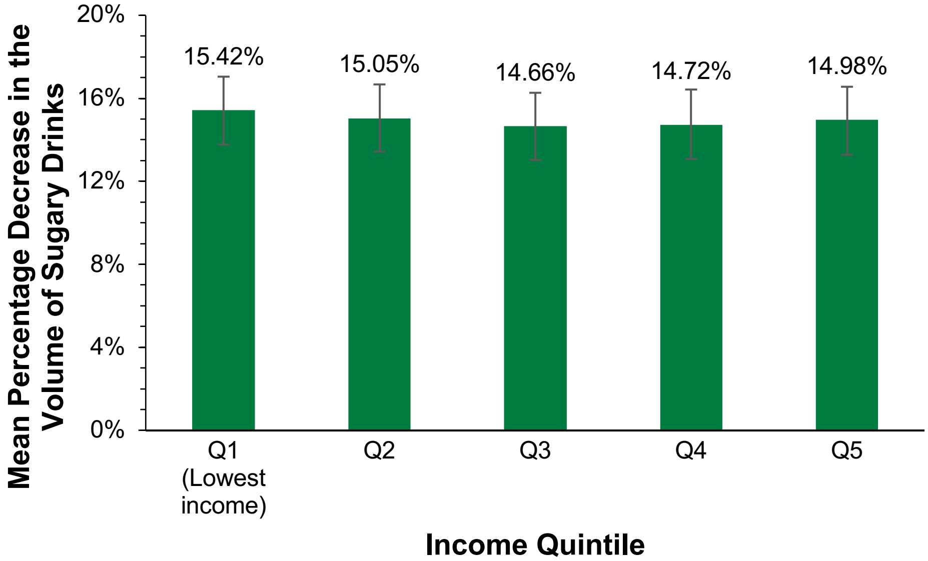


Figure 2.3 Percentage decrease in the volume of sugary drinks due to 20% sugary drink tax by income quintil

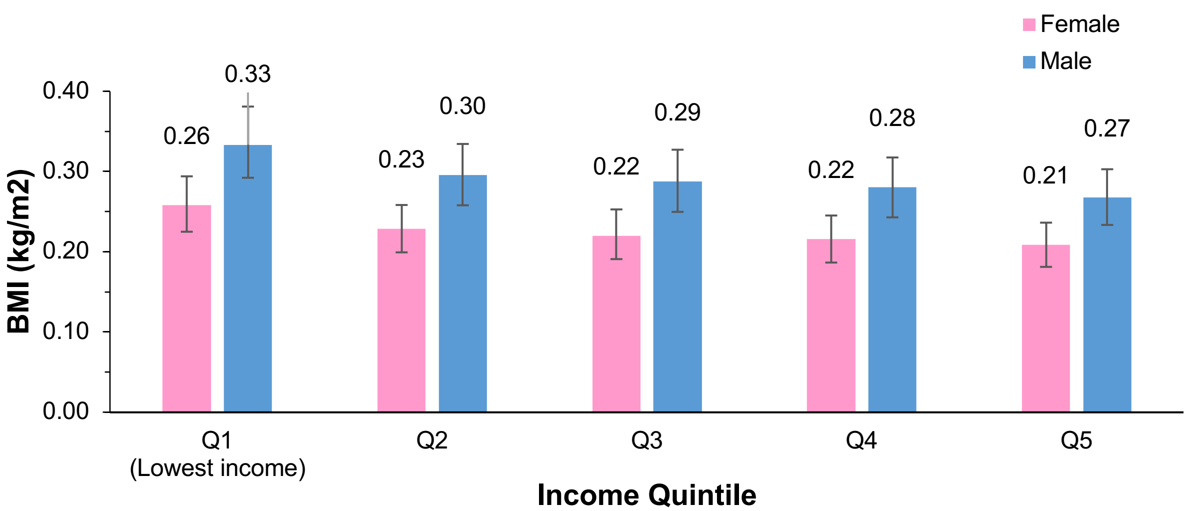


Figure 2.4 Mean Body Mass Index (BMI) reduction due to 20% sugary drink tax by sex and income quintile, one year after implementation

Table 2.5 Total prevented prevalent cases of overweight and obesity due to 20% sugary drink tax by income quintile, one year after implementation

	Q1 (Lowest income)	Q2	Q3	Q4	Q5	Total
Overweight	9,203	8,753	5,055	4,399	7,315	34,725
Obese	75,856	75,679	78,673	82,461	86,529	399,198

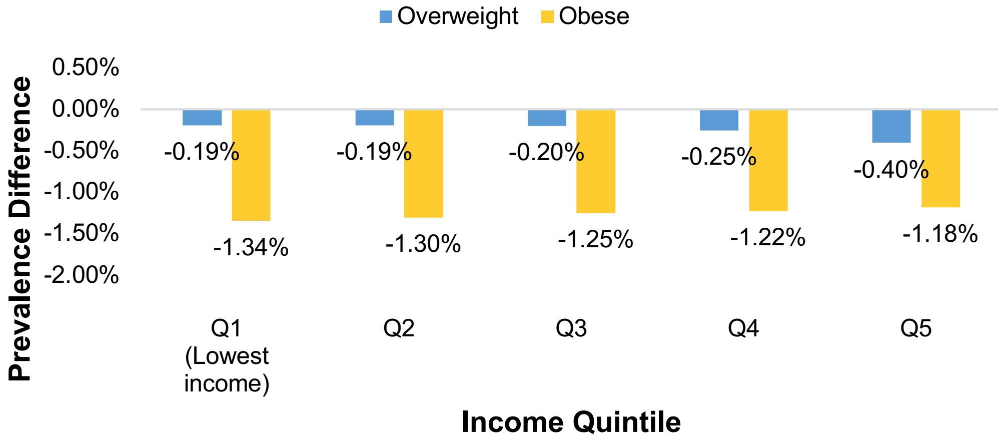


Figure 2.5 Prevalence difference, one year after implementation of 20% sugary drink tax - female

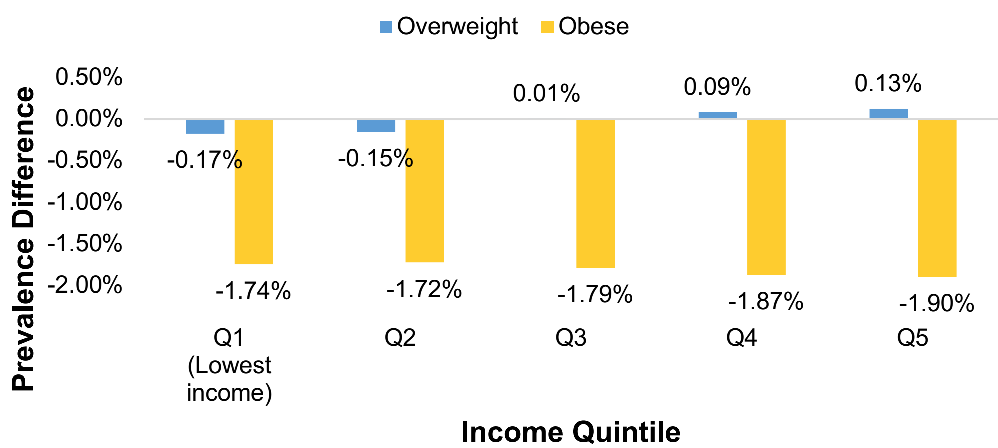


Figure 2.6 Prevalence difference, one year after implementation of 20% sugary drink tax – male

DISEASE REDUCTION

By reducing mean BMI, the sugary drink tax lowered the risk of type 2 diabetes and other obesity-related diseases, and further decreased the incidence and prevalence of these conditions over the next 25 years. The disease reduction rates presented for each income quintile are reported as estimated incident cases prevented per 1,000 people from 2016-2042, and as estimated prevalent cases prevented per 1,000 people in 2042 (Figure 2.7, Figure 2.8).

Total cases prevented are presented in the appendix (Appendix Tables B.12 and B.13). The estimated incidence difference between the 20% sugary drinks tax scenario and the 'business as usual' scenario was the highest in 2017, a year after implementation, decreasing over time. The estimated prevalence difference between the 20% sugary drinks tax scenario and the 'business as usual' scenario increased over time. The results for 2017 are reported in Appendix Table B.14, while the results for 2042 are reported in Appendix Table B.15.

The 20% sugary drink tax was estimated to prevent a total of 133,127 new cases of type 2 diabetes among the 2016 adult Canadian population from 2016 to 2042, with an average of more than 5,300 cases per year. The cases prevented per 1,000 people were highest in the lowest two income quintiles (Figure 2.7). The incidence in 2017 was estimated to decrease from -17.86 to -25.77 cases per 100,000 (equated to a -6.0% to -6.7% change in the incidence rate), with the largest reduction in the two lowest quintiles (Appendix Table B.14).

New cancer cases were estimated to be reduced by a total of 15,907 cases over the next 25 years, with the highest different found in breast cancer, uterine cancer, and colon and rectum cancer among 11 types of cancers included in the model (Appendix Table B.12). Cases prevented were greatest in the lowest income quintile (Figure 2.7). In 2017, the lowest income quintile had the greatest incidence difference and percentage change in incidence for all types of cancer in the model (Appendix Table B.14).

Over the next 25 years, new cases of ischemic heart disease (IHD) and stroke were estimated to decrease by 41,515 and 5,269 cases, respectively. The lowest income quintile had the highest number of new cases prevented per 1,000 people for both IHD and strokes (Figure 2.7). The incidence difference in 2017 was also the highest among the lowest income quintiles for IHD and strokes, decreasing as income increased (Appendix Table B.14). Prevalence difference of hypertensive heart disease in 2042 had similar trend (Appendix Table B.15).

For osteoarthritis and low back pain, the two highest income quintile were estimated to have a higher number of prevalent cases prevented per 1,000 people (Figure 2.8, Appendix Table B.13). The difference in prevalence between the 20% tax scenario and the ‘business as usual’ scenario in 2042 was still the largest among the lowest quintile for osteoarthritis knee and low back pain. For osteoarthritis hip, the fourth quintile had the highest estimated prevalence difference (Appendix Table B.15).

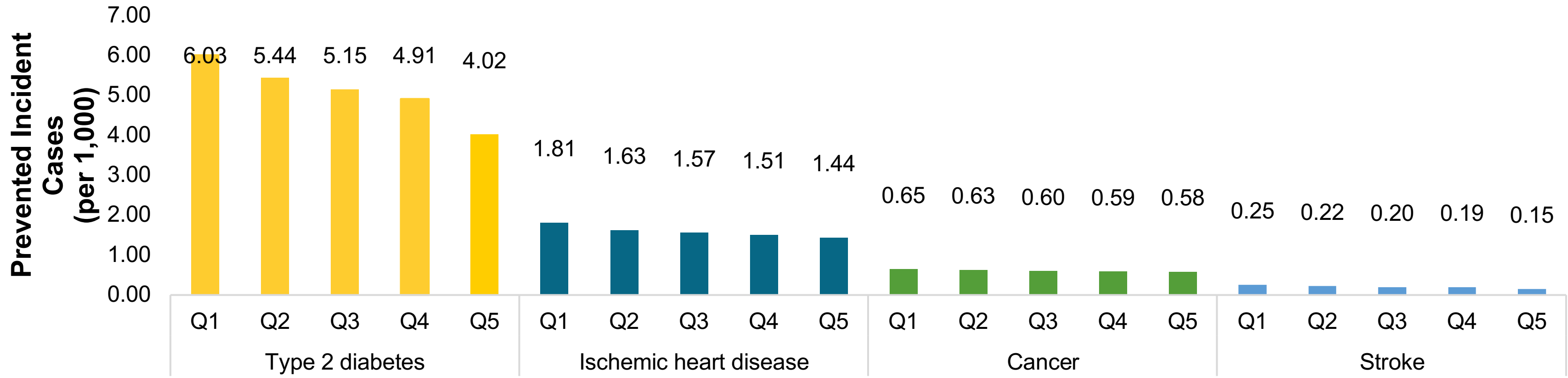


Figure 2.7 Disease incident cases prevented by 20% sugary drink tax (per 1,000), 2017-2042

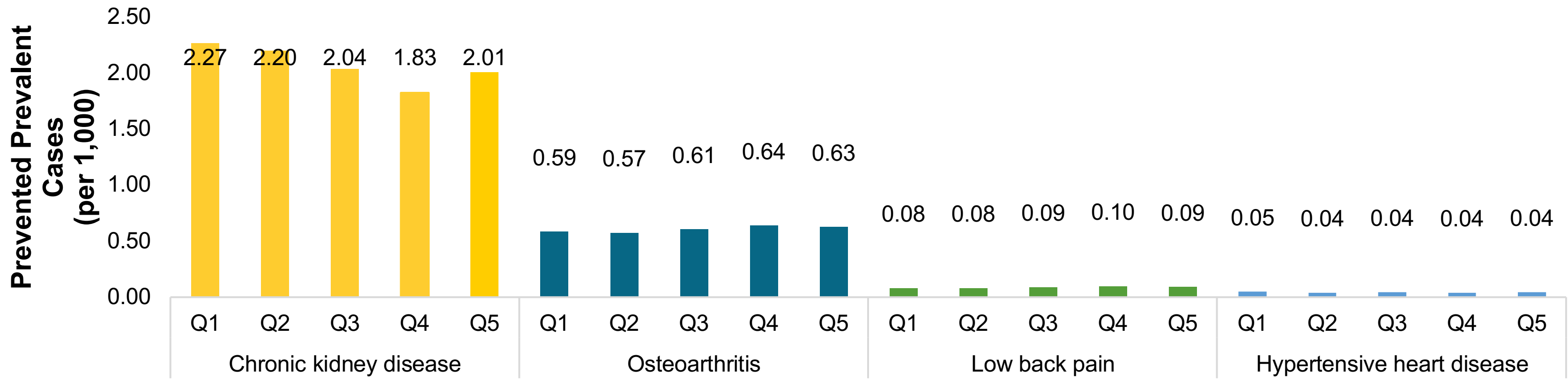


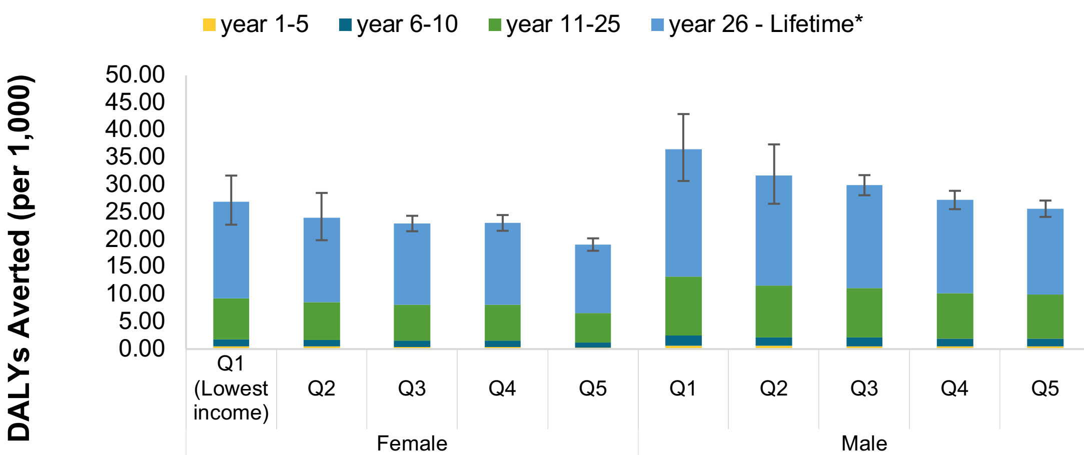
Figure 2.8 Disease prevalent cases prevented by 20% sugary drink tax (per 1,000), 2042

DISABILITY-ADJUSTED LIFE YEARS

The 20% sugary drink tax was estimated to avert approximately 690,000 DALYs over a lifetime period among the 2016 Canadian adult population.

