Predicting the potential health and economic impact of a sugary drink tax in Canada: a modelling study

by

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I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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ABSTRACT

BACKGROUND

Consistent with global trends, high body mass index (BMI) and high blood glucose have risen at rapid rates among Canadians. The consumption of sugar-sweetened beverages (SSBs) is a well-established and important dietary risk factor for these conditions. A growing body of research suggests that SSB taxes can achieve meaningful health impacts by shifting dietary preferences. However, there are several key literature gaps, including no estimations of the potential benefit of taxing 'sugary drinks', a beverage category that includes both SSBs and 100% juice, which is high in sugar. In addition, no published studies have simulated a tax on SSBs or sugary drinks for the Canadian population.

PURPOSE

The proposed study's objectives were: 1) to investigate Canadians' consumption of sugary drink types, and differences by socio-economic characteristics; and 2) to estimate the potential impact among the Canadian population of a simulated national tax on SSBs and a simulated tax on sugary drinks.

METHODS

The study was conducted in two components. First, sugary drink intake (volume and energy) was estimated using 24-hour dietary recall data from the 2015 Canadian Community Health Survey – Nutrition (respondents ages >1 year; final sample N=20,176). For 100% juice and 'total SSBs' (which included 15 beverage types), intake was reported overall and by socio-economic measures: sex, age, ethnicity, income, province, and BMI category. Student's t-test and Wald F-test tested for differences among population sub-groups. SSB and sugary drink intakes were also estimated for inclusion in the study's second component: a simulation of a sugary drink tax. The impact of the tax intervention was estimated using a proportional multi-state life table-based Markov model adapted to simulate the 2015 Canadian adult population. The model applied 10%, 20%, and 30% ad valorem taxes on SSBs and sugary drinks, and compared two populations: one with a tax intervention and one without a tax intervention. The model simulated the effect of energy intake from beverages on 19 diseases mediated by body mass, and the direct effects of intake on type 2 diabetes, accounting for beverage substitution. Sensitivity analyses examined key assumptions and Monte Carlo simulation assessed uncertainty.

RESULTS

A large proportion of respondents reported consuming 100% juice (children, 39.3%; adults 22.8%) or some type of SSB (children, 53.0%; adults, 40.8%) during the previous 24-hour period. In 2015, each Canadian consumed an average of 74.3 ml (33.7 kcal) of 100% juice and 203.6 ml (98.7 kcal) of SSBs per day. 100% juice was consumed more than any other sugary drink, followed closely by regular carbonated soft drinks. Compared to females, males' consumption was significantly higher for 100% juice (37% greater volume) and total SSBs (54% greater). Children consumed more sugary drinks on average each day than adults: nearly double the volume of 100% juice (86% more) and 14% more SSBs. Beverage intake differed by ethnicity, province, and BMI category, but not by income quintile. For the simulated taxes, there were sizeable differences in the impacts of a SSB tax versus sugary drinks tax: prevalence of overweight/obesity changed from 63.3% to 61.7% vs 61.0%; type 2 diabetes incidence rate decreased by -5.9% vs -7.4%. Over a 25-year period, compared to a SSB tax, a sugary drinks tax produced 47% more averted disability-adjusted life years (DALYs; 314,326 versus 460,812), 45% greater health care costs savings ($7.5 billion vs $10.9 billion Canadian dollars), and 37% more annual tax revenue ($1.0 billion CAD vs $1.4 billion CAD).

CONCLUSIONS

Consumption of sugary drinks remains an important disease risk factor among the Canadian population. Average intake of sugary drinks in 2015 is lower than 2004 estimates, but remains high, especially among children and youth. The current study suggests that a beverage tax in Canada has the potential to substantially reduce the health burden while generating health care savings and tax revenue, especially if 100% juice is among taxed beverages. Given Canadians' high 100% juice consumption, the mounting evidence on adverse effects associated with free sugar consumption, and the role of 100% juice as a substitute beverage to SSBs, there is a strong rationale for its inclusion as a taxed beverage. Future studies could examine the potential impact

of a ‘tiered’ tax based on beverage sugar content, as well as the effects of a tax relative to other nutrition interventions.

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LIST OF ABBREVIATIONS

ACE	Assessing Cost-Effectiveness
BMI	body mass index
CAD	Canadian dollars
CANSIM	Canadian Socio-Economic Information Management System
CCDSS	Canadian Chronic Disease Surveillance System
CCHS	Canadian Community Health Survey
CHMS	Canadian Health Measures Survey
CI	confidence interval
CIHR	Canadian Institutes of Health Research
CKD	chronic kidney disease
DALE	disability-adjusted life expectancy
DALY	disability-adjusted life year
EBIC	Economic Burden of Illness in Canada
FDC	Food Description
FID	Food and Ingredient Details
FRL	Food Recipe Level
g	gram
GBD	Global Burden of Disease
GDP	gross domestic product
HS	Health Survey
ICD	International Classification of Diseases
kcal	kilocalories
kg	kilogram
kJ	kilojoules
L	litre
LL	lower limit
m	metre
ml	millilitre

PIF	population impact fraction
pYLD	prevalent years lived with disability
RR	relative risk
RTD	ready-to-drink
SAS	Statistical Analysis System
SPSS	Statistical Package for the Social Sciences
SSB	sugar-sweetened beverage
SWO-RDC	South-Western Ontario Research Data Centre
UK	United Kingdom
UL	upper limit
USA	United States of America
YLD	years lived with disability

INTRODUCTION AND OVERVIEW

Chronic diseases are the leading source of death and disability worldwide.[1,2] Four dominant diseases—cancer, cardiovascular disease, diabetes, and chronic respiratory diseases—were responsible for 68% of deaths in 2012.[3] The economic toll is substantial. These conditions are projected to be responsible for more than $30 trillion USD in economic losses worldwide between 2010-2030.[4] Growing populations, increased longevity, and declines in infectious disease deaths have contributed to rising chronic disease rates within countries of all income levels.[5] Primary prevention is a key component for adverting this health and economic burden. By modifying four risk factors—poor diet, tobacco use, physical inactivity, and harmful alcohol use—a large portion of disease burden could be prevented: up to 80% of cardiovascular disease and type 2 diabetes, and at least one-third of all common cancers.[6] In follow-up to the landmark 2011 United Nations High-Level Meeting on Noncommunicable Diseases, the World Health Organization developed a set of voluntary targets to reduce chronic diseases. To meet these targets, the WHO's Global Action Plan for the Prevention and Control of NCDs 2013-2020 presents a comprehensive framework of prevention strategies based on a multisectoral approach to address the complex causes of chronic disease risk factors.[7]

Of the major modifiable risk factors, poor diet is the leading preventable cause of death and disability globally.[8] After marked reductions in undernutrition, 'overnutrition' is now a prevalent form of malnutrition and has resulted in escalating rates of excess weight and type 2 diabetes worldwide.[8] The causes of obesity are highly complex, spanning multiple health and non-health sectors, and further worsened by social and health disparities.[9] An important contributor is the multinational food and beverage companies that have changed the global food system by increasing the availability and affordability of energy-dense processed foods high in sugar, salt, and fat. Through intensive marketing, intake of these ultra-processed foods has risen, as consumption of more natural and traditional foods declines.[10] Given the multisectoral causes of the nutrition-related health crisis, addressing this crisis requires a systems approach that engages multiple sectors, including those outside of health.[11]

While the dietary causes of poor health are numerous and not linked to a single nutrient, food, beverage or diet,[3,12] there are key shifts in specific dietary patterns that highlight areas for action and inclusion within a comprehensive nutrition strategy. Notably, the supply of dietary sugars has risen over the past 50 years, with an accelerated rate in the past decade, and worldwide patterns linking sugar intake to type 2 diabetes.[13] In particular, high consumption of sugar-sweetened beverages (SSBs) is an important dietary risk factor internationally and within Canada, and health agencies have called for strategies to decrease intake of beverages with high sugar content.[7,14,15] Canada's Healthy Eating Strategy incorporates strategies that engage multiple methods and sectors, including the food environment, behaviour change communication, marketing, and modifications to the food system.[16] However, there remains opportunity for work on integrating fiscal policies, particularly given their potential for reducing the consumption of SSBs and other beverages high in sugar, such as 100% juice.