Estimated DALYs averted were approximately 156,000, 140,000, 137,000, 134,000, and 125,000 for quintile 1 to quintile 5, respectively. The lowest income quintile was estimated to have the most DALYs averted per 1,000 people (Figure 2.9).

Males were also predicted to have more DALYs averted than females (Figure 2.9).



	Female					Male				
	Q1 (Lowest income)	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5
year 26 - Lifetime*	17.63	15.44	14.86	14.96	12.47	23.22	20.13	18.78	17.03	15.68
year 11-25	7.50	6.91	6.53	6.56	5.40	10.74	9.40	9.03	8.30	8.09
year 6-10	1.34	1.23	1.12	1.12	0.88	1.85	1.62	1.55	1.41	1.38
year 1-5	0.47	0.44	0.39	0.39	0.30	0.63	0.56	0.53	0.48	0.47

Income Quintile

Figure 2.9 DALYs averted (per 1,000) due to 20% sugary drink tax over time by sex and income quintile

*Year 26 until remainder of life

2.4.3 ECONOMIC BENEFITS

HEALTH CARE COST SAVINGS

Direct health care costs were calculated based on disease incidence cases and prevalence cases, and accounted for health care costs of unrelated diseases due to additional years of life.

For the 2016 Canadian adult population, the direct health care savings for 2016-2042 from a health system's perspective were predicted to be $5.9 billion. Lifetime direct health care savings were estimated to be $10.7 billion, with the largest savings in the lowest income quintile.

Lifetime health care savings were estimated to be $2.27bn, $2.16bn, $2.17bn, $2.12bn, and $1.98bn for Q1 to Q5, respectively. Both total lifetime health care saving and health care saving per person were estimated to be the highest among the lowest quintile (Figure 2.10).

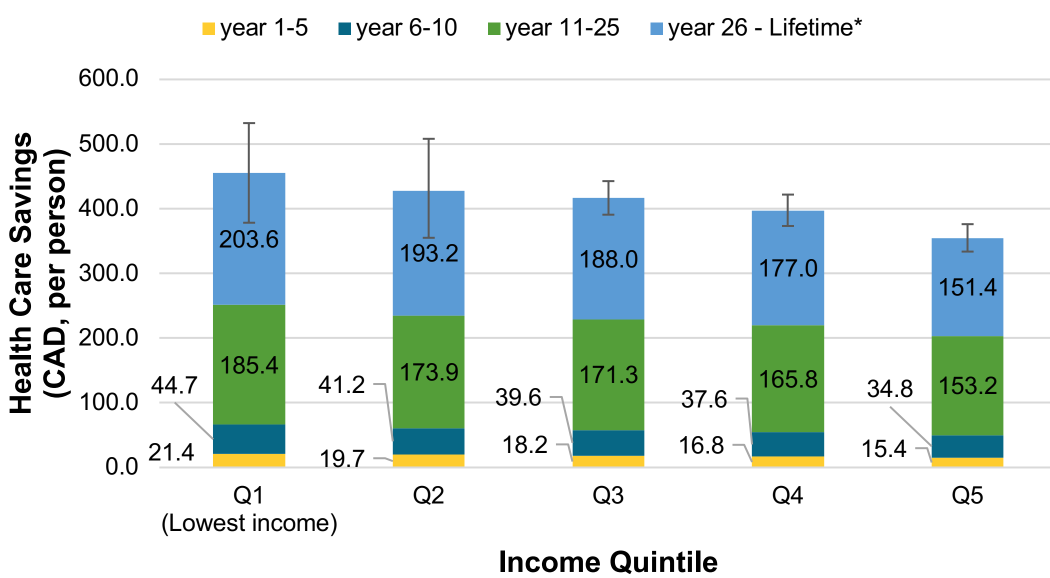


Figure 2.10 Health care savings due to 20% sugary drink tax over time by income quintile

*Year 26 until remainder of life

TAX BURDEN

The annual tax burden for the whole 2016 Canadian population (including children) was estimated to be $1.4 billion. Average tax burden per person was estimated to be $39.00 to $44.30, with the middle-income quintile bearing the heaviest burden (Figure 2.11).

When taking income into consideration, the lowest income quintile paid the highest proportion of their after-tax income in tax (Figure 2.12).

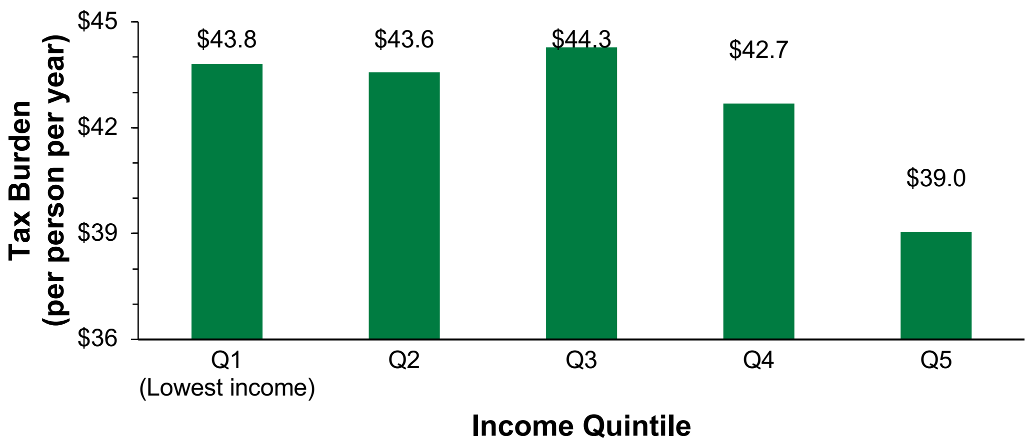


Figure 2.11 Annual tax burden (age 0 and older, per person) due to 20% sugary drink tax by income quintile

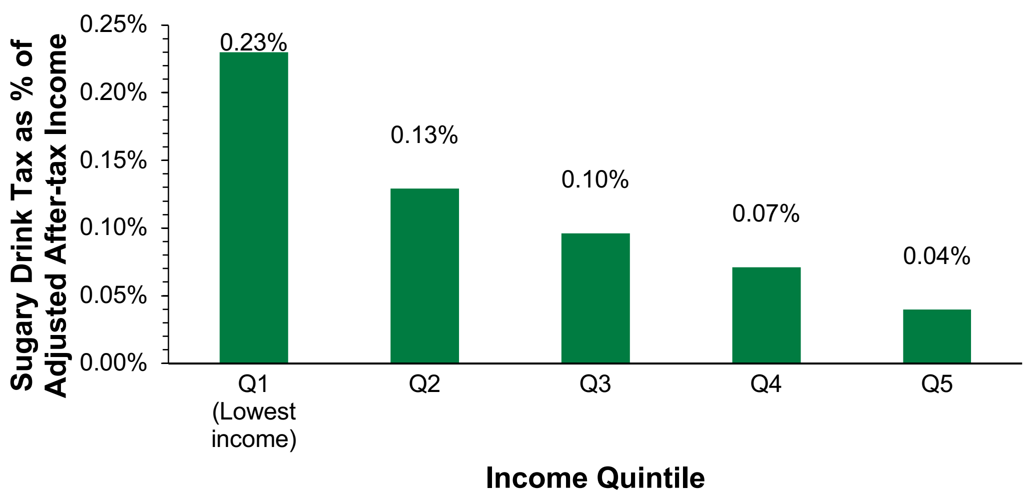


Figure 2.12 20% Sugary drink tax as % of adjusted after-tax income (age 0 and older, per person) by income quintile

2.4.4 IMPACT OF DIFFERENT TAX LEVELS AND EQUALITY ANALYSIS

In general, the higher the tax level, the more DALYs were averted, the greater the health care costs saved, but the higher the financial burden of the tax (Figure 2.13).

Concentration indices decreased as the tax level increased, implying that health was more equally distributed in the 30% tax level scenario versus the 10% tax level scenario (Table 2.6). However, financial regressivity increased as the tax level increased (Figure 2.13).

Table 2.6 Equality analysis and tax burden per person per year (CAD) comparing 10%, 20%, and 30% sugary drink tax levels

	Business as Usual	10% Sugary Drink Tax					20% Sugary Drink Tax					30% Sugary Drink Tax				
Concentration Index	0.02248	0.02243					0.02240					0.02237				
		Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
Tax burden per person per year (CAD) (Age 0+)		23.7	23.6	23.9	23.0	21.1	43.8	43.6	44.3	42.7	39.0	61.1	60.9	62.0	59.7	54.5

2.4.5 ONE-WAY SENSITIVITY ANALYSES

Seven one-way sensitivity analyses were conducted. For the assumption of uniform price elasticities of demand across income quintiles, the price elasticities used in the Jones' study (20) were applied to all the income quintiles. Total health benefits and health care savings were higher than the base case as the average price elasticities of the base case are more conservative. Health inequality would decrease compared to the base case, even though Q3 would gain more health than Q2 (Table 4.4). Financial regressivity was similar to the base case (Figure 2.14).

For the assumption of uniform disease epidemiology input across income quintiles, the distribution of health benefits and health care savings changed. The higher income quintiles were estimated to benefit more from the tax than the lower income quintiles were. Total DALYs averted were predicted to be higher than the base case but the health inequality was predicted to increase after the implementation of the tax (Table 4.4). Estimated financial regressivity was not affected (Figure 2.14).

Table 2.7 Equality analysis and tax burden per person per year (CAD) comparing different assumptions

	Business as Usual	Uniform price elasticities of demand across income quintiles					Base case					Uniform disease epidemiology input across income quintiles				
Concentration Index	0.02248	0.02239					0.02240					0.02249				
		Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5
Tax burden per person per year (CAD) (Age 0+)		41.6	41.2	41.7	40.2	36.9	43.8	43.6	44.3	42.7	39.0	43.8	43.6	44.3	42.7	39.0

When the pass-on rate was reduced to 43.1% (95% CI: 27.7%, 58.4%), the estimated health benefits and health care savings were lower compared to a 100% pass-on rate (Figure 2.15). Health inequality was estimated to decrease, but not as much as in the base case (Table 2.8). Financial regressivity was minimally affected. When the pass-on rate was raised slightly to 101% (95% CI: 89%, 112%), the results were nearly the same as those for a 100% pass-on rate.

Table 2.8 Equality analysis and tax burden per person per year (CAD) comparing different pass-on rate assumptions

	Business as Usual	43.1% (27.7%, 58.4%) pass-on rate					Base case (100% pass-on rate)					101% (89%, 112%) pass-on rate				
Concentration Index	0.02248	0.02244					0.02240					0.02240				
		Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5
Tax burden per person per year (CAD) (Age 0+)		22.5	21.9	22.2	21.6	19.9	43.8	43.6	44.3	42.7	39.0	44.1	43.9	44.6	43.0	39.4

The impact of removing the increasing trend in population's BMI was examined. Estimated health benefits and health care savings were slightly lower compared to the base case but health inequality was slightly affected. When a decreasing secular trend in sugary drinks consumption was applied for 10 years, estimated health benefits and health care savings became less and health inequality slightly increased compared to the base case.

When beverage consumption was assumed to be the same across income quintiles, estimated health benefits and health care savings were lower, with higher income quintiles benefiting more than middle income quintiles. Health inequality still decreases, but less than in the base case. For all three assumptions, financial regressivity did not change (Figure 4.15, Table 4.6).

Table 2.9 Equality analysis and tax burden per person per year (CAD) comparing different assumptions

	Business as Usual	Base Case					No BMI trend				
Concentration Index	0.02248	0.02240					0.02240				
		Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
Tax burden per person per year (CAD) (Age 0+)		43.8	43.6	44.3	42.7	39.0	43.8	43.6	44.3	42.7	39.0
		Decreasing beverage trend applied for 10 years					**Uniform beverage consumption across income quintiles**				
Concentration Index		0.02241					0.02243				
		Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
Tax burden per person per year (CAD) (Age 0+)		42.8	42.5	43.3	41.7	38.2	42.9	42.4	42.9	42.9	42.4

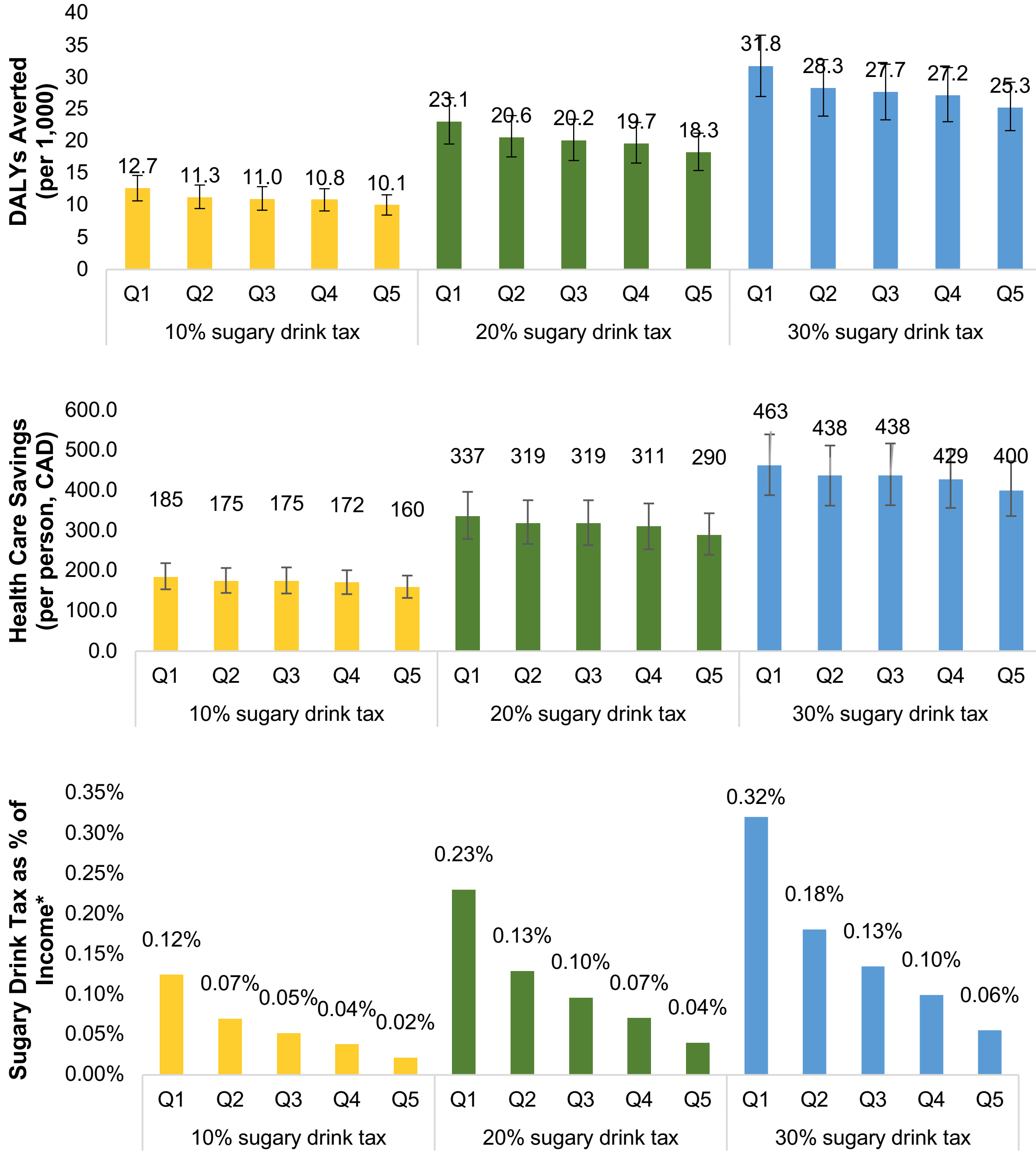


Figure 2.13 Comparison of 10%, 20%, and 30% sugary drink tax levels. Lifetime DALYs averted per 1,000 people (top). Lifetime health care savings per person (middle). Sugary drink tax as % of adjusted after-tax income (bottom)

*Adjusted after-tax income was used and it was adjusted by dividing the household income by the square root of the household size.

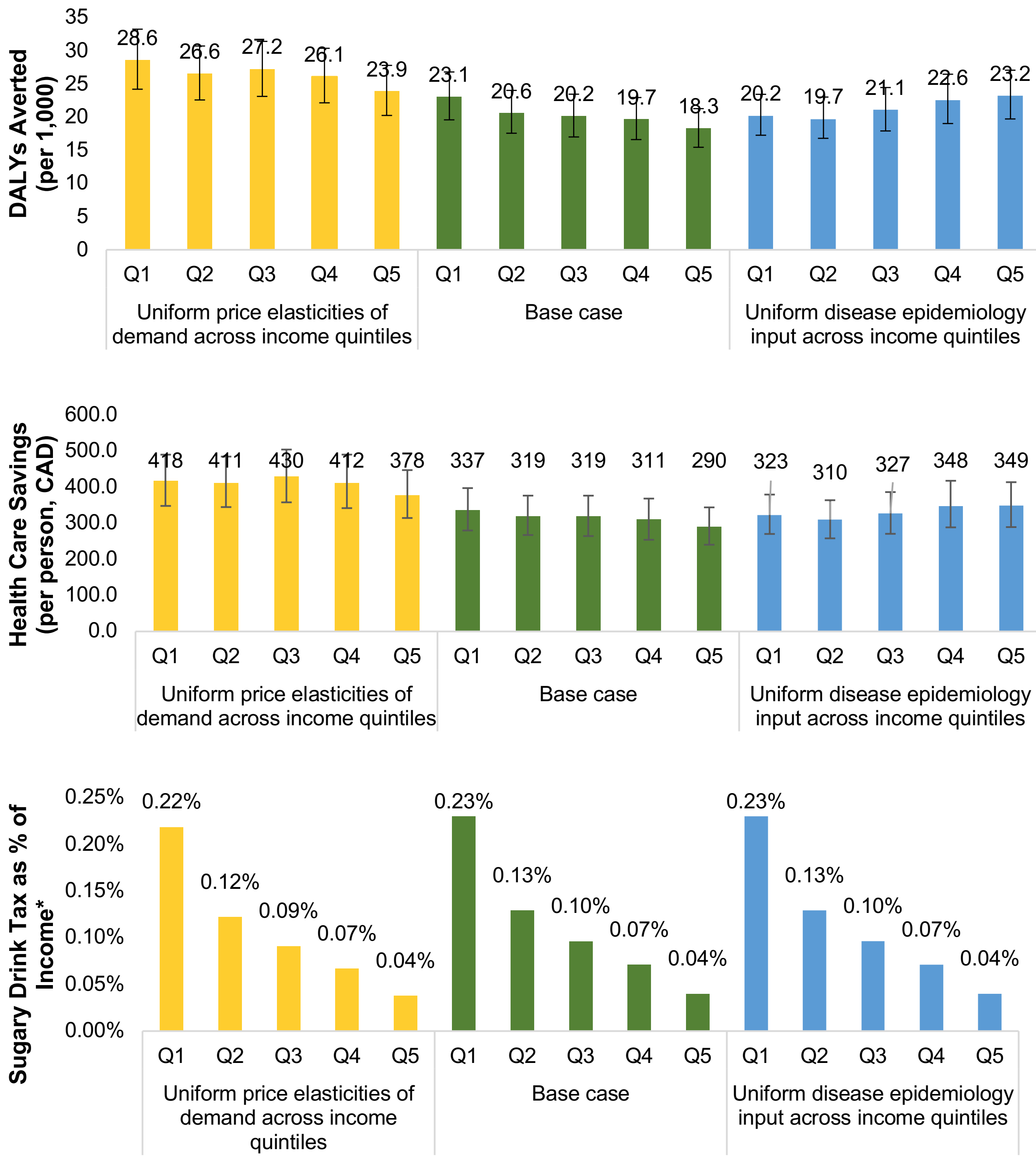


Figure 2.14 Comparison of different assumptions. Lifetime DALYs averted per 1,000 people (top). Lifetime health care savings per person (middle). Sugary drink tax as % of adjusted after-tax income (bottom)

*Adjusted after-tax income was used and it was adjusted by dividing the household income by the square root of the household size.

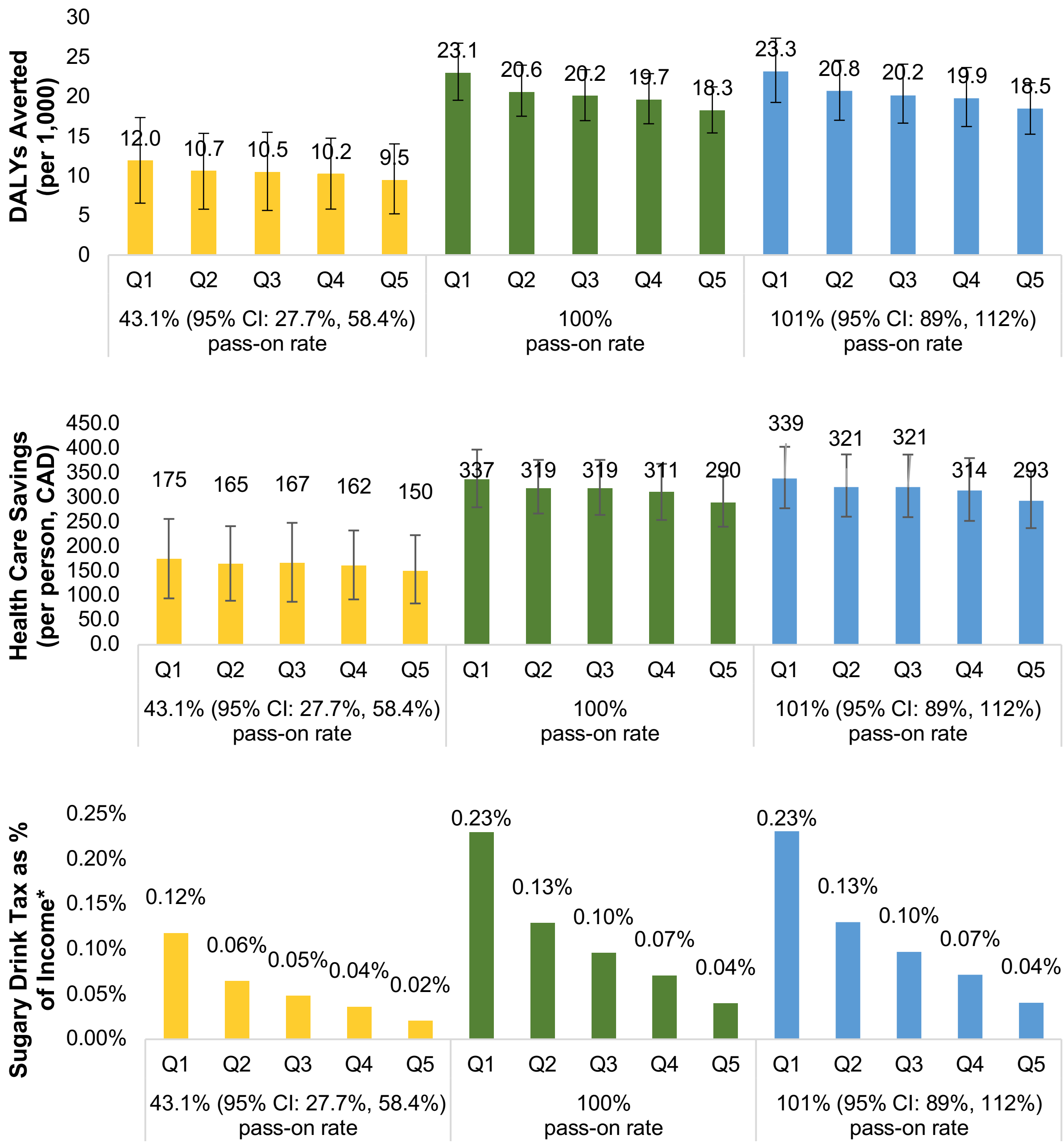


Figure 2.15 Comparison of different assumptions. Lifetime DALYs averted per 1,000 people (top). Lifetime health care savings per person (middle). Sugary drink tax as % of adjusted after-tax income (bottom)

*Adjusted after-tax income was used and it was adjusted by dividing the household income by the square root of the household size.

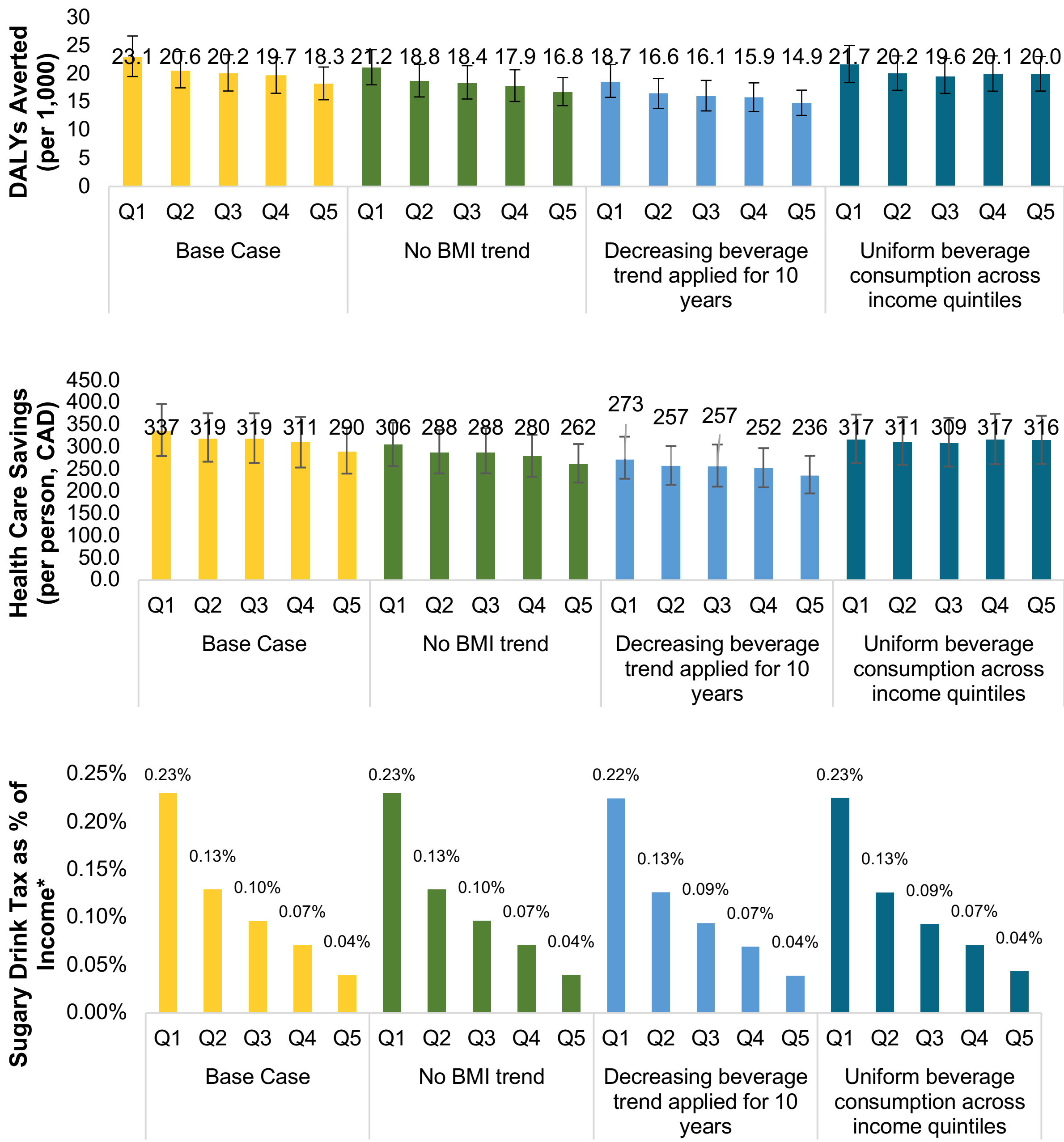


Figure 2.16 Comparison of different assumptions. Lifetime DALYs averted per 1,000 people (top). Lifetime health care savings per person (middle). Sugary drink tax as % of adjusted after-tax income (bottom)

*Adjusted after-tax income was used and it was adjusted by dividing the household income by the square root of the household size.

2.5 DISCUSSION

2.5.1 DISCUSSION

Following implementation of a tax on sugar-sweetened beverages, we estimate that greater DALYs averted and greater health care cost savings would accrue to lower income quintiles. This is due to their relatively higher baseline beverage consumption, relatively greater reaction to the price change, and relatively worse rates of disease incidence, prevalence and mortality.

Our findings show that the financial burden of such a tax would be regressive. However, the difference in the tax burden between the lowest and highest income quintile for a simulated 20% sugary drink tax was estimated to be less than $6 per person per year. For the 2016 Canadian adult population, such a tax was estimated to avert 250,580 DALYs and save $5.9 billion of direct health care costs over 25 years, and to generate $1.4 billion of revenue annually.

Our findings regarding health inequality are consistent with Australian research (45), but differ from an Indonesian study which predicted that higher income groups would gain more health benefit (46). This may be because higher income groups in Indonesia consume more SSBs (46), while lower income groups in Canada and Australia consume more SSBs (45). Also, the difference in DALYs averted between Q1 and Q5 in Australia's study is bigger than in our study, possibly due to the greater disparity in beverage consumption between Q1 and Q5 in Australia (45). Our findings regarding regressivity are also consistent with previous studies (75, 102, 103).

The predicted overall health benefit and health care savings in our study are less than those reported by Jones et al. (20). This is because we applied a 1.5% discount rate (consistent with CADTH's guidelines), whereas no discounting was applied to the base case in Jones' study. Furthermore, the population size in our study is approximately 5% smaller than in Jones' study; this is because our population included only private households. The price elasticities used in our study were also more conservative than those in Jones' study, which leads to smaller estimated health benefits and health care cost savings in our study.

Sugar-sweetened beverage taxes have been implemented in numerous countries (25), and a recent systematic review of real-world studies suggested that SSB taxes are effective in reducing beverage consumption (25, 29). Many modelling studies have also shown that lower socio-economic groups would benefit more from SSB taxes (41, 45, 75). Our study adds to the body of knowledge and predicts the impacts of sugary drink taxes on health and financial inequalities in a Canadian context. Canadian income-specific data were integrated into the model, including population demographics, beverage consumption, price elasticities, BMI distributions, mortality rates, and disease epidemiology data for seven main diseases.

To our knowledge, our study is the only SSB tax modelling study that has integrated disease prevalence and disease-specific mortality rates in the model. Our model can also be used to assess the equality impact of other weight loss programs in Canada in the future.

An important limitation is that the comparisons made between income quintiles in our study were based on point estimates. Although 95% credible intervals were reported for each income quintile, these cannot be used to determine if any *differences* in point estimates *between* income quintiles are statistically significant. This is due to a limitation in the model design: since the model was run separately for each income quintile, the credible intervals for each income quintile were generated independently. Since much of the uncertainty in the model was common across income quintiles, these credible intervals would be expected to be correlated (e.g. a low value for one income quintile would imply a correspondingly low value for the other quintiles). It follows that overlapping 95% credible intervals across income quintiles does *not* imply that differences in point estimates are statistically insignificant. Considering the uncertainty around differences in point estimates across income quintiles requires rebuilding the model to allow for the simultaneous consideration of all income quintiles, and should be a focus of future research.

A further limitation of modelling income quintiles independently is that individuals were assumed not to change their income quintile as they age. This is a meaningful limitation, since this is not usually the case in the real world. Furthermore, different income quintiles were assumed to purchase beverages at the same unit price, which might not be the case in practice.