The current study investigated the potential impact of an intervention to reduce Canadians' consumption of beverages high in sugar: a beverage tax. A growing body of research suggests that beverage taxes can achieve meaningful impacts on improving health outcomes by shifting dietary preferences away from these beverages. However, there are several key gaps in the literature. 100% juice is high in sugar and there are no estimations of the potential benefit of including 100% juice with SSBs in a beverage tax. Furthermore, no studies have simulated a beverage tax for the Canadian population. The current study aims to address these gaps.

The study was conducted in two components: an analysis of current SSB and 100% juice consumption based on dietary intake data for the Canadian population, and two separate simulations to determine the potential health and economic impact of a Canadian tax on SSBs and sugary drinks, a beverage category that consists of SSBs and 100% juice.

LITERATURE REVIEW

HEALTH EFFECTS OF SSB CONSUMPTION

Over the past 30 years, two prominent nutritionally-related conditions—high body mass index (BMI) and high blood glucose—have led to a near doubling of the global mortality burden from cardiovascular disease, chronic kidney disease, and diabetes.[17] Though incidence rates for some chronic diseases are declining in Canada, high BMI and high glucose have risen at rapid rates among Canadians, consistent with global trends.[8] In less than 30 years, obesity prevalence tripled in adults and increased by a factor of 2.5 in children and youth.[18,19] Despite a recent slowing in childhood obesity and overweight prevalence,[20,21] current measured BMI data indicates that an alarming one-third of children and youth and almost two-thirds of adults in Canada have overweight or obesity.[22,23]

High glucose is associated with type 1 diabetes and type 2 diabetes. One in ten Canadian adults live with diagnosed diabetes; the majority of cases (90% to 95%) are type 2 diabetes.[24] Diabetes prevalence nearly doubled between 2000 and 2011,[24] with some of the greatest relative increases in prevalence among younger age groups.[25] Overall, the predominance of high BMI and high glucose has contributed to rising rates of chronic disease in Canada,[26] and reinforces the critical role of diet in health and disease prevention. Compared to physical activity, diet has played a greater role in the development of overweight and obesity.[27]

The consumption SSBs is a well-established and important dietary risk factor for chronic disease.[8] A large body of evidence—including meta-analyses, prospective cohort studies, and randomized control trials—identify a high intake of SSBs as contributing to excess weight gain.[28,29] SSBs lead to weight gain through three major mechanisms. First, due to their high sugar content, SSBs contribute a substantial volume of caloric energy.[30] Second, SSBs are low in nutrients and are associated with nutritionally poorer diets.[31] Third, compared to foods, beverages lead to lower satiety than foods—people do not feel as 'full' after drinking beverage as eating. Later energy intake is insufficiently reduced and does not compensate for the liquid calories.[31] When caloric intake is greater than caloric expenditure, the body builds fat stores for the excess energy. Therefore, SSBs increase the risk of obesity-mediated disease, including type 2 diabetes, metabolic syndrome, cardiovascular disease, cancer, kidney disease, and musculoskeletal disorders.[32–41] In addition to obesity-mediated disease risk, high SSB intake has direct impacts on the risk of type 2 diabetes, cardiovascular disease, and dental caries.[42–45] The mechanisms of these independent effects on diabetes and cardiovascular disease are complex, but centre on the body's response to the high dietary glycemic load created by rapid absorption of high amounts of sugars. Triggered responses include inflammation, insulin resistance, and impaired β-cell function.[30] Furthermore, consuming fructose, which is found in sucrose and high-fructose corn syrup, may increase blood pressure and stimulate adiposity due to hepatic de novo lipogenesis.[30]

Most research on the impact of sugar consumption from beverages has excluded 100% juice. SSBs are commonly defined based on criteria for 'added sugars', and typically include 'regular' (i.e., caloric, non-diet) versions of carbonated soft drinks, ready-to-drink sweetened tea and coffee, energy drinks, sports drinks, flavoured bottled water, and fruit drinks with less than 100% juice.[46] Most definitions of SSBs also include flavoured milk and drinkable yogurt with added sugars, but exclude 100% juice. However, 100% juice contains 'free sugars' that contribute to the overall energy density of beverages and are metabolized the same way as the 'added sugars' found in SSBs.[47] Specifically, beverages with free or added sugars provide a rapid delivery of high volumes of sugar. The sugars are quickly broken down and absorbed into the body while triggering spikes in insulin and blood sugar levels, as well as the production of fat cells to absorb the excess energy from these energy-dense beverages. Free sugars are monosaccharides and disaccharides added to foods and beverages, plus sugars naturally present in honey, syrups, fruit juices, and fruit juice concentrates.[47] The World Health Organization recommends limiting the consumption of free sugars to no more than 10% of total energy intake, with further health benefits from reducing to less than 5%.[47] In the current study, 'sugary drinks' refers to beverages containing free sugars, specifically SSBs and 100% juice. The term 'SSBs' does not include 100% juice and is used distinctly from the term 'sugary drinks' including in regard to existing interventions and research.

SUGARY DRINK CONSUMPTION IN CANADA

Based on 2004 nationally-representative dietary intake data, sugary drinks account for a substantial proportion of Canadians' energy intake[48–51] and are the single leading source of sugar in Canadians' diet.[52] The highest intake is among youth and young adults (Table 1). Males typically consume a greater quantity of sugary drinks than females of the same age. Within sex and age groups, not all Canadians consume sugary drinks and, among consumers, some drink significantly more or less than the average.[48–51] Sugary drinks are often packaged in a 'ready-to-drink' (RTD) format, thereby contributing to easy and frequent consumption outside of the home.[53] Of the one in four Canadians who reported eating at a fast food restaurant during the previous 24 hours, 25% consumed a 'regular soft drink'.[54] Softs drinks, an undefined category used by Health Canada and Statistics Canada, typically includes carbonated soft drinks, fruit drinks, and some other but not all SSBs.

Table 1. Average daily consumption of sugary drinks (in millilitres), by age and gender, in Canada excluding territories

	Regular carbonated soft drinks		Regular fruit drinks		100% juice		Other sugary drinks*		Total	
Age group	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**
0 to 3	13	9	87	62	153	129	33	18	286	218
4 to 8	68	47	159	134	191	162	91	70	509	413
9 to 13	153	110	194	187	169	143	103	78	619	518
14 to 18	377	179	178	171	195	167	134	96	884	613
19 to 30	302	140	125	100	168	135	103	77	698	452
31 to 50	192	94	59	51	119	93	60	54	430	292
51 to 70	113	58	31	32	116	90	27	30	287	210
71 or older	37	28	28	29	87	92	17	19	169	168

Data source: Canadian Community Health Survey, Cycle 2.2 2004[55]

* Other sugary drinks: non-diet sports drinks, energy drinks, sweetened coffee, sweetened tea, hot chocolate, sweetened milk, and sweetened drinkable yogurt