There are also limitations resulting from the data used for obtaining income-specific parameters. The definition of ‘income quintile’ in each survey or dataset was inconsistent: some used income divided by the square root of the household size, and others used ‘low-income cut-offs’ ratios. It was assumed that the income quintiles generated using different methods were equivalent. For beverage consumption, the sample size of CCHS 2015 Nutrition (n = 20,176) was not large enough to conduct income, sex, and age subgroup analysis. Thus, it was assumed that the income effect on beverage consumption was the same across sex and age groups. However, studies have shown that the consumption differs by income for a few sex- and age-based groups, but not most sex- and age-based groups (48-52). One-way sensitivity analysis was conducted and showed that beverage consumption did affect the distribution of health benefits of the sugary drink tax. Future studies should investigate different data sources for better income-specific beverage consumption estimates. There are also inherent biases from the survey data, such as self-report data in CCHS 2017, which may affect the prevalence of heart and stroke disease. In some cases, when the sample size was too small, wider age groups were used and it was assumed that the income effect was the same within that age group.

Other limitations inherited from the original Jones model have been described elsewhere (20). Briefly, an *ad valorem* excise tax was modelled; however, specific excise taxes based on beverage volume or sugar content are more common in the real-world (28, 56, 104) and can better avoid people migrating to cheaper brands (53). Our model used one price elasticity for all sugary drinks, a fixed unit price of sugary drinks, and did not capture the impact of people migrating to a cheaper brand. Our model also did not consider potential shifts from beverages to sugary food, which may lead to overestimation of the intervention effect. It was assumed that all effects happened within a year, which may overestimate the intervention effect for the first three years (although the impact should be minimal for outcomes over the lifetime). Also, the model assumed that 100% juice had the same health effects as SSBs, which may overestimate the cases of type 2 diabetes and the number of cases prevented (66).

Future research should examine potential utilisation of the tax revenue and how the revenue could be used to further improve health and financial inequality. Research on the potential out-of-pocket cost health care savings and productivity loss should also be conducted to provide a clearer picture of the overall financial impact of the sugary drink tax for each income quintile.

2.5.2 CONCLUSIONS

We find that low-income Canadians would gain the most health benefit from a sugary drinks tax, but would pay the largest proportion of income in tax. However, the absolute difference in the tax burden across income groups is relatively small. If this regressivity is a concern, policy makers may consider mitigating this by investing the revenue raised from a sugary drinks tax into policies that reduce health or income inequalities.

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Chapter 3. Discussion

Discussion

Following the implementation of a tax on sugar-sweetened beverages, it is estimated that greater DALYs averted and greater health care cost savings would accrue to lower income quintiles. The findings show that the financial burden of such a tax would be regressive. However, the difference in the tax burden between the lowest and highest income quintile for a simulated 20% sugary drink tax was estimated to be less than $6 per person per year. For a couple with two children in the lowest income quintile, this would mean an annual incremental cost of $19.2 above the $156 paid by the same type of family in the highest income quintile.

Many real-world evaluation studies and modelling studies have investigated the equality impact of SSB taxes (29, 41-46). All studies in high-income countries (the US, the UK, Australia, and Germany), except the study in Chile, reported similar or greater health benefit for lower SES groups (29, 41-46). My study adds to the body of knowledge and predicts the impacts of sugary drink taxes on health and financial inequalities in a Canadian context. My study integrated Canadian income-specific data into the model, including population demographics, beverage consumption, price elasticities, BMI distributions, mortality rates, and disease epidemiology data for seven main diseases. My model can also be used to assess the equality impact of other weight loss programs in Canada in the future.

To my knowledge, my study is the only SSB tax modelling study that has integrated disease prevalence rate and disease-specific mortality rates that are income-specific into the model. Moreover, according to the sensitivity analyses, income-specific disease epidemiology data affected the distribution of the health benefit from the tax. The higher income quintiles would gain more health benefit than the lower income quintiles when uniform disease epidemiology data was used. Future equity-informed economic evaluations should also account for the difference of disease epidemiology between SES groups.

My findings regarding the gradient in health benefit and health care cost savings from the tax are consistent with an Australian research which also reported lifetime DALYs averted by SES groups (45). The difference in lifetime DALYs averted between Q1 and Q5 in the Australian study was bigger than in my study, possibly due to the greater disparity in beverage consumption and life expectancy between Q1 and Q5 in Australia (45, 105). The findings are also consistent with other simulation modelling research from Germany, the UK, and the US

(106-108). Two studies from the UK and Ireland found that the health benefits were similar across income groups (77, 109). Studies from low- and middle-income countries, such as Indonesia and the Philippines, have reported that higher income groups gained more health benefit due to higher income groups consuming more SSBs than lower income groups (46, 110). The finding that the tax is regressive is consistent with previous studies (41, 45). In future studies, to thoroughly consider the financial impact of the tax on individuals, productivity losses and out-of-pocket health care costs savings should also be considered as Lal's study did (45).

For the 2016 Canadian adult population, a 20% sugary drink tax was estimated to avert 250,580 DALYs and save $5.9 billion of direct health care costs over 25 years, and to generate $1.4 billion of revenue annually. The predicted overall health benefit and health care savings in my study are less than those reported by Jones et al. (20). This is because a 1.5% discount rate (consistent with CADTH's guidelines) was applied (111), whereas no discounting was applied to the base case in Jones' study. Furthermore, the population size in my study is approximately 5% smaller than in Jones' study; this is because the population used in my study included only private households. To model different reactions to price changes of different income groups, income-specific price elasticities were used. These price elasticities were more conservative than the one in Jones' study, which leads to smaller estimated health benefits and health care cost savings in my study.

My model extended on Jones' Canadian Sugary Drink Model to explore the impact on different income groups (54). It was based on a well-established Australian model approach called Assessing Cost-Effectiveness-Prevention, a collaborative project of 130 top health experts and have been used to evaluate many obesity interventions (59-62). It uses a cohort life table model while some other SSB tax models used micro-simulation models (44, 112). Micro-simulation models are generally more complicated than cohort models and require more data input. They are often used for modeling chronic diseases that have interrelated risk factors and complicated clinical paths (113). Micro-simulation SSB tax models often focus on the health outcomes of a single disease. For instance, Wilde et al.'s study examined the impact of the SSB tax on cardiovascular disease (112). The advantage of my model is that it accounts for 19 diseases. It is nearly impossible and unnecessary to identify risk factors and their interactions for 19 diseases. Micro-simulation models might be useful to simulate complicate consumer behaviours while it is not being used in this way in the current micro-simulation SSB tax models (44, 112).

Relative risks of high BMI from GBD for modelled diseases were used to link the reduction in BMI to improvement in disease outcomes (9). In the GBD study, the relative risks are only applicable to persons with a BMI higher than 22.5 kg/m^2. In my study, it was assumed that everyone in the model would benefit from reducing BMI and did not take the underweight population into account. This assumption might overestimate the health benefits and health care cost savings. Approximate 19% of the Canadian adult population have BMI lower than 22.5 kg/m^2 (79). Future studies should apply different relative risks for the population with a BMI under 22.5 kg/m^2 or exclude this population in the study. My study might also ignore the increased health risks resulted from losing weight for the underweight population (BMI≤18.5 kg/m^2) (114). However, only 2.8% of the Canadian adult population is underweight (114). This should not have a great impact on the results.

Data for price elasticities for Canada were limited. Own-price elasticities were from Lundy's study that analyzed 2001 national survey data (76). Firstly, the data are outdated but that is the most updated data available as Food Expenditure Survey has not been updated since 2001. Secondly, beverage types used in Lundy's study were not the same as the definition of sugary drinks in my study. It was assumed that the elasticity would be the same for both definitions of the sugary drinks. Thirdly, the relationships between Q1 and Q3, Q3 and Q5 were assumed to be linear. The assumption might not hold as no linear relationship was observed among low- middle- and high-income groups. Lal et al. made the same assumption to obtain quintile-specific elasticities from elasticities of three income groups (45). Lastly, cross-price elasticities between sugary drinks and milk and between sugary drinks and diet beverages were from another country. However, data used were the best evidence available and the sensitivity analysis showed that price elasticities had minimal effect on the conclusion regarding the equity impact of the tax.

My model simulated the consumption of sugary drinks as a whole. One price elasticity and a fixed unit price were used for all sugary drinks. It prevented the model from capturing the impact of people migrating to a cheaper type of drinks, such as migrating from more expensive juice to cheaper soda. Unlike my study, Lal et al.'s model categorized SSBs into soft drinks, cordial, and fruit drink (45). According to the price elasticities used by Lal's study, each income group reacted differently to each SSB type (75). For example, the reduction in consumption of soft drinks was estimated to be higher among the low-income group while the reduction in consumption of fruit drink was estimated to be higher among the high-income group (75). Also, shifting effect was not strong enough as consumption of three SSB types were all estimated to be reduced for all three income groups (75). Future Canadian studies could calculate own- and cross-price elasticities for more types of beverages, disaggregating consumption of sugary drinks for different types of sugary drinks, and used different price estimates for each beverage category.

It was challenging to obtain income-specific disease incidence, prevalence, and mortality rate for nine diseases that contribute to most of the health care burden attributable to obesity and overweight. Linked administrative data and national health surveys provided by Statistics Canada made it possible to estimate cancer incidence, disease-specific mortality rates, and prevalence for chronic diseases. Many studies have used these linked data to explore the relationship between socioeconomic characteristics and health outcomes (115-118). However, data for chronic disease incidence are lacking on a national level. Also, as discussed in the report, the self-report response bias of the prevalence of chronic diseases exists. The next step for Statistics Canada should be linking chronic disease data such as the Canadian Chronic Disease Surveillance System to the census or national surveys to allow researchers to explore relationships between chronic diseases and socioeconomic characteristics in Canada as it is central to public health and economic research.

As discussed earlier, disease epidemiology data are not always available (119). Dismod II was used to obtain case fatality and to smooth the gaps between different age groups to generate coherent data using one-year intervals. Dismod II was originally developed to model and estimate missing data for Global Burden Disease studies by Jan Barendregt of the Department of Public Health of Erasmus University in the Netherlands (120, 121). While the validity of Dismod II has been challenged by Scarborough et al. which found inconsistency in the incidence of heart attack between the modelled estimates of Dismod and estimates derived from administrative data (122), Dismod II is still the best available method to estimate epidemiology data when data are not available for direct measurement.

Income was chosen as a proxy to socioeconomic status in my study as a common deprivation index is not available in Canada (123). Popular deprivation indices include the one developed by Pampalon et al. (124) and the Canadian Marginalization Index (125). Different government reports have been using different indices or developed indices of their own (11, 126, 127), making it difficult to compare or use in further research. Unlike Canada, Australia developed Socio-Economic Indexes for Areas (SEIFA) and it has been consistently used in many studies

(45, 128). Statistics Canada should develop a deprivation index and integrate it into national surveys and administrative data to promote its use.

Limitations

Some limitations have been discussed in the previous chapter including statistical significance of differences between income quintiles, non-dynamic income status throughout the lifetime, assumption of income-specific beverage consumption, self-report response bias from the survey data, and limitations inherited from the original Jones' model. Additional limitations include the following: the model assumed the whole Canadian population had the same relative risk of high BMI for obesity-related diseases because relative risks for people with BMI under 22.5 is unavailable. The income-specific own-price elasticities were estimates from 2001 data and the cross-price elasticities were from Australia. It may not well represent the current Canadian population consumption behavior but it is the best available data source. Related to this the model did not capture the potential migrating effects between different types of sugary drinks because income-specific price elasticities for these were not available. Finally, Dismod II was used to estimate disease epidemiology data as directly measured data were unavailable for case fatality and the sample size of the data was not big enough for the estimations by one-year age group. In summary, the assumption of income-specific beverage consumption might make health benefit more progressive. However, the impact of the rest of the limitations on financial and health regressivity is unclear.

Policy Implications

Though the sugary drink tax seems effective and does not harm health equality, it has strong opposition from the beverage industry. Besides, there are legislative and administrative costs which are not included in my study. Future research should include these costs to provide a cost-effectiveness analysis from an overall government's perspective.

The study results may not be applicable to the indigenous population in Canada. Firstly, the indigenous populations have higher consumption of sugary drinks, higher prevalence of obesity and diabetes (49, 129, 130). Secondly, the costs of food in northern Canada are also much higher. Thus, the potential sugary drink tax burden could be much higher for the indigenous community compared to the rest of the Canada. Additionally, some critics argue that owing to the lack of safe drinking water, indigenous population rely on sugary drinks for hydration (131). However, sugary drinks should not be the primary source for hydration. Canadian government should invest on policies that can provide safe and cheap water and the revenue raised by the sugary drink tax may be used to invest such programs.

Other policies that could curb consumption of sugary drinks should also be considered, such as limiting the sizes of single-serving drinks or banning free refills of sugary drinks in restaurants. Limiting the sizes of drinks was predicted to be cost-effective in New Zealand's modelling study (132). France has banned free refill since 2017 (133), and the government of the UK is also interested in this policy (134).

It is important to remember that obesity results from a complex combination of determinants and contributing factors such as physical activity, sedentary behaviours and screen time, diet, and socioeconomic status (12). Reducing consumption of sugary drinks address the issue among diet domain, and policies tackle different factors are also required to improve the obesity crisis.

Conclusion

Low-income Canadians would gain the most health benefit from a sugary drinks tax but would pay the largest proportion of income in tax. However, the absolute difference in the tax burden across income groups is relatively small. If this regressivity is a concern, policy makers may consider mitigating this by investing the revenue raised from a sugary drinks tax into policies that reduce health or income inequalities.

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Appendix A: Data Input

Appendix Table A.1 Mean consumed volume (ml) of sugary drinks in 2015 by sex, age, and income quintile

		Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Sex	*Age group*	*Mean ± SD*	*Mean ± SD*	*Mean ± SD*	*Mean ± SD*	*Mean ± SD*
Female	0-9	236.98±6.30	236.98±6.30	236.98±6.30	236.98±6.30	236.98±6.30
	10-19	349.90±8.00	349.90±8.00	349.90±8.00	349.90±8.00	349.90±8.00
	20-29	298.48±13.19	301.36±13.31	302.99±13.39	286.47±12.66	258.73±11.43
	30-39	234.83±10.36	237.09±10.46	238.38±10.52	225.38±9.95	203.55±8.98
	40-49	191.63±8.94	193.48±9.03	194.53±9.07	183.92±8.58	166.11±7.75
	50-59	181.94±8.79	183.70±8.88	184.69±8.93	174.62±8.44	157.71±7.62
	60-69	159.49±7.64	161.02±7.71	161.90±7.75	153.07±7.33	138.24±6.62
	70-79	164.43±7.70	166.02±7.77	166.92±7.82	157.82±7.39	142.53±6.67
	80-89	176.58±9.82	178.28±9.92	179.25±9.97	169.47±9.43	153.06±8.52
	90+	192.43±19.60	194.29±19.79	195.34±19.90	184.69±18.81	166.80±16.99
Male	0-9	275.30±7.20	275.30±7.20	275.30±7.20	275.30±7.20	275.30±7.20
	10-19	518.65±11.74	518.65±11.74	518.65±11.74	518.65±11.74	518.65±11.74
	20-29	482.74±20.07	487.39±20.26	490.04±20.37	463.32±19.26	418.44±17.40
	30-39	393.87±15.70	397.66±15.85	399.82±15.94	378.02±15.07	341.41±13.61
	40-49	302.70±12.65	305.62±12.77	307.28±12.84	290.52±12.14	262.39±10.96
	50-59	250.14±10.46	252.55±10.56	253.92±10.62	240.08±10.04	216.82±9.06
	60-69	234.57±11.19	236.84±11.30	238.12±11.36	225.14±10.74	203.33±9.70
	70-79	170.56±9.07	172.21±9.16	173.14±9.21	163.70±8.71	147.85±7.86
	80-89	216.34±19.62	218.42±19.81	219.61±19.92	207.63±18.83	187.52±17.01
	90+	235.65±40.50	237.92±40.89	239.21±41.11	226.17±38.87	204.26±35.11

Appendix Table A.2 Mean consumed volume (ml) of milk in 2015 by sex, age, and income quintile

		Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Sex	*Age group*	*Mean ± SD*	*Mean ± SD*	*Mean ± SD*	*Mean ± SD*	*Mean ± SD*
Female	0-9	257.44±6.64	257.44±6.64	257.44±6.64	257.44±6.64	257.44±6.64
	10-19	176.29±5.97	176.29±5.97	176.29±5.97	176.29±5.97	176.29±5.97
	20-29	91.90±7.41	91.11±7.35	91.26±7.36	89.70±7.24	83.93±6.77
	30-39	90.66±4.51	89.88±4.47	90.03±4.48	88.50±4.40	82.80±4.12
	40-49	102.17±5.12	101.29±5.07	101.46±5.08	99.73±4.99	93.31±4.67
	50-59	82.06±4.53	81.35±4.49	81.48±4.50	80.09±4.42	74.94±4.14
	60-69	105.62±4.85	104.71±4.81	104.88±4.81	103.09±4.73	96.46±4.43
	70-79	108.31±5.48	107.38±5.44	107.55±5.45	105.72±5.35	98.92±5.01
	80-89	110.20±6.42	109.25±6.36	109.43±6.37	107.57±6.26	100.64±5.86
	90+	111.77±12.43	110.81±12.32	110.99±12.35	109.10±12.13	102.08±11.35
Male	0-9	300.80±7.60	300.80±7.60	300.80±7.60	300.80±7.60	300.80±7.60
	10-19	221.95±7.05	221.95±7.05	221.95±7.05	221.95±7.05	221.95±7.05
	20-29	137.27±8.94	136.10±8.86	136.32±8.88	133.99±8.73	125.37±8.17
	30-39	105.58±7.53	104.67±7.46	104.84±7.48	103.05±7.35	96.42±6.88
	40-49	96.80±6.05	95.97±6.00	96.13±6.01	94.49±5.90	88.41±5.53
	50-59	105.21±5.58	104.30±5.53	104.48±5.54	102.69±5.44	96.09±5.09
	60-69	117.98±6.76	116.97±6.70	117.16±6.71	115.16±6.60	107.75±6.17
	70-79	145.32±6.38	144.07±6.33	144.31±6.34	141.85±6.23	132.72±5.83
	80-89	138.66±9.64	137.47±9.56	137.70±9.57	135.35±9.41	126.64±8.81
	90+	190.97±32.48	189.33±32.20	189.64±32.26	186.40±31.71	174.41±29.67

Appendix Table A.3 Mean consumed volume (ml) of diet beverages in 2015 by sex, age, and income quintile

		Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Sex	*Age group*	*Mean ± SD*	*Mean ± SD*	*Mean ± SD*	*Mean ± SD*	*Mean ± SD*
Female	0-9	7.32±1.56	7.32±1.56	7.32±1.56	7.32±1.56	7.32±1.56
	10-19	13.67±2.00	13.67±2.00	13.67±2.00	13.67±2.00	13.67±2.00
	20-29	23.14±3.79	25.04±4.10	28.94±4.74	33.22±5.44	43.25±7.09
	30-39	42.02±4.54	45.47±4.91	52.54±5.68	60.33±6.52	78.53±8.49
	40-49	38.88±4.21	42.07±4.55	48.62±5.26	55.82±6.04	72.67±7.86
	50-59	40.75±5.02	44.10±5.44	50.96±6.28	58.51±7.21	76.17±9.39
	60-69	39.07±3.72	42.28±4.03	48.86±4.65	56.10±5.34	73.03±6.96
	70-79	32.73±3.61	35.42±3.91	40.94±4.51	47.00±5.18	61.18±6.74
	80-89	14.41±3.66	15.59±3.96	18.02±4.57	20.69±5.25	26.93±6.83
	90+	6.86±4.92	7.42±5.32	8.58±6.15	9.85±7.06	12.82±9.19
Male	0-9	4.38±1.09	4.38±1.09	4.38±1.09	4.38±1.09	4.38±1.09
	10-19	20.77±2.79	20.77±2.79	20.77±2.79	20.77±2.79	20.77±2.79
	20-29	16.32±3.67	17.66±3.97	20.41±4.59	23.43±5.27	30.50±6.86
	30-39	30.81±3.87	33.34±4.18	38.53±4.83	44.24±5.55	57.59±7.23
	40-49	58.20±6.54	62.99±7.07	72.79±8.17	83.57±9.38	108.79±12.22
	50-59	46.20±4.07	50.00±4.40	57.78±5.09	66.34±5.84	86.36±7.60
	60-69	43.47±4.52	47.05±4.89	54.37±5.65	62.42±6.49	81.26±8.45
	70-79	66.36±6.96	71.82±7.54	82.99±8.71	95.28±10.00	124.03±13.01
	80-89	17.37±3.67	18.79±3.97	21.72±4.59	24.94±5.27	32.46±6.86
	90+	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00

Appendix Table A.4 Mean energy density (kcal/litre) of milk, diet beverages, sugary drinks by sex, age, and income quintile

		Milk					Diet beverages					Sugary drinks				
Sex	*Age group*	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
Female	0-9	516.5	516.5	516.5	516.5	516.5	61.8	61.8	61.8	61.8	61.8	520.0	520.0	520.0	520.0	520.0
	10-19	475.6	475.6	475.6	475.6	475.6	37.9	37.9	37.9	37.9	37.9	493.0	493.0	493.0	493.0	493.0
	20-29	531.9	515.1	505.4	498.1	478.6	27.7	30.4	22.5	21.5	52.1	501.7	471.7	472.4	477.9	498.9
	30-39	510.6	494.5	485.2	478.2	459.5	18.2	20.0	14.8	14.1	34.2	482.2	453.4	454.0	459.3	479.5
	40-49	503.1	487.2	478.1	471.2	452.8	22.5	24.8	18.3	17.5	42.4	454.6	427.4	428.0	433.0	452.0
	50-59	486.3	470.9	462.1	455.4	437.6	12.4	13.7	10.1	9.7	23.4	476.0	447.5	448.1	453.4	473.3
	60-69	481.6	466.4	457.6	451.0	433.4	23.7	26.1	19.3	18.5	44.6	459.6	432.1	432.7	437.8	457.0
	70-79	463.1	448.5	440.1	433.7	416.8	24.3	26.8	19.8	19.0	45.8	445.4	418.8	419.4	424.3	442.9
	80-89	470.6	455.7	447.1	440.7	423.5	22.9	25.1	18.6	17.8	43.0	458.1	430.6	431.2	436.3	455.4
	90+	494.8	479.1	470.1	463.4	445.2	9.8	10.8	8.0	7.6	18.4	477.9	449.3	450.0	455.2	475.2
Male	0-9	525.6	525.6	525.6	525.6	525.6	30.8	30.8	30.8	30.8	30.8	518.0	518.0	518.0	518.0	518.0
	10-19	480.8	480.8	480.8	480.8	480.8	39.4	39.4	39.4	39.4	39.4	470.0	470.0	470.0	470.0	470.0
	20-29	549.5	532.1	522.1	514.7	494.5	25.5	28.0	20.7	19.8	48.0	486.5	457.4	458.1	463.4	483.8
	30-39	495.3	479.7	470.7	463.9	445.8	30.3	33.3	24.7	23.6	57.0	521.0	489.8	490.5	496.2	518.0
	40-49	506.6	490.6	481.4	474.5	455.9	16.0	17.6	13.1	12.5	30.2	452.0	424.9	425.5	430.5	449.4
	50-59	497.0	481.3	472.3	465.5	447.3	25.1	27.6	20.4	19.6	47.3	450.7	423.7	424.3	429.3	448.1
	60-69	485.6	470.3	461.4	454.8	437.0	16.7	18.4	13.6	13.0	31.5	448.5	421.7	422.3	427.2	446.0
	70-79	493.4	477.8	468.9	462.1	444.0	24.6	27.0	20.0	19.1	46.2	438.3	412.0	412.6	417.5	435.8
	80-89	492.6	477.0	468.1	461.3	443.3	24.0	26.4	19.5	18.7	45.1	470.5	442.4	443.0	448.2	467.9
	90+	550.0	532.6	522.6	515.1	494.9	0.0	0.0	0.0	0.0	0.0	485.4	456.3	457.0	462.3	482.6

Appendix Table A.5 Data sources for adjustment ratios of 7 selected diseases.

Disease	Data Sources for Adjustment Ratios
Colon and rectum cancer	Incidence rates: CanCHEC 2001 (72) Prevalence rate: Did not adjust Mortality rate: CanCHEC 2001 (72)
Ischemic heart disease	Incidence rates: Australian Institute of Health and Welfare (45, 135) Prevalence rate: CCHS 2017 (92) Mortality rate: CanCHEC 2001 (72)
Ischemic stroke	Incidence rates: Australian Institute of Health and Welfare (45, 135) Prevalence rate: CCHS 2017 (92) Mortality rate: CanCHEC 2001 (72)
Hemorrhagic stroke	Incidence rates: Australian Institute of Health and Welfare (45, 135) Prevalence rate: CCHS 2017 (92) Mortality rate: CanCHEC 2001 (72)
Hypertensive heart disease	Incidence rates: Did not adjust Prevalence rate: CCHS 2017 (92) Mortality rate: CanCHEC 2001 (72)
Type 2 diabetes mellitus	Incidence rates: Ross's study that analyzed the National Population Health Survey (136) Prevalence rate: CCHS 2017 (92) Mortality rate: CanCHEC 2001 (72)
Chronic kidney disease	Incidence rates: Did not adjust Prevalence rate: CHMS cycle 3&4 (93) Mortality rate: CanCHEC 2001 (72)

Appendix Table A.6 Direct health care costs (2016 Canadian dollars)

Sex	Age	*Esophageal cancer*	*Colon & rectum cancer*	*Liver cancer*	*Gallbladder & biliary tract cancer*	*Pancreatic Cancer*	*Breast cancer*	*Uterine cancer*	*Ovarian cancer*
		Per incident case	*Per incident case*	*Per incident case*	*Per incident case*	*Per incident case*	*Per incident case*	*Per incident case*	*Per incident case*
Male	<55	64,583	60,551	57,370	151,966	45,537	N/A	N/A	N/A
	55–64	89,061	54,350	62,578	85,778	48,956	N/A	N/A	N/A
	65–74	75,539	56,968	60,165	102,863	66,919	N/A	N/A	N/A
	75+	60,370	64,586	42,770	60,863	39,656	N/A	N/A	N/A
Female	<55	86,945	51,334	131,990	192,251	52,548	47,643	24,686	48,800
	55–64	117,168	53,782	62,294	165,044	54,271	67,183	24,169	66,544
	65–74	86,554	57,268	64,939	101,328	50,575	39,019	28,116	59,901
	75+	53,698	55,551	56,461	64,801	36,486	30,411	28,458	38,368
Sex	*Age*	***Kidney cancer***	***Thyroid cancer***	***Leukemia***	***IHD***	***Ischemic stroke***	***Hemorrhagic stroke***	***HHD***	***T2DM***
		Per incident case	*Per incident case*	*Per incident case*	*Per prevalent case*	*Per prevalent case*	*Per prevalent case*	*Per prevalent case*	*Per prevalent case*
Male	<55	28,646	20,329	151,282	4,767	13,276	13,276	35,126	3,232
	55–64	28,910	25,424	67,727	4,856	17,371	17,371	38,248	2,063
	65–74	35,087	23,534	44,480	4,636	19,179	19,179	47,595	1,979
	75+	29,433	34,848	28,571	3,426	29,836	29,836	23,908	1,683
Female	<55	29,381	18,752	186,803	2,534	10,765	10,765	59,797	2,107
	55–64	24,144	19,657	125,409	2,999	10,956	10,956	88,638	2,043
	65–74	38,968	23,784	53,561	3,194	15,719	15,719	47,577	2,076
	75+	33,572	26,467	30,489	2,468	29,594	29,594	14,569	1,406
Sex	*Age*	***CKD due to DM***	***CKD due to hypertension***	***CKD due to glomerulonephritis***	***CKD due to other causes***	***Osteoarthritis of the hip***	***Osteoarthritis of the knee***	***Low back pain***	***All other conditions***
		Per prevalent case	*Per prevalent case*	*Per prevalent case*	*Per prevalent case*	*Per prevalent case*	*Per prevalent case*	*Per prevalent case*	*Per person*
Male	<55	1,690	1,690	1,690	1,690	1,023	1,023	691	2,798
	55–64	1,583	1,583	1,583	1,583	1,463	1,463	664	6,232
	65–74	1,355	1,355	1,355	1,355	1,925	1,925	587	10,504
	75+	1,808	1,808	1,808	1,808	2,046	2,046	718	17,545
Female	<55	986	986	986	986	1,152	1,152	539	3,921
	55–64	597	597	597	597	1,502	1,502	420	6,437
	65–74	733	733	733	733	1,925	1,925	477	9,103
	75+	954	954	954	954	2,074	2,074	746	14,803

CKD: chronic kidney disease; IHD: ischemic heart disease; HHD: hypertensive heart disease

Appendix B: Additional Results

Appendix Table B.1 Mean change in per capita daily energy intake (kcal) from sugary drinks due to 20% sugary drink tax by income quintile and 5-year age groups, females

	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5	
Age group	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*
20-24	-23.10	(-26.24, -19.98)	-21.39	(-24.38, -18.58)	-20.97	(-24.02, -18.16)	-20.17	(-23.03, -17.35)	-19.31	(-22.08, -16.74)
25-29	-23.11	(-26.35, -19.96)	-21.40	(-24.34, -18.57)	-20.97	(-24.05, -18.11)	-20.17	(-23.13, -17.32)	-19.35	(-22.16, -16.65)
30-34	-17.45	(-19.86, -15.11)	-16.15	(-18.45, -13.94)	-15.88	(-18.23, -13.72)	-15.23	(-17.49, -13.14)	-14.64	(-16.73, -12.67)
35-39	-17.44	(-19.88, -15.08)	-16.19	(-18.49, -14.02)	-15.88	(-18.21, -13.63)	-15.23	(-17.50, -13.10)	-14.64	(-16.75, -12.61)
40-44	-13.44	(-15.41, -11.59)	-12.45	(-14.22, -10.69)	-12.23	(-14.06, -10.56)	-11.72	(-13.43, -10.09)	-11.24	(-12.89, -9.70)
45-49	-13.42	(-15.39, -11.56)	-12.43	(-14.23, -10.72)	-12.21	(-13.92, -10.56)	-11.72	(-13.53, -10.04)	-11.27	(-12.88, -9.65)
50-54	-13.36	(-15.27, -11.42)	-12.38	(-14.25, -10.68)	-12.14	(-13.92, -10.45)	-11.66	(-13.44, -10.11)	-11.18	(-12.84, -9.61)
55-59	-13.36	(-15.21, -11.54)	-12.38	(-14.11, -10.73)	-12.15	(-13.96, -10.44)	-11.65	(-13.38, -9.92)	-11.17	(-12.85, -9.59)
60-64	-11.32	(-13.01, -9.77)	-10.45	(-12.04, -8.93)	-10.27	(-11.81, -8.82)	-9.84	(-11.38, -8.37)	-9.47	(-10.84, -8.16)
65-69	-11.31	(-13.06, -9.71)	-10.47	(-11.99, -9.08)	-10.29	(-11.78, -8.90)	-9.86	(-11.34, -8.45)	-9.47	(-10.91, -8.14)
70-74	-11.30	(-12.97, -9.77)	-10.46	(-11.95, -9.07)	-10.25	(-11.68, -8.85)	-9.88	(-11.33, -8.52)	-9.46	(-10.80, -8.24)
75-79	-11.29	(-12.89, -9.73)	-10.47	(-11.93, -9.11)	-10.24	(-11.73, -8.79)	-9.87	(-11.36, -8.49)	-9.47	(-10.88, -8.14)
80+	-12.99	(-14.83, -11.19)	-11.99	(-13.75, -10.39)	-11.75	(-13.39, -10.14)	-11.30	(-12.83, -9.83)	-10.86	(-12.38, -9.43)
Total (20+)†	-15.36	(-17.04, -13.70)	-13.86	(-15.38, -12.37)	-13.69	(-15.24, -12.10)	-13.23	(-14.75, -11.69)	-12.64	(-14.09, -11.25)