Consumption of alcohol is another source of sugar within the Canadian diet. Among Canadian adults in 2004, alcoholic beverages represented a major beverage category in terms of volume, sugar content, and energy, though consumption did not exceed sugary drink intake.[48] Alcohol intake among Canadian children and youth is not reported.[49] Like SSBs, Canada's Food Guide recommends limiting the intake of alcohol owing to high sugar and calorie content.[56] Due to alcohol's impairing effects and other health and social risks, the Canadian regulatory framework for the marketing and sale of alcohol is very different than that for sugary drinks. In particular, alcohol can be neither marketed to nor sold to minors and pricing policies such as taxation are intended to discourage consumption.[57] There is strong rationale, including recent evidence on the carcinogenic risk of alcohol consumption, even at low levels, for greater alcohol control measures.[58] However, it is non-alcoholic sugary drinks that are consumed more widely and in greater quantities across the population, and are freely marketed to all ages, including children, in almost all Canadian jurisdictions.[59]

No published studies have examined temporal trends in Canadians' sugary drink intakes. In the USA, consumption remains high despite declines in the past decade.[60–62] Statistics Canada provides data from the Canadian Beverage Association reporting a 45% decline between 2000 and 2016 in the number of litres of soft drinks available per person (95.72 L to 53.08 L).[63,64] However, this decrease was preceded by decades of increasing soft drink consumption. Between 1938 and 2001, soft drinks and fruit juices increased from 0.1% of total household energy available in Canada to 6.3%, an increase of 6,200%. Beverage manufacturers' recent introduction of new drinks and categories has changed the landscape of products consumed by populations. As reported for the USA, carbonated soft drinks continue to be the most widely consumed SSB.[65] the consumption of newer or smaller beverage categories, such as flavoured water, sweetened coffees and teas, drinkable yogurt, and flavoured milk, has increased in recent years.[66] Consumption of some sugary drink types may decrease, while other categories increase.[60–62] These 'emerging' beverage categories are often marketed on the basis of 'health-promoting' properties, such as high vitamin content, despite their high sugar content.[67]

Lower income groups typically have poorer diets[68,69] and studies in the USA, France, and other settings show higher consumption of sugary drinks in low income groups.[70–72] However, studies on the Canadian population, though limitied, generally report no inverse relationship between income and SSB consumption,[50,51,73] except among select sex and age groups, such as males aged 6-11 years.[51] Similarly inconsistent associations are seen between food security status and SSB intake. For example, among children and youth who lived in food-insecure households, only teenage girls consumed more servings of SSBs than their sex and age counterparts who lived in food-secure households.[73] Overall, the limited evidence to date suggests little to no effect of income on sugary drink consumption in the Canadian population, although examining the potential role of income remains a priority for future work. Continued special attention toward low income groups is warranted given their generally poorer diet and the observed international trends.

HEALTH AND ECONOMIC BURDEN OF SSB CONSUMPTION IN CANADA

SSB consumption contributes to a substantial health burden at the population level. The Global Burden of Disease study quantified the magnitude of the health impact attributable to SSB intake for each of 187 countries, and is the only study to examine the impact of this risk factor for Canada.[74] The 'attributable burden' is the current or future disease burden if a risk factor had been eliminated in the past. The study modelled the effect of SSB intake on type 2 diabetes and BMI, and included 10 BMI-mediated diseases: ischemic heart disease, stroke, type 2 diabetes, esophageal cancer, colon cancer, pancreatic cancer, breast cancer, uterine cancer, kidney cancer, and gallbladder cancer. For the worldwide adult population, SSB consumption (which excluded 100% juice) contributed to 184,000 deaths and 8.5 million disability-adjusted life years (DALYs) in 2010. In Canada, this risk factor accounted for 1,598 deaths and 45,474 DALYs for the same year. The study's findings report a sizable effect of SSB intake on type 2 diabetes incidence and mortality: SSBs contributed to 5.9% of all diabetes deaths and 7.2% of all diabetes DALYs for Canada. Younger Canadians are affected to a greater extent: among 20-44 year olds, almost one quarter of diabetes deaths (22.0-23.4%) are attributable to SSB consumption. Compared to females, males disproportionately account for 57% of the disease burden,[74] reflecting their higher SSB consumption.[75]

The large disease burden attributable to excess weight reflects the relationship between SSB consumption and weight gain, and shows concerning health impacts. Though modelling methods vary between studies, expected BMI-related cancer incidence ranges between 8,649 to 10,320 new cases annually among Canadians.[26,76,77] One study reports this accounts for 5.7% of all cancer cases (males 4.9%, females 6.5%).[77]

The health care costs of SSB consumption have not been reported for Canada, but are likely to reflect the high costs of obesity and diabetes and their risk for numerous related diseases. Canada's publicly funded health care spending in 2015 was an estimated $219.1 billion Canadian dollars (CAD 2015).[78] The most recent estimates of the direct health care costs of obesity for Canada are $6.8 billion (CAD 2013), which includes costs associated with BMI-mediated type 2 diabetes.[79–81] Diabetes is also an expensive disease. The Canadian Economic Burden of Illness study estimated hospital care, drugs, and physician care expenditures from diabetes at $2.2 billion (CAD 2011)—1.3% of all direct health care costs in 2008.[82] These estimates include neither indirect health costs, such as decreased work productivity, nor out-of-pocket expenditures which can average $2,300 annually (CAD 2010).[83] The financial burden of diabetes is predicted to persist: the direct health care costs from diabetes in 2011-2021 are estimated at $15.35 billion.[84] By comparison, inadequate consumption of vegetables and fruits was estimated to cost $1.0 billion (CAD 2013; $28 per person) in direct health care costs.[85]

INTRODUCTION TO SSB AND SUGARY DRINK TAXES

Taxation of drinks high in sugar has recently gained prominence with public health advocates and authorities as a potential strategy for reducing diet-related disease. The formidable and growing worldwide chronic disease burden has prompted health experts to call for increased emphasis on population-wide interventions that achieve large population health gains through small changes in many individuals. Taxes on unhealthy foods and beverages are cost-effective and feasible, and therefore considered a 'priority intervention'.[86,87] The effective use of tobacco taxes for reducing cigarette consumption and smoking-related diseases provides a clear demonstration of the potential health impact of diet-related fiscal policies.[88]

The basis of tax interventions is standard economic theory. Consumer demand for a good adjusts when the price of a good is changed. A tax will raise the price of an unhealthy food or beverage, prompting consumers to purchase less. Lower intake of unhealthy foods or beverages reduces disease risk and achieves lower diet-related disease incidence at the broad population level.[89] 'Price elasticities' numerically represent the relationship between a price change and the consumer response, including any changes in substitute or complement foods and beverages.

Apart from consumer demand, pricing instruments have additional benefits that can help drive efforts toward implementation. By reducing diet-related diseases, tax interventions are predicted to generate savings to health care systems.[90] Tax revenue can offset sugary drinks' costs to the health care system and to society (e.g., decreased work productivity). The potential use of tax revenue to fund health and community initiatives can be a strong incentive for enacting a tax.[88] Beyond the price effects, consumers may change their dietary patterns in response to the advocacy, health education, and publicity that accompanies a tax intervention.[91] Together, price effects and increased awareness about the taxed product's adverse health impacts can serve to encourage reassessment of food preferences and de-normalize consumption.[92] Lastly, tax interventions have been shown to influence the food system by motivating food reformulation to remove or decrease unhealthy ingredients.[93]

Researchers and policymakers have compared the potential impact and feasibility of taxing different food and beverage categories, including 'junk foods' (e.g., confectionary), foods high in saturated fats, and drinks high in sugar.[94–96] However, recent fiscal policy initiatives primarily focus on taxing SSBs rather than other food categories. As the leading dietary source of sugar, there is a strong health rationale.[52] Additionally, the products are a non-essential diet component providing little or no nutritional value. Healthier substitute beverages, specifically water and low fat milk, are generally widely accessible and affordable.[97] From a policymaking perspective, it is relatively straightforward to demarcate taxable beverage products to administer the tax.[98]