95% CI, 95% credible interval
†Total group was adjusted for Canadian population size

Appendix Table B.2 Mean change in per capita daily energy intake (kcal) from sugary drinks due to 20% sugary drink tax by income quintile and 5-year age groups, males

	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5	
Age group	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*
20-24	-36.28	(-41.55, -31.50)	-33.56	(-38.13, -29.22)	-32.98	(-37.67, -28.48)	-31.57	(-36.05, -27.36)	-30.32	(-34.45, -26.48)
25-29	-36.24	(-41.20, -31.54)	-33.50	(-38.04, -29.21)	-32.88	(-37.53, -28.52)	-31.60	(-36.03, -27.36)	-30.33	(-34.62, -26.39)
30-34	-31.70	(-36.02, -27.71)	-29.33	(-33.40, -25.66)	-28.76	(-32.56, -24.85)	-27.58	(-31.50, -23.94)	-26.49	(-30.13, -23.05)
35-39	-31.65	(-36.01, -27.54)	-29.29	(-33.23, -25.46)	-28.76	(-32.80, -24.93)	-27.57	(-31.45, -23.95)	-26.47	(-30.08, -23.12)
40-44	-21.11	(-23.98, -18.26)	-19.52	(-22.36, -17.01)	-19.19	(-21.79, -16.57)	-18.41	(-20.98, -15.86)	-17.66	(-20.22, -15.27)
45-49	-21.10	(-23.97, -18.32)	-19.55	(-22.31, -17.09)	-19.16	(-21.85, -16.70)	-18.38	(-20.90, -15.77)	-17.66	(-20.14, -15.34)
50-54	-17.39	(-19.87, -15.12)	-16.11	(-18.27, -14.06)	-15.81	(-18.09, -13.69)	-15.17	(-17.36, -13.06)	-14.56	(-16.65, -12.66)
55-59	-17.38	(-19.84, -15.18)	-16.10	(-18.33, -13.98)	-15.80	(-18.00, -13.71)	-15.18	(-17.35, -13.09)	-14.54	(-16.58, -12.68)
60-64	-16.22	(-18.56, -13.96)	-15.04	(-17.23, -12.97)	-14.75	(-17.02, -12.68)	-14.18	(-16.27, -12.07)	-13.56	(-15.58, -11.66)
65-69	-16.21	(-18.62, -13.91)	-15.03	(-17.17, -12.90)	-14.73	(-16.92, -12.70)	-14.13	(-16.32, -12.12)	-13.59	(-15.61, -11.76)
70-74	-11.54	(-13.31, -9.78)	-10.68	(-12.38, -9.16)	-10.49	(-12.14, -8.95)	-10.06	(-11.60, -8.61)	-9.65	(-11.16, -8.27)
75-79	-11.51	(-13.28, -9.81)	-10.66	(-12.30, -9.09)	-10.47	(-12.01, -8.90)	-10.08	(-11.62, -8.55)	-9.64	(-11.14, -8.27)
80+	-16.18	(-19.20, -13.43)	-15.05	(-17.74, -12.55)	-14.64	(-17.35, -12.18)	-14.10	(-16.67, -11.65)	-13.58	(-16.17, -11.19)
Total (20+)†	-23.51	(-26.13, -21.01)	-21.13	(-23.51, -18.86)	-20.97	(-23.29, -18.63)	-20.22	(-22.56, -17.80)	-19.12	(-21.35, -17.07)

95% CI, 95% credible interval
†Total group was adjusted for Canadian population size

Appendix Table B.3 Mean change in per capita daily energy intake (kcal) from plain milk due to 20% sugary drink tax by income quintile and 5-year age groups, females

	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5	
Age group	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*
20-24	0.20	(0.08, 0.34)	0.44	(0.18, 0.71)	0.68	(0.25, 1.11)	0.48	(0.19, 0.77)	0.27	(0.11, 0.44)
25-29	0.20	(0.08, 0.33)	0.44	(0.17, 0.72)	0.68	(0.26, 1.12)	0.48	(0.19, 0.78)	0.27	(0.12, 0.45)
30-34	0.19	(0.08, 0.31)	0.42	(0.17, 0.67)	0.64	(0.25, 1.06)	0.45	(0.18, 0.72)	0.26	(0.11, 0.42)
35-39	0.19	(0.08, 0.32)	0.42	(0.16, 0.68)	0.64	(0.25, 1.04)	0.45	(0.18, 0.72)	0.26	(0.11, 0.42)
40-44	0.21	(0.09, 0.35)	0.47	(0.18, 0.74)	0.71	(0.28, 1.16)	0.50	(0.20, 0.81)	0.29	(0.12, 0.46)
45-49	0.21	(0.09, 0.35)	0.47	(0.18, 0.74)	0.71	(0.28, 1.16)	0.50	(0.20, 0.81)	0.29	(0.12, 0.45)
50-54	0.17	(0.07, 0.27)	0.36	(0.14, 0.58)	0.55	(0.21, 0.90)	0.39	(0.16, 0.63)	0.22	(0.10, 0.36)
55-59	0.17	(0.07, 0.27)	0.36	(0.14, 0.58)	0.55	(0.21, 0.90)	0.39	(0.16, 0.63)	0.22	(0.09, 0.36)
60-64	0.21	(0.09, 0.35)	0.46	(0.18, 0.74)	0.71	(0.27, 1.15)	0.50	(0.20, 0.80)	0.28	(0.12, 0.46)
65-69	0.21	(0.09, 0.35)	0.46	(0.18, 0.74)	0.71	(0.27, 1.17)	0.49	(0.20, 0.80)	0.28	(0.12, 0.46)
70-74	0.21	(0.09, 0.34)	0.45	(0.18, 0.72)	0.70	(0.27, 1.14)	0.49	(0.20, 0.78)	0.28	(0.12, 0.45)
75-79	0.21	(0.09, 0.34)	0.45	(0.18, 0.72)	0.70	(0.27, 1.14)	0.49	(0.20, 0.78)	0.28	(0.12, 0.45)
80+	0.22	(0.09, 0.36)	0.48	(0.18, 0.77)	0.73	(0.28, 1.20)	0.51	(0.20, 0.82)	0.29	(0.13, 0.48)
Total (20+)†	0.20	(0.08, 0.32)	0.44	(0.17, 0.69)	0.66	(0.26, 1.07)	0.46	(0.18, 0.74)	0.26	(0.11, 0.42)

95% CI, 95% credible interval
†Total group was adjusted for Canadian population size

Appendix Table B.4 Mean change in per capita daily energy intake (kcal) from plain milk due to 20% sugary drink tax by income quintile and 5-year age groups, males

	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5	
Age group	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*
20-24	0.31	(0.13, 0.52)	0.68	(0.27, 1.10)	1.05	(0.39, 1.71)	0.73	(0.29, 1.19)	0.42	(0.18, 0.69)
25-29	0.31	(0.13, 0.51)	0.68	(0.26, 1.09)	1.04	(0.41, 1.71)	0.73	(0.29, 1.20)	0.42	(0.18, 0.69)
30-34	0.22	(0.09, 0.36)	0.47	(0.18, 0.77)	0.73	(0.27, 1.20)	0.51	(0.20, 0.83)	0.29	(0.12, 0.47)
35-39	0.22	(0.09, 0.36)	0.47	(0.19, 0.77)	0.72	(0.28, 1.21)	0.51	(0.20, 0.84)	0.29	(0.12, 0.48)
40-44	0.20	(0.08, 0.33)	0.44	(0.18, 0.72)	0.68	(0.27, 1.12)	0.48	(0.19, 0.78)	0.27	(0.11, 0.44)
45-49	0.20	(0.08, 0.33)	0.44	(0.17, 0.72)	0.68	(0.26, 1.13)	0.48	(0.19, 0.77)	0.27	(0.12, 0.45)
50-54	0.22	(0.09, 0.36)	0.47	(0.18, 0.76)	0.72	(0.28, 1.20)	0.51	(0.20, 0.83)	0.29	(0.12, 0.47)
55-59	0.22	(0.09, 0.35)	0.47	(0.18, 0.76)	0.73	(0.28, 1.19)	0.51	(0.20, 0.83)	0.29	(0.12, 0.47)
60-64	0.24	(0.10, 0.39)	0.52	(0.20, 0.84)	0.80	(0.30, 1.29)	0.56	(0.22, 0.91)	0.32	(0.14, 0.52)
65-69	0.24	(0.10, 0.39)	0.52	(0.20, 0.83)	0.79	(0.30, 1.30)	0.56	(0.22, 0.90)	0.32	(0.14, 0.52)
70-74	0.30	(0.12, 0.49)	0.65	(0.25, 1.04)	1.00	(0.39, 1.63)	0.70	(0.28, 1.12)	0.40	(0.17, 0.64)
75-79	0.30	(0.12, 0.49)	0.65	(0.26, 1.04)	1.00	(0.39, 1.62)	0.70	(0.28, 1.13)	0.40	(0.17, 0.64)
80+	0.32	(0.13, 0.53)	0.70	(0.27, 1.14)	1.07	(0.41, 1.77)	0.75	(0.30, 1.22)	0.43	(0.19, 0.70)
Total (20+)[†]	0.25	(0.11, 0.41)	0.55	(0.22, 0.87)	0.82	(0.32, 1.33)	0.57	(0.23, 0.91)	0.32	(0.14, 0.52)

95% CI, 95% credible interval
[†]Total group was adjusted for Canadian population size

Appendix Table B.5 Mean change in per capita daily energy intake (kcal) from diet beverages due to 20% sugary drink tax by income quintile and 5-year age groups, females

	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5	
Age group	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*
20-24	-0.01	(-0.01, 0.00)	0.02	(0.00, 0.05)	0.04	(0.00, 0.10)	0.03	(0.00, 0.07)	0.04	(0.00, 0.09)
25-29	-0.01	(-0.01, 0.00)	0.02	(0.00, 0.05)	0.04	(0.00, 0.10)	0.03	(0.00, 0.07)	0.04	(0.00, 0.09)
30-34	-0.01	(-0.01, 0.00)	0.03	(0.00, 0.06)	0.05	(0.00, 0.12)	0.04	(0.00, 0.08)	0.05	(0.00, 0.11)
35-39	-0.01	(-0.02, 0.00)	0.03	(0.00, 0.06)	0.05	(0.00, 0.12)	0.04	(0.00, 0.08)	0.05	(0.00, 0.10)
40-44	-0.02	(-0.03, 0.00)	0.06	(0.00, 0.13)	0.13	(0.00, 0.29)	0.09	(0.00, 0.20)	0.11	(-0.01, 0.24)
45-49	-0.02	(-0.04, 0.00)	0.06	(0.00, 0.13)	0.13	(-0.01, 0.28)	0.09	(0.00, 0.19)	0.11	(-0.01, 0.25)
50-54	-0.01	(-0.02, 0.00)	0.03	(0.00, 0.06)	0.06	(0.00, 0.13)	0.04	(0.00, 0.08)	0.05	(0.00, 0.11)
55-59	-0.01	(-0.02, 0.00)	0.03	(0.00, 0.06)	0.06	(0.00, 0.12)	0.04	(0.00, 0.08)	0.05	(0.00, 0.11)
60-64	-0.01	(-0.03, 0.00)	0.05	(0.00, 0.11)	0.10	(0.00, 0.22)	0.07	(0.00, 0.15)	0.09	(-0.01, 0.19)
65-69	-0.01	(-0.03, 0.00)	0.05	(0.00, 0.10)	0.10	(0.00, 0.22)	0.07	(0.00, 0.15)	0.09	(0.00, 0.19)
70-74	-0.02	(-0.04, 0.00)	0.08	(0.00, 0.16)	0.16	(-0.01, 0.35)	0.11	(0.00, 0.24)	0.14	(-0.01, 0.30)
75-79	-0.02	(-0.04, 0.00)	0.08	(0.00, 0.17)	0.16	(-0.01, 0.35)	0.11	(0.00, 0.23)	0.14	(-0.01, 0.30)
80+	0.00	(-0.01, 0.00)	0.01	(0.00, 0.03)	0.03	(0.00, 0.06)	0.02	(0.00, 0.04)	0.02	(0.00, 0.06)
Total (20+)[†]	-0.01	(-0.02, 0.00)	0.04	(0.00, 0.08)	0.08	(0.00, 0.18)	0.06	(0.00, 0.12)	0.07	(0.00, 0.15)

95% CI, 95% credible interval
[†]Total group was adjusted for Canadian population size

Appendix Table B.6 Mean change in per capita daily energy intake (kcal) from diet beverages due to 20% sugary drink tax by income quintile and 5-year age groups, males

	Quintile 1		**Quintile 2**		**Quintile 3**		**Quintile 4**		**Quintile 5**	
Age group	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*
20-24	-0.01	(-0.01, 0.00)	0.02	(0.00, 0.05)	0.04	(0.00, 0.09)	0.03	(0.00, 0.07)	0.04	(0.00, 0.08)
25-29	-0.01	(-0.01, 0.00)	0.02	(0.00, 0.05)	0.04	(0.00, 0.10)	0.03	(0.00, 0.06)	0.04	(0.00, 0.08)
30-34	-0.01	(-0.03, 0.00)	0.04	(0.00, 0.09)	0.09	(0.00, 0.20)	0.06	(0.00, 0.14)	0.08	(-0.01, 0.17)
35-39	-0.01	(-0.02, 0.00)	0.04	(0.00, 0.09)	0.09	(0.00, 0.20)	0.06	(0.00, 0.14)	0.08	(0.00, 0.18)
40-44	-0.01	(-0.02, 0.00)	0.04	(0.00, 0.09)	0.09	(0.00, 0.20)	0.06	(0.00, 0.14)	0.08	(0.00, 0.18)
45-49	-0.01	(-0.02, 0.00)	0.04	(0.00, 0.10)	0.09	(0.00, 0.20)	0.06	(0.00, 0.14)	0.08	(0.00, 0.18)
50-54	-0.01	(-0.03, 0.00)	0.05	(0.00, 0.12)	0.11	(-0.01, 0.25)	0.08	(0.00, 0.17)	0.10	(-0.01, 0.22)
55-59	-0.01	(-0.03, 0.00)	0.05	(0.00, 0.12)	0.11	(0.00, 0.25)	0.08	(0.00, 0.17)	0.10	(-0.01, 0.21)
60-64	-0.01	(-0.02, 0.00)	0.03	(0.00, 0.08)	0.07	(0.00, 0.15)	0.05	(0.00, 0.10)	0.06	(0.00, 0.13)
65-69	-0.01	(-0.02, 0.00)	0.03	(0.00, 0.07)	0.07	(0.00, 0.16)	0.05	(0.00, 0.10)	0.06	(0.00, 0.14)
70-74	-0.02	(-0.04, 0.00)	0.08	(0.00, 0.17)	0.16	(0.00, 0.35)	0.11	(0.00, 0.24)	0.14	(-0.01, 0.30)
75-79	-0.02	(-0.04, 0.00)	0.08	(0.00, 0.17)	0.16	(-0.01, 0.35)	0.11	(0.00, 0.23)	0.14	(-0.01, 0.31)
80+	0.00	(-0.01, 0.00)	0.01	(0.00, 0.03)	0.03	(0.00, 0.07)	0.02	(0.00, 0.05)	0.03	(0.00, 0.06)
Total (20+)[†]	-0.01	(-0.02, 0.00)	0.04	(0.00, 0.09)	0.09	(0.00, 0.19)	0.06	(0.00, 0.13)	0.08	(0.00, 0.17)

95% CI, 95% credible interval
[†]Total group was adjusted for Canadian population size

Appendix Table B.7 Mean change in per capita daily total energy intake (kcal) due to 20% sugary drink tax by income quintile and 5-year age groups, females

	Quintile 1		**Quintile 2**		**Quintile 3**		**Quintile 4**		**Quintile 5**	
Age group	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*
20-24	-22.91	(-25.98, -19.79)	-20.93	(-23.97, -18.05)	-20.25	(-23.37, -17.48)	-19.67	(-22.53, -16.92)	-19.00	(-21.82, -16.41)
25-29	-22.92	(-26.12, -19.77)	-20.93	(-23.92, -18.07)	-20.24	(-23.31, -17.31)	-19.66	(-22.61, -16.85)	-19.04	(-21.88, -16.33)
30-34	-17.26	(-19.69, -14.92)	-15.71	(-18.09, -13.54)	-15.19	(-17.58, -12.99)	-14.74	(-17.01, -12.65)	-14.33	(-16.46, -12.35)
35-39	-17.26	(-19.73, -14.90)	-15.74	(-18.07, -13.57)	-15.18	(-17.45, -12.91)	-14.74	(-16.98, -12.60)	-14.33	(-16.46, -12.29)
40-44	-13.24	(-15.22, -11.41)	-11.92	(-13.76, -10.10)	-11.39	(-13.27, -9.70)	-11.13	(-12.85, -9.47)	-10.84	(-12.51, -9.28)
45-49	-13.23	(-15.21, -11.35)	-11.90	(-13.71, -10.15)	-11.37	(-13.15, -9.64)	-11.14	(-12.95, -9.42)	-10.87	(-12.52, -9.30)
50-54	-13.20	(-15.10, -11.26)	-12.00	(-13.91, -10.26)	-11.53	(-13.32, -9.81)	-11.23	(-13.03, -9.66)	-10.91	(-12.60, -9.32)
55-59	-13.20	(-15.06, -11.37)	-11.99	(-13.76, -10.33)	-11.54	(-13.42, -9.79)	-11.22	(-12.98, -9.45)	-10.90	(-12.61, -9.29)
60-64	-11.12	(-12.81, -9.54)	-9.94	(-11.53, -8.44)	-9.46	(-11.03, -7.97)	-9.28	(-10.84, -7.80)	-9.10	(-10.48, -7.79)
65-69	-11.11	(-12.85, -9.51)	-9.96	(-11.54, -8.55)	-9.48	(-11.10, -7.99)	-9.30	(-10.76, -7.86)	-9.10	(-10.52, -7.75)
70-74	-11.11	(-12.78, -9.57)	-9.93	(-11.45, -8.51)	-9.39	(-10.90, -7.94)	-9.28	(-10.73, -7.94)	-9.05	(-10.42, -7.79)
75-79	-11.10	(-12.70, -9.54)	-9.94	(-11.47, -8.53)	-9.38	(-10.92, -7.91)	-9.27	(-10.78, -7.86)	-9.05	(-10.50, -7.67)
80+	-12.77	(-14.63, -10.98)	-11.50	(-13.31, -9.87)	-10.99	(-12.67, -9.35)	-10.77	(-12.34, -9.22)	-10.54	(-12.10, -9.10)
Total (20+)†	-15.17	(-16.84, -13.50)	-13.39	(-14.94, -11.84)	-12.94	(-14.52, -11.35)	-12.71	(-14.27, -11.18)	-12.31	(-13.77, -10.91)

95% CI, 95% credible interval
†Total group was adjusted for Canadian population size

Appendix Table B.8 Mean change in per capita daily total energy intake (kcal) due to 20% sugary drink tax by income quintile and 5-year age groups, males

	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5	
Age group	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*
20-24	-35.98	(-41.20, -31.23)	-32.85	(-37.51, -28.44)	-31.90	(-36.55, -27.45)	-30.81	(-35.28, -26.64)	-29.87	(-34.01, -25.95)
25-29	-35.93	(-40.94, -31.19)	-32.80	(-37.34, -28.51)	-31.80	(-36.39, -27.44)	-30.84	(-35.27, -26.61)	-29.88	(-34.15, -25.95)
30-34	-31.49	(-35.85, -27.52)	-28.81	(-32.92, -25.05)	-27.94	(-31.76, -23.98)	-27.00	(-30.96, -23.31)	-26.12	(-29.74, -22.72)
35-39	-31.44	(-35.79, -27.28)	-28.77	(-32.74, -24.90)	-27.95	(-31.94, -24.09)	-26.99	(-30.82, -23.46)	-26.10	(-29.71, -22.72)
40-44	-20.92	(-23.78, -18.08)	-19.03	(-21.86, -16.47)	-18.42	(-21.08, -15.79)	-17.87	(-20.41, -15.32)	-17.31	(-19.90, -14.96)
45-49	-20.91	(-23.75, -18.13)	-19.06	(-21.92, -16.57)	-18.39	(-21.06, -15.89)	-17.84	(-20.40, -15.19)	-17.31	(-19.82, -14.98)
50-54	-17.19	(-19.66, -14.93)	-15.59	(-17.79, -13.47)	-14.97	(-17.33, -12.79)	-14.58	(-16.79, -12.47)	-14.17	(-16.25, -12.21)
55-59	-17.18	(-19.63, -14.94)	-15.58	(-17.85, -13.40)	-14.96	(-17.14, -12.88)	-14.59	(-16.77, -12.49)	-14.15	(-16.22, -12.28)
60-64	-15.99	(-18.32, -13.73)	-14.48	(-16.72, -12.41)	-13.88	(-16.22, -11.82)	-13.57	(-15.69, -11.46)	-13.18	(-15.20, -11.31)
65-69	-15.98	(-18.41, -13.70)	-14.48	(-16.60, -12.37)	-13.87	(-16.07, -11.81)	-13.52	(-15.70, -11.49)	-13.21	(-15.22, -11.31)
70-74	-11.26	(-13.03, -9.51)	-9.95	(-11.69, -8.37)	-9.34	(-11.14, -7.71)	-9.26	(-10.86, -7.75)	-9.11	(-10.62, -7.73)
75-79	-11.23	(-13.03, -9.51)	-9.94	(-11.66, -8.33)	-9.32	(-10.95, -7.63)	-9.27	(-10.89, -7.66)	-9.10	(-10.62, -7.68)
80+	-15.86	(-18.88, -13.13)	-14.33	(-16.98, -11.75)	-13.54	(-16.32, -10.97)	-13.33	(-15.94, -10.88)	-13.12	(-15.71, -10.71)
Total (20+)†	-23.27	(-25.94, -20.76)	-20.54	(-23.00, -18.21)	-20.06	(-22.44, -17.72)	-19.59	(-22.05, -17.16)	-18.72	(-20.98, -16.63)

95% CI, 95% credible interval
†Total group was adjusted for Canadian population size

Appendix Table B.9 Mean change in body mass index (kg/m^2) due to 20% sugary tax by income quintile, 1 year after the implementation, females

	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5	
Age group	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*
20-24	-0.38	(-0.44, -0.32)	-0.35	(-0.40, -0.30)	-0.34	(-0.39, -0.28)	-0.33	(-0.38, -0.28)	-0.31	(-0.37, -0.27)
25-29	-0.38	(-0.44, -0.32)	-0.35	(-0.40, -0.30)	-0.34	(-0.39, -0.28)	-0.33	(-0.38, -0.28)	-0.32	(-0.37, -0.27)
30-34	-0.29	(-0.33, -0.24)	-0.26	(-0.31, -0.22)	-0.25	(-0.29, -0.21)	-0.24	(-0.28, -0.21)	-0.24	(-0.28, -0.20)
35-39	-0.29	(-0.33, -0.24)	-0.26	(-0.30, -0.22)	-0.25	(-0.30, -0.21)	-0.24	(-0.29, -0.21)	-0.24	(-0.27, -0.20)
40-44	-0.23	(-0.26, -0.19)	-0.20	(-0.24, -0.17)	-0.19	(-0.23, -0.16)	-0.19	(-0.22, -0.16)	-0.18	(-0.22, -0.16)
45-49	-0.23	(-0.26, -0.19)	-0.20	(-0.24, -0.17)	-0.19	(-0.23, -0.16)	-0.19	(-0.22, -0.16)	-0.19	(-0.22, -0.16)
50-54	-0.23	(-0.26, -0.19)	-0.21	(-0.24, -0.17)	-0.20	(-0.23, -0.17)	-0.19	(-0.22, -0.16)	-0.19	(-0.22, -0.16)
55-59	-0.23	(-0.26, -0.19)	-0.20	(-0.24, -0.17)	-0.20	(-0.23, -0.17)	-0.19	(-0.23, -0.16)	-0.19	(-0.22, -0.16)
60-64	-0.20	(-0.23, -0.17)	-0.18	(-0.21, -0.15)	-0.17	(-0.20, -0.14)	-0.16	(-0.19, -0.14)	-0.16	(-0.19, -0.14)
65-69	-0.20	(-0.23, -0.17)	-0.18	(-0.21, -0.15)	-0.17	(-0.20, -0.14)	-0.16	(-0.19, -0.14)	-0.16	(-0.19, -0.14)
70-74	-0.20	(-0.23, -0.17)	-0.18	(-0.21, -0.15)	-0.17	(-0.20, -0.14)	-0.16	(-0.19, -0.14)	-0.16	(-0.19, -0.14)
75-79	-0.20	(-0.23, -0.17)	-0.18	(-0.21, -0.15)	-0.17	(-0.20, -0.14)	-0.16	(-0.19, -0.14)	-0.16	(-0.19, -0.13)
80+	-0.23	(-0.26, -0.19)	-0.20	(-0.24, -0.17)	-0.19	(-0.23, -0.16)	-0.19	(-0.22, -0.16)	-0.19	(-0.22, -0.16)
Total (20+)[†]	-0.26	(-0.29, -0.22)	-0.23	(-0.26, -0.20)	-0.22	(-0.25, -0.19)	-0.22	(-0.25, -0.19)	-0.21	(-0.24, -0.18)

95% CI, 95% credible interval
[†]Total group was adjusted for Canadian population size

Appendix Table B.10 Mean change in body mass index (kg/m^2) due to 20% sugary tax by income quintile, 1 year after the implementation, males

	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5	
Age group	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*
20-24	*-0.51*	*(-0.60, -0.44)*	*-0.47*	*(-0.54, -0.40)*	*-0.45*	*(-0.53, -0.38)*	*-0.44*	*(-0.51, -0.37)*	*-0.42*	*(-0.49, -0.36)*
25-29	*-0.51*	*(-0.59, -0.44)*	*-0.47*	*(-0.54, -0.40)*	*-0.45*	*(-0.52, -0.39)*	*-0.44*	*(-0.50, -0.37)*	*-0.42*	*(-0.49, -0.36)*
30-34	*-0.45*	*(-0.52, -0.39)*	*-0.41*	*(-0.47, -0.35)*	*-0.40*	*(-0.46, -0.34)*	*-0.38*	*(-0.44, -0.33)*	*-0.37*	*(-0.43, -0.32)*
35-39	*-0.45*	*(-0.52, -0.38)*	*-0.41*	*(-0.47, -0.35)*	*-0.40*	*(-0.46, -0.34)*	*-0.38*	*(-0.44, -0.33)*	*-0.37*	*(-0.43, -0.32)*
40-44	*-0.30*	*(-0.34, -0.25)*	*-0.27*	*(-0.32, -0.23)*	*-0.26*	*(-0.31, -0.22)*	*-0.26*	*(-0.30, -0.22)*	*-0.25*	*(-0.28, -0.21)*
45-49	*-0.30*	*(-0.35, -0.25)*	*-0.27*	*(-0.32, -0.23)*	*-0.26*	*(-0.31, -0.22)*	*-0.25*	*(-0.30, -0.21)*	*-0.25*	*(-0.28, -0.21)*
50-54	*-0.25*	*(-0.29, -0.21)*	*-0.22*	*(-0.26, -0.19)*	*-0.21*	*(-0.25, -0.18)*	*-0.21*	*(-0.24, -0.18)*	*-0.20*	*(-0.23, -0.17)*
55-59	*-0.25*	*(-0.28, -0.21)*	*-0.22*	*(-0.26, -0.19)*	*-0.21*	*(-0.25, -0.18)*	*-0.21*	*(-0.24, -0.18)*	*-0.20*	*(-0.23, -0.17)*
60-64	*-0.24*	*(-0.28, -0.20)*	*-0.22*	*(-0.25, -0.18)*	*-0.21*	*(-0.24, -0.17)*	*-0.20*	*(-0.23, -0.17)*	*-0.20*	*(-0.23, -0.16)*
65-69	*-0.24*	*(-0.28, -0.20)*	*-0.21*	*(-0.25, -0.18)*	*-0.21*	*(-0.24, -0.17)*	*-0.20*	*(-0.24, -0.17)*	*-0.20*	*(-0.23, -0.17)*
70-74	*-0.17*	*(-0.20, -0.14)*	*-0.15*	*(-0.17, -0.12)*	*-0.14*	*(-0.17, -0.11)*	*-0.14*	*(-0.16, -0.11)*	*-0.13*	*(-0.16, -0.11)*
75-79	*-0.17*	*(-0.20, -0.14)*	*-0.15*	*(-0.17, -0.12)*	*-0.14*	*(-0.16, -0.11)*	*-0.14*	*(-0.16, -0.11)*	*-0.13*	*(-0.16, -0.11)*
80+	*-0.23*	*(-0.28, -0.19)*	*-0.21*	*(-0.26, -0.17)*	*-0.20*	*(-0.24, -0.16)*	*-0.20*	*(-0.24, -0.16)*	*-0.19*	*(-0.23, -0.16)*
Total (20+)†	*-0.33*	*(-0.38, -0.29)*	*-0.30*	*(-0.33, -0.26)*	*-0.29*	*(-0.33, -0.25)*	*-0.28*	*(-0.32, -0.24)*	*-0.27*	*(-0.30, -0.23)*

95% CI, 95% credible interval
†Total group was adjusted for Canadian population size

Appendix Table B.11 Prevalence of overweight and obesity for business as usual scenario and 20% sugary drink tax scenario by sex and income quintile, 1 year after implementation

Overweight

	Females			*Males*			*Total*		
Income quintile	*Business as usual*	*20% sugary drink tax*	*Difference*	*Business as usual*	*20% sugary drink tax*	*Difference*	*Business as usual*	*20% sugary drink tax*	*Difference*
Q1	30.90%	30.70%	-0.19%	31.57%	31.40%	-0.17%	31.20%	31.02%	-0.18%
Q2	34.30%	34.11%	-0.19%	35.79%	35.64%	-0.15%	35.00%	34.83%	-0.17%
Q3	34.13%	33.94%	-0.20%	36.81%	36.81%	0.01%	35.45%	35.35%	-0.10%
Q4	34.04%	33.78%	-0.25%	38.27%	38.36%	0.09%	36.16%	36.08%	-0.08%
Q5	34.98%	34.57%	-0.40%	40.01%	40.14%	0.13%	37.55%	37.42%	-0.13%

Obese

	Females			*Males*			*Total*		
Income quintile	*Business as usual*	*20% sugary drink tax*	*Difference*	*Business as usual*	*20% sugary drink tax*	*Difference*	*Business as usual*	*20% sugary drink tax*	*Difference*
Q1	29.11%	27.77%	-1.34%	30.86%	29.12%	-1.74%	29.90%	28.38%	-1.52%
Q2	28.23%	26.93%	-1.30%	30.52%	28.80%	-1.72%	29.30%	27.80%	-1.50%
Q3	27.56%	26.31%	-1.25%	33.42%	31.64%	-1.79%	30.44%	28.93%	-1.51%
Q4	26.57%	25.35%	-1.22%	34.41%	32.54%	-1.87%	30.50%	28.96%	-1.55%
Q5	22.69%	21.51%	-1.18%	34.12%	32.23%	-1.90%	28.53%	26.98%	-1.55%