IMPLEMENTED SSB TAXES

Early efforts to pass health-oriented taxes were largely unsuccessful, such as New York City's penny per ounce of beverage tax proposed by child and health care advocates in 2008.[88] Prior to these failed proposals, several USA states applied sales taxes to SSBs.[99] However, these taxes were intended to generate revenue, not impact health, and were applied at rates too low to encourage consumer behaviour change or influence health outcomes.[10091] Two key events are often attributed as launching a new era of SSB taxes.[91] First, in September 2013, Mexico's

President Enrique Peña Nieto announced a national peso per litre tax on SSBs. Though other countries such as Finland and Samoa had long taxed SSBs, Mexico proposed and passed their tax as an explicit health-oriented initiative, part of a comprehensive strategy to reduce Mexico's alarming obesity and diabetes rates.[101] The second event occurred in November 2014 when Berkeley, California became the first USA jurisdiction to pass a SSB tax.[102] Building upon the successes of these forerunners, a remarkable shift has occurred in recent years as a quickly increasing number of jurisdictions have implemented, or are in the process of implementing, excise taxes on SSBs. In addition to Mexico and Berkeley, jurisdictions include the United Kingdom (UK), Ireland, France, South Africa, Chile, and other countries, as well as a growing list of cities in the United States (e.g., Philadelphia, Colorado, and Seattle).[101–109]

FEATURES OF BEVERAGE TAXES

The impact of a tax is influenced by several characteristics, including the type of tax, taxation level, and scope of taxable products.

TYPE OF TAX

The most widely used tax in SSB tax interventions is an excise tax. A SSB excise tax is a tax levied on beverage manufacturers, distributors, or retailers. These parties may pass on the tax to consumers by increasing product prices, with the price increase reflected in product price tags. Excise taxes are different from sales taxes in that sales taxes are typically applied at the point of purchase, whereas price increases from excise taxes appear on price tags. Consumers are more likely to modify their behaviour when they can see differences in cost displayed in the price tags at the time of product selection.[110]

There are different types of excise taxes. An *ad valorem* excise tax is a tax set equal to a percentage of the beverage's pre-tax value (e.g., 20% of the beverage's price). A *specific* excise tax is set as a fixed rate per amount of a product (e.g., per volume, calories, or grams of sugar). An example of a specific excise tax based on volume, referred to as a volumetric tax, is $0.30 per litre. Compared to ad valorem taxes, specific taxes have been used more frequently for beverage taxes. With an ad valorem tax, the absolute price increase is smaller for cheaper products than expensive products. A specific tax increases the price of brand name products and generic brand products by the same amount per volume, thereby discouraging downshifting from expensive to cheaper–but equally unhealthful–beverages. A disadvantage of a specific tax is that it does not keep pace with inflation, unlike an ad valorem tax.[110]

Existing SSB taxes are commonly designed as specific volumetric taxes. For example, Mexico's tax is roughly equivalent to 1 cent per ounce and applied to an array of SSBs. However, there may be an emerging trend toward nutrient-based specific taxes. The UK will implement a 'tiered' tax based on the sugar content in SSBs (excluding milk-based drinks), with the beverages higher in sugar having a higher absolute increase: a tax of 18 pence per litre for beverages with total sugar of 50 grams or more per litre (equivalent to approximately 25 cents Canadian) and a tax of 24 pence per litre for beverages with total sugar of 80 grams or more per litre (approximately 34 cents Canadian).[106,111] A tiered tax based on sugar content may avoid substitution in favour of other products with high sugar content and incentivize the beverage industry to reduce SSBs' sugar content.[112] Several beverage companies in the UK have announced reformulation efforts to reduce sugar content, suggesting that the tax may be achieving the latter outcome.[113,114] Consumer responses to a tiered tax are not yet known as the tax takes effect in April 2018. Thailand recently proposed a tiered tax on sugary drinks, including 100% juice.[115]

TAXATION LEVEL

A beverage tax must be sufficiently large to stimulate consumers to reassess their beverage selections.[97] Based on the available evidence, World Health Organization recommends as best practice that the level of tax be equivalent to a minimum of 20% of the product base price.[116] A tax as this level has been found substantive enough to stimulate sufficient consumer behaviour change.[116] Notably, most implemented SSB taxes fall below this level. Taxes in Mexico, Cook County, Berkeley, San Francisco, Albany, and Oakland were set at 1 cent per ounce, which is approximately 10%.[101,102,117–120] There may be a new trend toward higher tax levels. More recently announced taxes in Philadelphia and Boulder are closer to 20% and 30%,[105,121] which may have been accomplished by leveraging the success of earlier tax initiatives.[98] To identify a possible taxation level, price elasticities must be considered. Price elasticities are a measure of consumer responsiveness to price changes, and can differ by country, gross domestic product (GDP), household income, and consumption level.[122,123] For example, individuals from lower income groups are typically more price sensitive.[123–125]

TAXABLE PRODUCTS

The scope of the products to be taxed is a key characteristic of a tax. Which products are taxed influences how broadly or narrowly the tax will be applied, the potential health impact, and, possibly, the political feasibility of passing the tax. Taxing a narrower range of products may invite less public and industry resistance. However, by taxing some but not all sugary drinks, the tax sets up the non-taxed beverages as potentially appealing substitutes for consumers. Substituting one sugary drink for another diminishes the overall reduction in caloric intake. Taxing a broader suite of beverages limits consumers' ability to switch to similar non-taxed products and produces a larger improvement in nutrition than taxing a single beverage category, such as carbonated soft drinks. Alternatively, some researchers advise that taxing beverages may not be as effective as taxing all food and beverage products based on sugary content.[126] As seen with Denmark's former tax on saturated fats, taxes based on nutrients can be administratively complex and subject to strong public resistance.[98]

Commonly taxed beverages are non-diet versions of carbonated soft drinks, fruit drinks with less than 100% juice, sports drinks, and energy drinks. As carbonated soft drinks and fruit drinks are two of the three beverages that make up a large share of total sugary drink intake (100% juice is the third beverage), a tax of this design applies to a considerable proportion of total sugary drink intake. Sugary tea, coffee, and flavoured bottled water are less commonly included. Sweetened dairy drinks like milk and drinkable yogurt are infrequently taxed. Philadelphia and France stand out in their approaches to selecting of taxable products. In these settings, taxed beverages are not defined by sugar content. Instead, the taxes apply to sugar-sweetened and 'diet' (i.e., low calorie) beverages, though the original policy proposals were for only SSBs.[98] In the case of Philadelphia, the inclusion of sugar-sweetened and diet beverages may be explained by how the tax was framed and promoted as a revenue generation measure to fund popular community programs such as universal preschool, libraries, and parks, and not as an obesity or diabetes reduction initiative.

As suggested by the inclusion of diet beverages in France's and Philadelphia's taxes, the public health approaches and evidence on the health effects of diet beverages are varied. The question of whether or not to include diet beverages should be informed by research showing beneficial or adverse effects of diet beverage consumption. However, national food-based dietary guidelines typically exclude any recommendations pertaining to the consumption of artificial sweeteners.[127] Of the provided recommendations, the advice is conflicting, with some guides referring to artificial sweeteners as having detrimental effects and others advising artificial sweeteners as a potential alternative to added sugars.[127] An additional consideration is whether higher SSB prices stimulate consumers to switch to diet beverages. Meta-analysis of price elasticity studies from around the world reported that diet beverage consumption decreases when SSB consumption decreases, not increases.[112] Accordingly, a tax on SSBs may decrease diet beverage consumption without specifically taxing this beverage group.