Overweight + Obese

	Females			*Males*			*Total*		
Income quintile	*Business as usual*	*20% sugary drink tax*	*Difference*	*Business as usual*	*20% sugary drink tax*	*Difference*	*Business as usual*	*20% sugary drink tax*	*Difference*
Q1	60.01%	58.48%	-1.53%	62.43%	60.51%	-1.91%	61.11%	59.40%	-1.70%
Q2	62.53%	61.04%	-1.49%	66.31%	64.44%	-1.87%	64.30%	62.63%	-1.67%
Q3	61.69%	60.24%	-1.44%	70.23%	68.45%	-1.78%	65.89%	64.28%	-1.61%
Q4	60.61%	59.13%	-1.48%	72.68%	70.90%	-1.78%	66.67%	65.04%	-1.63%
Q5	57.66%	56.08%	-1.58%	74.14%	72.37%	-1.77%	66.08%	64.40%	-1.68%

Appendix Table B.12 Prevented disease incident cases due to 20% sugary drink tax by income quintile, 2017-2042

	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5	
Disease	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*
					Type 2 diabetes					
Type 2 diabetes	30141	(36257,24401)	27558	(33254,22145)	26778	(32488,21060)	26224	(32065,20746)	22696	(27847,17745)
					Cancer					
Breast cancer	1130	(1954,363)	1103	(1904,393)	1093	(1893,378)	1093	(1870,392)	1162	(2033,416)
Colon and rectum cancer	537	(667,425)	517	(642,410)	485	(597,380)	454	(558,354)	418	(514,329)
Esophageal cancer	146	(253,50)	149	(263,51)	153	(267,51)	155	(266,52)	170	(295,60)
Gallbladder and biliary track cancer	100	(138,65)	99	(137,65)	95	(131,60)	90	(129,57)	92	(130,59)
Kidney cancer	259	(322,202)	257	(317,201)	269	(334,208)	278	(347,215)	298	(375,233)
Leukemia	102	(147,60)	105	(149,63)	104	(147,65)	105	(146,66)	109	(151,72)
Liver cancer	137	(218,61)	137	(216,66)	144	(226,66)	149	(237,72)	161	(254,78)
Ovarian cancer	16	(39,-4)	17	(36,-3)	16	(36,-3)	16	(36,-3)	17	(38,-2)
Pancreatic cancer	72	(121,29)	73	(124,25)	74	(126,28)	74	(125,29)	77	(134,28)
Thyroid cancer	143	(197,94)	139	(192,91)	146	(202,96)	152	(212,100)	157	(217,105)
Uterine cancer	583	(684,495)	555	(650,467)	560	(662,467)	564	(663,471)	601	(706,507)
					Cardiovascular disease					
Ischemic heart disease	9010	(11133,7024)	8232	(10094,6433)	8177	(10225,6427)	8071	(9980,6281)	8046	(9991,6303)
Ischemic stroke	745	(987,536)	684	(915,472)	616	(820,440)	608	(783,443)	527	(679,391)
Hemorrhagic stroke	498	(679,340)	445	(620,288)	413	(558,282)	399	(549,276)	339	(467,230)

Appendix Table B.13 Prevented disease prevalent cases due to 20% sugary drink tax by income quintile, 2042

	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5	
Disease	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*
					Type 2 diabetes					
Type 2 diabetes	24428	(29334,19781)	23107	(27853,18585)	22767	(27589,17937)	22453	(27427,17784)	19413	(23783,15215)
					Cardiovascular disease					
Ischemic heart disease	5519	(6842,4283)	5228	(6424,4086)	5478	(6860,4311)	5617	(6957,4343)	5724	(7113,4484)
Ischemic stroke	333	(421,255)	312	(399,237)	300	(381,230)	320	(401,244)	256	(325,195)
Hemorrhagic stroke	144	(188,104)	147	(198,101)	128	(167,91)	142	(191,102)	97	(133,66)
Hypertensive heart disease	237	(371,119)	207	(319,106)	229	(359,112)	218	(343,111)	234	(376,116)
					Other conditions					
CKD diabetes mellitus	3514	(6023,1322)	3551	(6255,1382)	3515	(6153,1317)	3159	(5665,1186)	3412	(6000,1381)
CKD due to hypertension	1933	(3276,729)	1895	(3334,723)	1765	(3087,649)	1194	(2484,229)	1850	(3192,790)
CKD due to glomerulonephritis	3123	(5513,1178)	3091	(5630,1002)	3001	(5084,1262)	2939	(5221,980)	3437	(6101,1315)
CKD due to other causes	2676	(4758,879)	2585	(4611,985)	2418	(4296,972)	2431	(4388,803)	2561	(4455,1036)
Osteoarthritis of the hip	279	(422,147)	296	(438,165)	337	(489,191)	370	(550,219)	394	(567,226)
Osteoarthritis of the knee	2650	(3885,1621)	2604	(3673,1628)	2851	(4058,1792)	3010	(4241,1926)	3171	(4417,2026)
Low back pain	405	(583,240)	410	(587,253)	468	(644,312)	516	(696,349)	518	(697,354)

Appendix Table B.14 Disease incidence for business as usual scenario and 20% sugary drink tax scenario, incidence difference, and % change in incidence by income quintile, 2017

Scenario	*T2DM*	*Breast cancer*	*Colon and rectum cancer*	*EC*	*GB and BT cancer*	*Kidney cancer*	*Leukemia*	*Liver cancer*	*Ovarian cancer*	*PC*	*TC*	*UC*	*IHD*	*IS*	*HS*
						Quintile 1									
Business as usual†	383.9	155.5	97.6	7.6	7.6	19.6	20.9	11.1	20.3	19.5	21.0	39.1	562.6	62.8	24.3
20% sugary drink tax†	358.1	153.9	97.2	7.5	7.6	19.4	20.8	11.0	20.2	19.5	20.8	38.3	554.3	62.2	23.9
Difference	-25.77	-1.59	-0.43	-0.10	-0.07	-0.20	-0.08	-0.10	-0.03	-0.06	-0.12	-0.80	-8.28	-0.61	-0.40
% change	-6.7%	-1.0%	-0.4%	-1.4%	-1.0%	-1.0%	-0.4%	-0.9%	-0.1%	-0.3%	-0.6%	-2.0%	-1.5%	-1.0%	-1.6%
						Quintile 2									
Business as usual†	353.4	162.8	97.2	8.4	8.1	21.1	22.9	11.9	21.0	21.1	21.5	41.3	560.8	66.5	24.6
20% sugary drink tax†	330.4	161.2	96.8	8.3	8.1	20.9	22.8	11.8	21.0	21.0	21.4	40.5	553.4	65.9	24.3
Difference	-23.06	-1.54	-0.41	-0.10	-0.07	-0.19	-0.08	-0.10	-0.03	-0.06	-0.12	-0.76	-7.42	-0.55	-0.36
% change	-6.5%	-0.9%	-0.4%	-1.2%	-0.8%	-0.9%	-0.4%	-0.9%	-0.1%	-0.3%	-0.6%	-1.8%	-1.3%	-0.8%	-1.5%
						Quintile 3									
Business as usual†	340.8	153.0	73.6	7.4	6.5	19.6	19.6	10.7	19.4	17.8	21.6	39.1	479.9	44.5	17.5
20% sugary drink tax†	318.9	151.6	73.3	7.3	6.5	19.4	19.5	10.6	19.4	17.8	21.5	38.4	473.2	44.0	17.2
Difference	-21.88	-1.33	-0.31	-0.09	-0.05	-0.17	-0.07	-0.09	-0.02	-0.05	-0.12	-0.68	-6.64	-0.44	-0.31
% change	-6.4%	-0.9%	-0.4%	-1.2%	-0.8%	-0.9%	-0.3%	-0.9%	-0.1%	-0.3%	-0.6%	-1.8%	-1.4%	-1.0%	-1.7%
						Quintile 4									
Business as usual†	332.7	144.9	59.7	6.6	5.5	18.3	17.2	9.9	18.3	15.5	21.8	36.8	423.5	35.0	14.3
20% sugary drink tax†	311.8	143.6	59.4	6.5	5.4	18.2	17.2	9.8	18.2	15.4	21.6	36.2	417.5	34.6	14.0
Difference	-20.95	-1.22	-0.25	-0.08	-0.04	-0.16	-0.06	-0.09	-0.02	-0.04	-0.12	-0.64	-6.04	-0.38	-0.28
% change	-6.3%	-0.8%	-0.4%	-1.2%	-0.8%	-0.9%	-0.3%	-0.9%	-0.1%	-0.3%	-0.5%	-1.7%	-1.4%	-1.1%	-2.0%
						Quintile 5									
Business as usual†	297.3	142.6	46.4	6.2	4.8	18.0	15.8	9.6	17.8	13.9	22.3	36.2	388.2	24.9	10.8
20% sugary drink tax†	279.5	141.5	46.2	6.1	4.8	17.9	15.7	9.6	17.8	13.9	22.2	35.6	382.6	24.6	10.6
Difference	-17.86	-1.11	-0.19	-0.07	-0.03	-0.15	-0.05	-0.08	-0.02	-0.04	-0.12	-0.60	-5.55	-0.26	-0.20
% change	-6.0%	-0.8%	-0.4%	-1.2%	-0.7%	-0.9%	-0.3%	-0.9%	-0.1%	-0.3%	-0.5%	-1.7%	-1.4%	-1.0%	-1.8%

T2DM: type 2 diabetes, EC: Esophageal cancer, GB and BT cancer: gallbladder and biliary track cancer, PC: pancreatic cancer, TC: thyroid cancer, UC: uterine cancer, IHD: ischemic heart disease, IS: ischemic stroke, HS: hemorrhagic stroke

†cases per 100,000

Appendix Table B.15 Disease prevalence for business as usual scenario and 20% sugary drink tax scenario, prevalence difference, and % change in prevalence by income quintile, 2042

Scenario	*T2DM*	*IHD*	*IS*	*HS*	*HHD*	*CKD DM*	*CKD H*	*CKD G*	*CKD O*	*OA Hip*	*OA Knee*	*Low back pain*
Quintile 1												
Business as usual†	17245.2	14740.3	808.7	217.0	258.7	5914.5	3055.8	4682.9	4288.6	3182.3	8501.6	9858.8
20% sugary drink tax†	16468.2	14563.9	798.1	212.4	251.1	5799.7	2994.6	4583.8	4203.0	3173.3	8417.6	9845.9
Difference	-777.00	-176.43	-10.64	-4.58	-7.60	-114.80	-61.22	-99.02	-85.66	-9.00	-84.01	-12.95
% change	-4.5%	-1.2%	-1.3%	-2.1%	-2.9%	-1.9%	-2.0%	-2.1%	-2.0%	-0.3%	-1.0%	-0.1%
Quintile 2												
Business as usual†	16608.6	14896.4	881.0	250.0	244.2	6329.6	3213.8	5124.1	4389.9	3458.9	8970.4	10776.9
20% sugary drink tax†	15886.0	14732.8	871.2	245.4	237.7	6219.5	3153.9	5026.0	4309.3	3449.7	8888.8	10764.0
Difference	-722.66	-163.62	-9.80	-4.62	-6.47	-110.08	-59.91	-98.15	-80.60	-9.24	-81.64	-12.85
% change	-4.4%	-1.1%	-1.1%	-1.8%	-2.6%	-1.7%	-1.9%	-1.9%	-1.8%	-0.3%	-0.9%	-0.1%
Quintile 3												
Business as usual†	15281.1	14531.2	734.5	190.2	266.0	5907.3	2820.8	4495.2	3833.7	3611.5	9161.5	11427.2
20% sugary drink tax†	14642.6	14378.0	726.1	186.7	259.6	5809.6	2771.0	4412.9	3766.2	3602.1	9082.2	11414.2
Difference	-638.44	-153.15	-8.44	-3.56	-6.42	-97.61	-49.83	-82.25	-67.47	-9.44	-79.37	-13.08
% change	-4.2%	-1.1%	-1.1%	-1.9%	-2.4%	-1.7%	-1.8%	-1.8%	-1.8%	-0.3%	-0.9%	-0.1%
Quintile 4												
Business as usual†	14398.7	14238.6	749.0	188.1	233.8	5048.8	1946.7	4248.7	3779.3	3727.3	9295.5	12052.3
20% sugary drink tax†	13818.3	14093.8	740.7	184.4	228.2	4966.8	1915.3	4173.4	3716.0	3717.7	9216.8	12038.9
Difference	-580.35	-144.88	-8.25	-3.68	-5.64	-82.01	-31.42	-75.26	-63.26	-9.58	-78.66	-13.41
% change	-4.0%	-1.0%	-1.1%	-2.0%	-2.4%	-1.6%	-1.6%	-1.8%	-1.7%	-0.3%	-0.8%	-0.1%
Quintile 5												
Business as usual†	12152.7	14350.6	698.8	168.0	242.8	5090.0	2602.8	4606.7	3582.6	3841.7	9565.8	11878.7
20% sugary drink tax†	11697.7	14215.4	692.7	165.8	237.2	5009.0	2559.1	4526.6	3521.8	3832.5	9491.9	11866.6
Difference	-455.00	-135.17	-6.02	-2.27	-5.55	-81.08	-43.68	-80.09	-60.75	-9.24	-73.87	-12.15
% change	-3.7%	-0.9%	-0.9%	-1.4%	-2.3%	-1.6%	-1.7%	-1.7%	-1.7%	-0.2%	-0.8%	-0.1%

T2DM: type 2 diabetes, IHD: ischemic heart disease, IS: ischemic stroke, HS: hemorrhagic stroke, HDD: hypertensive heart disease, CKD DM: chronic kidney disease due to diabetes mellitus, CKD H: chronic kidney disease due to hypertension, CKD G: chronic kidney disease due to glomerulonephritis, CKD O: chronic kidney disease due to other causes, OA Hip: osteoarthritis of the hip , OA Knee: osteoarthritis of the knee. †cases per 100,000

Appendix Table B.16 Life expectancy and disability-adjusted life expectancy (DALE) for business as usual scenario and 20% sugary drink tax scenario by sex, income quintile

	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5	
Scenario	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*	*Mean*	*(95% CI)*
Females										
Life expectancy										
Business as usual	42.22	(42.22, 42.22)	43.77	(43.77, 43.77)	44.81	(44.81, 44.81)	45.29	(45.29, 45.29)	46.09	(46.09, 46.09)
20% sugary drink tax	42.26	(42.25, 42.26)	43.80	(43.80, 43.81)	44.84	(44.83, 44.84)	45.31	(45.31, 45.32)	46.11	(46.11, 46.12)
DALE										
Business as usual	34.45	(34.45, 34.45)	35.67	(35.67, 35.67)	36.46	(36.46, 36.46)	36.82	(36.82, 36.82)	37.44	(37.44, 37.44)
20% sugary drink tax	34.54	(34.52, 34.55)	35.74	(35.73, 35.76)	36.53	(36.51, 36.54)	36.89	(36.88, 36.90)	37.49	(37.48, 37.50)
Males										
Life expectancy										
Business as usual	38.69	(38.69, 38.69)	40.66	(40.66, 40.66)	41.46	(41.46, 41.46)	41.99	(41.99, 41.99)	42.60	(42.60, 42.60)
20% sugary drink tax	38.74	(38.73, 38.75)	40.71	(40.70, 40.72)	41.50	(41.49, 41.51)	42.02	(42.02, 42.03)	42.63	(42.62, 42.64)
DALE										
Business as usual	31.94	(31.94, 31.94)	33.48	(33.48, 33.48)	34.09	(34.09, 34.09)	34.50	(34.50, 34.50)	34.96	(34.96, 34.96)
20% sugary drink tax	32.05	(32.03, 32.07)	33.58	(33.56, 33.60)	34.18	(34.17, 34.20)	34.58	(34.56, 34.59)	35.04	(35.03, 35.05)