'PASS-THROUGH' RATE

An excise tax relies on manufacturers, distributors, or retailers to pass the tax through to consumers. The level of pass-through is largely beyond the control of policymakers and influences the degree to which the intervention impacts consumer behaviour. A 100% pass through rate means that the entire price increase appears on the retail price tags. If companies choose to absorb some of the tax cost rather than shift it entirely to consumers, the pass-through rate will be less than 100%, referred to as 'under-shifting'. In some cases, the companies may increase the product price above the tax rate, creating a profit. A pass-through rate higher than 100% is an indication of this 'over-shifting.' When designing a sugary drink tax, a further consideration is that pass-through rates may differ across sales venues and beverage types.[128,129] Products that are not stipulated in the tax policy as being taxable may undergo a price increase by companies as a tactic to lessen or avoid price increases on taxable products. Pass-through rates should be carefully monitored for implemented taxes and considered in research and policy design.

POLICY PROCESS AND INDUSTRY INFLUENCE

The design of a proposed tax is shaped by its movement through the policy process, including the impact of opposition levelled by beverage industry players. The beverage industry and interest groups, which are sometimes industry funded, have strongly contested proposed SSB taxes or the suggestion of a tax.[130] Studdert and colleagues identify five predominant arguments used by the industry: 1) SSB regulation would result in job and revenue losses by jeopardizing the livelihoods of SSB industry workers and companies; 2) since lower income households spend more on food proportional to their income, a SSB tax would be the cause of inequities; 3) SSB taxes would neither reduce consumption, nor improve health; 4) the SSB tax's design appears 'arbitrary' by singling out beverages when foods may be the cause of obesity; 5) taxes are a product of a 'nanny state' trying to impinge on personal freedom.[130] The beverage industry has expended millions of dollars on efforts to resist potential taxes and perpetuate these arguments. The American Beverage Association and other tax opponents spent $22.4 million fighting San Francisco's SSB taxation efforts, nearly double the $12 million donated from tax supporters and philanthropists.[131] Examples exist for other jurisdictions.[132] The industry's resistance does not cease once a SSB tax is passed. The American Beverage Association has launched a lawsuit against the Philadelphia sweetened beverage tax and recently filed their complaint to the Pennsylvania Supreme Court, after being dismissed and losing appeals in two lower courts.[133]

Contrary to arguments from the beverage industry, evidence suggests that a SSB tax will lead to greater health improvements among low income individuals because this population typically consumes higher volumes and is more responsive to price changes.[134,135] SSB taxes can reduce disparities and are therefore 'progressive for health',[96,97,136] despite being slightly fiscally regressive.[137] Health and social programs funded by tax revenues can further work to reduce disparities,[135] which is an explicit component of the Berkeley tax.[138] Minimal net economic impact is expected on jobs and consumer spending.[139,140] The financial benefits associated with SSBs taxes provide an advantage over other policy interventions.[98] Though health-related food taxes are not a panacea for obesity–no single intervention is[141]–these measures are among the most cost-effective diet-related disease prevention strategies.[142,143]

Despite the recently passed taxes, fiscal policies for dietary interventions are rare and efforts to pass taxes encounter substantial resistance that may prevent their success. Philadelphia's tax only succeeded after two failed attempts.[144] Voters in Sante Fe, New Mexico recently rejected a two cent per ounce sugary drink tax to fund pre-kindergarten programs.[145] The WHO recommends that governments tax sugary drinks and other unhealthy products.[116] Research evidence is crucial to informing and strengthening future fiscal policy initiatives.

THE IMPACT OF SSB AND SUGARY DRINK TAXES ON CONSUMER BEHAVIOUR

Empirical research on the effects of beverage taxes, which principally examines SSB taxes and rather than sugary drinks, fits under three broad study designs: experimental studies, 'natural experiments' from real-world taxes, and simulation modelling studies.

EXPERIMENTAL STUDIES

Experimental studies use a controlled setting to apply an intervention and measure differences between groups of participants randomized to different intervention conditions, including a control condition. Following a systematic approach to searching the research literature, experimental studies on beverage tax interventions were identified (N=13 articles). Settings consisted of the USA (n=7),[146–152] Netherlands (n=3),[153–155] Canada (n=1),[156] New Zealand (n=1),[157] and Taiwan (n=1).[158] One study focused on 'sugary drinks'[156] and four studies focused on sugar-sweetened beverages;[152,155,157,158] the remaining studies examined both foods and beverages. Many studies assigned participants with a task of shopping for groceries, either in an online three-dimensional grocery store,[154,155] grocery store website,[147,148,153] or an analogue laboratory grocery store.[149,152] Other studies involved purchasing lunch,[146,150,151] purchasing beverages,[156,158] or measures gathered by survey.[157] Tax levels were based on price and varied from 5%[154] to 100%,[152] with a medium of 25%. Six studies tested multiple tax rates.[147,149,150,152,156,158] One study tested the difference between including or excluding the tax in product price tags.[146]

Taxable beverages and the criteria used to identify them differed substantially across studies. Of the five studies focusing on sugary drinks or SSBs, Acton et al. had a broad range of taxable sugary beverages (soft drinks, fruit drinks, 100% juice, sports drinks, flavoured water, iced tea, and flavoured milk),[156] as well as Waterlander et al. (soft drinks, fruit juice, flavored milk, energy drinks, ice tea, ice coffee, fruit syrup, sparkling fruit drink, lemonade).[155] Bollard et al. used a single carbonated SSB product in their online survey.[157] Yang and Chiou classified 'unhealthy beverages' as regular carbonated soft drinks, fruit drinks, sweetened iced tea, and sports drinks.[158] Temple et al. taxed energy drinks only.[152] The remaining studies applied taxation criteria to food and beverage products. Regular carbonated soft drinks were the most commonly taxed beverages, followed by non-carbonated soft drinks (e.g., iced tea) and sweetened juice drinks.[146–151,154] Temple et al. taxed additional beverage types: sweetened milk, sports drinks, and diet soda.[151] Two studies did not clearly delineate which beverages were and were not taxable.[153,154] Several studies used nutrient profiling systems to identify taxable products. Sugar content was one of numerous nutritional properties considered.[147–151,153,154] Chen et al. included lunch options identified by the researchers as 'healthy' or 'unhealthy'.[146] Numerous studies examined other interventions than only taxation: subsidies to reduce food prices,[147–149,154,158] nutrition labelling,[148,150–152,156,157] nutrition education,[151,158] and plain packaging of products.[157]

Experimental studies varied in the type of outcomes examined. Most studies reported tax interventions as improving nutrition-related outcomes: reduced purchases or improved nutritional characteristics,[146–153,155,156,158] or decreased preference for sugary beverages.[157] The one study with non-significant findings examined three tax levels (5%, 10%, 25%) combined with three subsidy levels (no, 25%, 50%) and reported non-significant effects across the tax levels on food selections. The authors note that this may be because of comparably high subsidy levels.[154] Experimental studies have also tested for beverage switching or compensatory behaviours. Beverage taxes prompted consumers to switch from a preferred unhealthy beverage to a healthier alternative.[146,156] Other researchers found that the tax reduced purchased SSBs and had no significant effects on purchases of potential substitute beverages, including alcoholic, or snack foods.[155] Including the tax in the price had a more favourable impact on nutrition content than adding the tax at the point of sale.[146] Due to small sample sizes and heterogeneity, the body of experimental literature does not currently support any conclusions on how personal characteristics (e.g., weight status) may moderate these outcomes.[159]

Overall, experimental studies report that beverage taxation has the additional effect of influencing food selections. Consumers tend to reduce their consumption of high-calorie and less-healthful products, but more research is required the relationship between beverage taxes and food choices, especially any substitution effects.[160] Related evidence from experimental non-randomized intervention trials in hospitals and schools report similar findings for these more naturalistic settings.[161–163] Experimental studies are useful for understanding consumer choice in a controlled setting by recreating and manipulating aspects of interest in the consumer experience. However, experimental studies cannot determine whether the magnitude of these effects is sufficient to reduce diet-related disease risk at the population level.

NATURAL EXPERIMENTS ON SSBS

'Natural experiments' examine changes in outcomes following the implementation of SSB taxes in real-world settings. Peer-reviewed English-language articles are published for five jurisdictions with SSBs taxes (N=12 articles): Mexico (n=7),[164–169] Berkeley, California (n=3),[129,140,170] France (n=1),[128] Barbados (n=1),[171] and Philadelphia (n=1).[172] All studies used data from before and after the tax implementation date (pre/post design) and compared taxed and untaxed beverages. The Berkeley and Philadelphia studies incorporated comparison cities.[129,140,170,172] Data sources were diverse, consisting of: point of sale transaction data,[129,171] product scans,[129,170,172] intercept or telephone surveys of residents,[129,140] consumer panels,[165,169] and mobile apps.[128] The Mexico studies made use of several government-administered datasets: point of sale data,[164] household spending surveys,[168] and industry surveys.[166] Several studies examined populations more vulnerable to health disparities: low-income neighbourhoods,[140,170] rural or semi-rural,[167] or stratified by rural/urban or income.[168] Three studies used data for only urban populations.[164,165,169,172] Of the studies examining the general population,[129,166] one adjusted for income.[129] For the France and Barbados studies, the populations were not specified, but the data collection methods suggest urban populations.[128,171]

Overall, the evidence indicates that the SSB taxes are having a favourable impact on the following outcomes. Studies consistently report that taxes have been passed through to consumer price, though not fully and in a heterogeneous manner.[172] For example, carbonated soft drinks prices increased to a greater degree than non-carbonated drinks.[128,129,164,167,170] Evidence from Barbados reported a divergence in pricing trends of taxed and untaxed beverages, suggesting that the tax increased the prices of taxable beverages.[171] Sales or purchases of taxed beverages have decreased either on a per capita or volume per transaction basis, and untaxed beverages have increased,[129,166] especially among low SES groups.[165,168,169] Two Berkeley studies examined beverage consumption with differing results, which may be due to methodological differences.[129] Using a beverage frequency questionnaire that included taxed beverages and water, Falbe et al. found that frequency of consuming taxed beverages decreased whereas the same beverages in comparator cities increased.[140] Silver et al. used a 24-hour beverage intake recall that asked consumers to report on a comprehensive range of untaxed beverages, and had no comparison city for this study component. The authors found a non-significant decrease in calories and volume from taxed beverages and a significant increase in calories and volume from untaxed beverages, particularly high fat or high sugar beverages like milk, yogurt smoothies, and milkshakes.[129]

Two additional studies examined SSB taxes that were initiated on a small-scale by restaurant or convenience store operators. Both studies report decreases in taxed beverages and substitution with untaxed beverages.[173,174] Aside from studies on implemented SSB taxes, several studies examining low level SSB taxes in USA states or differential SSB prices within prospective cohorts suggest that higher SSB prices are associated with reduced consumption and may be linked to lower BMI.[175–179]

Evidence from real-world taxes is incredibly valuable and a key component to successfully passing taxes in new jurisdictions. The identified studies reported on an array of outcomes, including shifts in consumption patterns. However, given the newness of these taxes, it is too soon to evaluate the medium- to long-term outcomes, such as health effects or health care savings.

SIMULATION STUDIES

In settings with neither SSB nor sugary drink taxes, mathematical simulations are an important tool for estimating the potential impact of a tax for a given population and can bridge the gap between empirical research and long-term health outcomes.[180] Building on econometric studies that estimate how price changes affect consumer purchasing patterns,[95,112] simulation studies quantify how a theoretical tax influences modelled beverage consumption and subsequently impacts weight and health outcomes, health care costs, and tax revenue.[90,142,181–183] Simulations incorporate parameters obtained from natural experiments and experimental studies.

44 peer-reviewed studies use simulation methods to estimate the effects of a SSB tax, and 3 key reports (N=47 publications). Authors from one study disclosed that the study was funded by the Union of European Soft Drinks Association.[184] Authors from an additional three studies disclosed competing interests related to having previously received funding from food and beverage industry.[185–188] No studies examined a Canadian population. Study settings included the following countries: USA (n=21)[122,126,134,142,182,188–203], UK (n=5)[184–186,204,205], Australia (n=6)[90,124,137,181,206,207], South Africa (n=3)[208–210], Mexico (n=2)[211,212], Germany (n=2)[183,213], and one study each for Great Britain,[214] Ireland,[215] England,[216] Norway,[217] New Zealand,[218] India,[187] Chile,[219] and Brazil.[220]

Studies varied in the type of interventions that were simulated. Studies examined multiple tax levels,[124,137,184,185,190,195,200,206,211,212,214,217] or compared taxes to other interventions.[126,142,181,184,185,188,190,193,195,199–202,205,207,219,220] A handful of studies estimated the relative cost-effectiveness of different interventions.[137,142,181,189,199,207] The majority of studies applied the tax to a range of SSBs. Four studies taxed only carbonated drinks.[134,202,217,218] One study applied a tax to individual beverage categories.[214]

Within simulation studies there is a wide range in the outcomes and methods. Specifically, a number of studies focused on estimating price elasticities of demand for foods and beverages using regression analysis.[124,126,134,184,186,187,190,191,194,196,198,202,205,206,214,217,219,220] Weight change or change in BMI category was a common outcome;[122,124,134,137,142,181,183–187,189,193,194,196–199,204,206–208,212,215,217,221] however, 8 of 26 studies used weight change ratios now regarded as outdated and inaccurate.[122,134,192,196–198,211,217] Two studies examined only food consumption or calorie changes.[195,200] The remainder of studies examined diseases,[137,181,182,185,187–189,192,203–205,207,209–213,216,218,221] health care costs,[137,142,181,182,189,192,199,203,204,207,209–211,213,216,221] or tax revenue.[137,142,182,183,186,189,194,201,203,207,210,218,221] Of the studies examining these last three outcomes, the most common method was macrosimulation,[137,181,182,186,188,189,192,203,207–211,216,218,221] followed by microsimulation[142,183,187,193,204,212,213] or other methods.[185,194,199] Comparison of simulation study outcomes is challenging due to different model structures, physiological pathways, populations, assumptions, and interventions. A recent systematic review of simulation models reported that sugary drink tax simulations predicted 'modest to effective' reductions in calorie intake, and 'modest' improvements in health outcomes.[222]

100% JUICE AS A TAXED BEVERAGE

The inclusion of 100% juice as part of a beverage tax is relatively unexplored in the experimental and simulation literature. Using an experimental marketplace design, Acton and Hammond included 100% juice among taxed sugary drinks containing free sugar.[156] Of the simulation studies, only one examined the implications of taxing 100% juice, but did not investigate the effects of combining SSBs and 100% juice into a single tax.[214] There is growing epidemiological evidence to support examination of the potential impacts of a tax that includes 100% juice. The consumption of free sugars is a determinant of body weight and further influences cardiometabolic factors independent of weight.[29,35] In long-term studies, 100% juice is reported as showing metabolic functions similar to SSBs in terms of dietary compensation and the effects of sugars in juice on diabetes and other health conditions.[223] Compared to SSBs, meta-analysis of longitudinal evidence on 100% juice is limited: a single study on children and youth. Following analysis of 8 prospective cohort studies, the authors reported the consumption of 6-8 ounces 100% juice daily (177-237 ml) of juice per day as being associated with a small amount of (clinically non-significant) weight gain among young children (1-6 years) and not associated with weight gain among older children (7-18 years);[224] similar meta-analyses for adults have not been published.

Until Thailand announced a tax on sugary drinks, no taxes have included 100% juice despite its sizable contribution to total sugar intake, especially among children. Canada's 2007 national food guide lists 100% fruit juice as a serving of fruits or vegetables, though cautions to consume fruits and vegetables more than juice.[56] Only recently have guidelines, such as those of the American Academy of Pediatrics, further distinguished between fruit and 100% juice by advising minimal to no intake of 100% juice by babies and children, and no longer classifying 100% juice as a serving of fruit.[225] Health experts and beverage industry representatives have criticized the UK tax for excluding some beverages containing free sugar from the tax, arguing that a tax which comprehensively taxes beverages containing free sugar would be more equitable.[226] The potential impact of a tax on 100% juice is an important research priority.

SUGARY DRINK TAXES IN CANADA

Several narrative reviews discuss the need and possible implications of a sugary drink tax for the Canadian population.[227,228] However, to-date there is one experimental study[156] and no real-world or simulation studies specific to Canada. Canadian provinces and territories currently apply sales taxes to sugary drinks (5%-15%), as they do many purchased foods and drinks; however, there is no health-oriented tax on SSBs or sugary drinks designed to reduce consumption. Media reports in early 2016 indicate that the Canadian government examined the potential implications of a SSB tax.[229] Public health stakeholders support a tax.[230–232] Public support for a tax on SSBs is modest, with support increasing if revenues were used toward health initiatives.[228,233] There is an urgent need for Canada-specific evidence on the potential impact of a tax on sugary drinks to inform the policy process.

RATIONALE

The current study addresses several evidence gaps. First, relatively little is known about Canadians' sugary drink consumption, including any relationship between sugary drink consumption and socio-economic status. To date, no studies have examined Canada's recently released dietary intake data to determine Canadians' current sugary drink consumption. Based on findings from other jurisdictions, it was expected that the beverage types and volumes consumed by Canadians have shifted since the last national dietary recall in 2004. Despite the known hazardous metabolic effects of 100% juice,[47] few sugary drink quantifications from any setting include 100% juice.[234] The current study provides critical evidence on recent sugary drink intake patterns, including 100% juice, new and emerging beverage products, and differences by sex, age, and socio-economic status. These data has the potential to inform policy decisions on a sugary drink tax, and may be used toward other policy measures proposed by the federal government, including prepackaged food labelling and restrictions on marketing of unhealthy foods and beverages to kids.[235,236]

The second critical gap is that no simulation studies have examined a tax that includes 100% juice. Given the high consumption of 100% juice, especially among children,[48,49] there is a need to quantify the potential added health benefit and health care cost savings from including 100% juice in a tax. In addition to modelling a tax on SSBs, the current study explores the potential impact of including 100% juice in a beverage tax. This comprehensive approach to identifying taxable products is consistent with scientific evidence on metabolic effects of sugary drinks[47] and the associated health effects of free sugar intake.[29,35] It avoids the appearance of an 'arbitrary' selection of taxable products by including all beverages with free sugar content.[130] Furthermore, 100% juice is eliminated as a substitute beverage for SSBs, enhancing the potential effectiveness of the intervention.

Third, no published studies have modelled a SSB or sugary drink tax for the Canadian population. Canadians currently experience a tremendous health burden from obesity and diabetes.[22,23] A substantial proportion of energy intake comes from sugary drinks.[52] Evidence from implemented SSB taxes supports the policy's effectiveness at reducing this dietary risk factor.[140,165,166,168,169,212]

As a result, the government of Canada's Northwest Territories has announced the introduction of a sugary drink tax in 2018-19.[237] As of yet, there is no indication of a federal national tax intervention. Evidence on Canada-specific health and economic impacts on a tax would be directly aligned with calls for action and could be an important piece for informing Canadian decision makers by providing setting-specific evidence. The current study contributes evidence to bridge this gap. Mathematical simulations provide useful evidence to policymakers, and have preceded—and perhaps helped to instigate—the implementation of SSB taxes in the UK, Ireland, and South Africa.[186,208,215] The current study also contributes to the very limited Canadian literature on simulated dietary interventions,[85,238] which is a relatively unexplored area of research for Canada, and provide essential inputs, such as disease-specific health care costs, that may be applied in future modelling of other obesity or diabetes prevention interventions.

Lastly, existing simulation studies do not account for the combined impact of the direct effects of sugary drinks on diabetes and the BMI-mediated effects on the risk of a comprehensive profile of diseases associated with high BMI, such as those reported by the most recent Global Burden of Disease.[239] Previous simulation studies modelled fewer BMI-related diseases or did not include type 2 diabetes direct effects.[90,142,182,204] Excessive weight gain has far-reaching health effects, and sugary drinks directly increase type 2 diabetes risk apart from weight-mediated effects.[42] Inclusion of these conditions and pathways is important when quantifying the possible impact of a sugary drink tax. The current study models what could be considered the most comprehensive selection of BMI-related diseases, while also accounting for type 2 diabetes direct effects.

RESEARCH QUESTIONS

The study's overall objective is to investigate Canadians' sugary drink consumption and the potential impact among the Canadian population of a simulated national tax on SSBs or sugary drinks. To achieve this objective, the study addressed the following research questions:

1. What is the mean intake (volume and energy) of sugary drinks and sugary drink types among Canadians by sex, age, ethnicity, socio-economic status, province, and BMI subgroups?
2. What is the estimated health and economic impact of a simulated national tax on sugar-sweetened beverages (SSBs) or sugary drinks among the 2015 Canadian adult population?

Based on the existing literature, several hypotheses have been formulated to be examined in the current study. Hypothesis 1 corresponds to research question 1. Hypotheses 2-4 correspond to research question 2.

Hypothesis 1: Sugary drink intake will be significantly higher among males, youth and young adults, non-white ethnicities, lower socio-economic status, the Atlantic provinces, and individuals experiencing overweight or obesity.

Hypothesis 2: A tax on SSBs or sugary drinks will have larger health and economic benefits than a 'business as usual' scenario.

Hypothesis 3: A tax on SSBs or sugary drinks will have larger health and economic benefits among males than females.

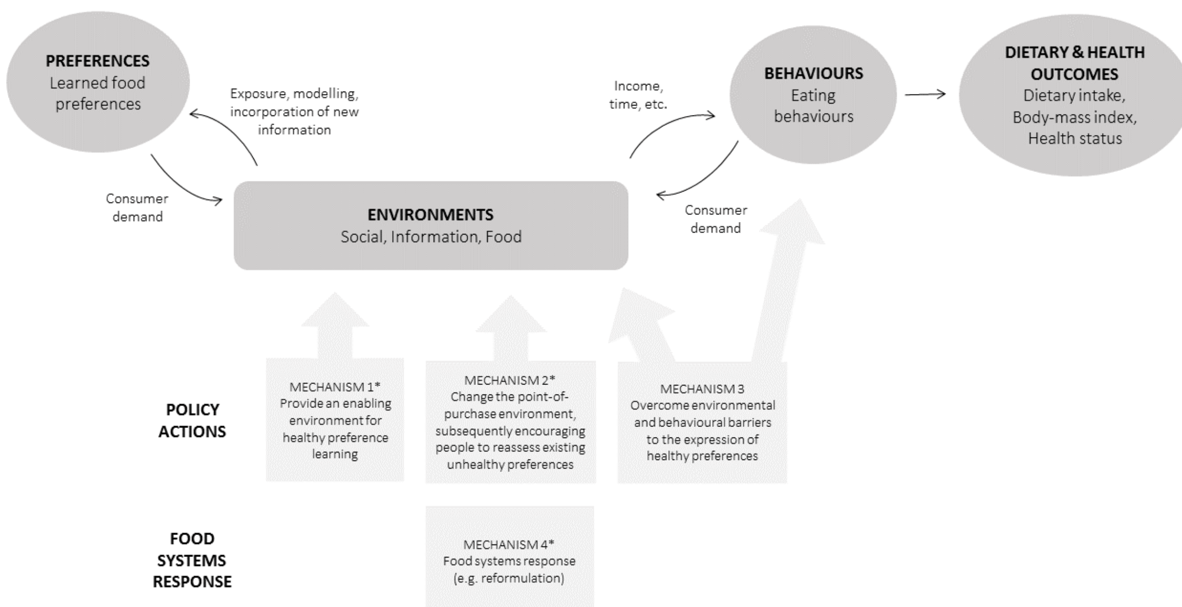
Hypothesis 4: A tax on sugary drinks will have larger health and economic benefits than a tax on SSBs.

METHODS

STUDY DESIGN

The methods for the current study are presented in two sections. The first section, *Sugary Drink Data and Analyses*, describes the analysis of Canadians' sugary drink intake using cross-sectional 2015 national dietary intake data. The second section, *Health and Economic Costs Model*, describes the methods for estimating the potential impact of SSB and sugary drink tax interventions on health and economic outcomes in the Canadian population over a 25-year time period using simulation modelling.

Figure 1. Framework of the theory of change and the four mechanisms through which food policy actions could be expected to work



Adapted from Hawkes et al 2015[92]
*Mechanisms through which food and beverage taxes work

The study's overarching conceptual framework is from Hawkes et al [92] in which food and beverage taxes are one type of food policy aimed at improving diet-related health outcomes (Figure 1). Taxes work through three of four mechanisms. On the basis of economic theory, the price increase of the taxed product encourages people to reassess pre-existing unhealthy preferences and reduce their purchases and intake of sugary drinks (Mechanism 1). The tax encourages healthy preference learning, with support from media and education (Mechanism 2).

Tax interventions can also incentivize food companies to reformulate their products to reduce sugar content, thereby influencing the food environment (Mechanism 4).

SUGARY DRINK DATA AND ANALYSES

Nutrition data analysis consisted of two components: first, to report consumption patterns, SSB and sugary drink intake among Canadians was examined; second, to simulate the effects of a beverage tax, SSB and sugary drinks intake was quantified specifically for inclusion in simulation models.

SURVEY

Sugary drink intake was calculated from the 2015 Canadian Community Health Survey – Nutrition (2015 CCHS-Nutrition), a cross-sectional survey which provides the most recent national estimates of dietary intake.[240] The survey used a stratified multistage cluster design with probability sampling of Canadians residing in the 10 provinces ages 1 year and older (N=20,487). Excluded persons were those living on reserve and other Indigenous peoples' settlements, full-time members of the Canadian Forces, and the institutionalized population. Respondents were limited to one person per household. The survey consists of a representative sample of the majority of Canadians residing in the 10 provinces, drawing from a sampling frame that covers above 95% of the population in 'mail-out' areas and above 90% of the population in 'non-mail-out' areas for the provinces.[240] Using a computer-assisted interviewing tool, respondents were administered a General Health Survey and a dietary recall of all foods and beverages consumed over the previous day's 24-hour period (24-hour recall). The survey included only one respondent per household. The 24-hour recall used the five steps of the Automated Multiple-Pass Method: quick list, forgotten foods and beverages, time and occasion, detailed information including amounts consumed and preparation method, and a final review.[241] A proxy (e.g., parent or guardian) provided information for respondents below age 6 and assisted respondents aged 6 to 11. Respondents aged 12 and older provided their own information. Using probability sampling, approximately 30% of respondents completed a second dietary recall, conducted 3 to 10 days later.[240] The current study included all respondents with a valid first dietary recall, and used first dietary recall data only. No respondents consumed breastmilk exclusively. Respondents who were pregnant (n=119) or breastfeeding (n=188) were excluded, for a final sample size of N=20,176. Data was accessed through the South-Western Ontario Research Data Centre (SWO-RDC) at the University of Waterloo.

MEASURES

BEVERAGE INTAKE

For the first component, intake was examined for all non-alcoholic beverages containing free sugars. These 'regular calorie' non-diet beverages were based on 17 mutually-exclusive categories and grouped under two headings: '100% juice' and 'total sugar-sweetened beverages' (Figure 2). 'Total sugar-sweetened beverages' consisted of 15 categories of beverages: regular carbonated soft drinks, regular fruit drinks, regular sports drinks, regular energy drinks, coffee pre-sweetened with sugar, coffee with sugar added at the table by the consumer 'coffee sugar-sweetened at the table', tea pre-sweetened with sugar, hot chocolate pre-sweetened with sugar, hot chocolate prepared from scratch, sugar-sweetened milk (e.g., chocolate milk), sugar-sweetened drinkable yogurt, regular flavoured water, smoothies, sugar-sweetened protein drinks, and sugar-sweetened meal replacement beverages.

Figure 2. Categories of sugary drinks

For the second component, intakes of two groups of beverages were calculated for use in simulation models: 'sugary drinks' and 'SSBs'. In the scientific literature, sugary drinks are classified using different criteria, particularly with respect to 100% juice. For the tax simulations, 'taxed sugary drinks' were 12 mutually-exclusive categories: regular carbonated soft drinks, regular fruit drinks, regular sports drinks, regular energy drinks, coffee pre-sweetened with sugar, tea pre-sweetened with sugar, hot chocolate pre-sweetened with sugar, sugar-sweetened milk (e.g., chocolate milk), sugar-sweetened drinkable yogurt, regular flavoured water, smoothies, and 100% juice (Figure 3). 'Taxed SSBs' were the same as sugary drinks, except that 100% juice was omitted (Figure 4). Sugar-sweetened protein drinks and sugar-sweetened meal replacement beverages were not included as taxable beverages, though these products are sweetened during the manufacturing process. Future tax simulations may include these beverages. Excluded sugar-sweetened beverages were also those prepared at home from scratch (e.g., hot chocolate prepared from unsweetened cocoa and sugar) and sweetened at the table (e.g., coffee with sugar added by the consumer), since these beverages are not sweetened during the manufacturing process and would not be subject to a beverage tax.

Figure 3. Beverage group used in sugary drink tax simulation model

Figure 4. Beverage group used in SSB tax simulation model

Based on food codes and descriptions in the 2015 CCHS-Nutrition Food Description (FDC) file, a total of 240 unique food codes (variable name: 'FID_CDE') were used to identify non-alcoholic beverages containing free sugars (Appendix A, Table 1). Some assumptions were made due to limited descriptive and nutrition information. The Food and Ingredient Details (FID) file and the Food Recipe Level (FRL) file report dietary intake, with FID_CDE identifying each type of food or beverage consumed by a respondent. After combining the two survey files, FID_CDE was used to identify sugary drinks based on the 240 FID_CDE sugary drink codes. Double-counting due to combining the two files was eliminated. Sugary drink intake consisted of only volume consumed as a non-alcoholic beverage, and excluded volume consumed as part of food recipes (e.g., orange juice in a stir fry recipe) or alcoholic beverage recipes (e.g., regular cola in a 'rum and coke'). Survey cases were aggregated from one case per reported food or beverage item to form one case per respondent. For each of 16 sugary drink categories, volume and energy variables were derived from 'FDC_WTG' (quantity consumed of a food or beverage, grams) and 'FDC_EKC' (energy per food item, kilocalories). One fruit drink beverage code was missing energy data (FID_CDE 404292 'Juice drink, fruit, without added vitamin C, ready-to drink'). To impute this value, the mean energy density for the fruit drink category was calculated. Then, for consumers of FID_CDE 404292, the fruit drink mean energy density was multiplied by the volume of FID_CDE 404292 consumed, thereby yielding as estimate of energy intake from this particular beverage.

To permit the calculation of per capita estimates, volume and energy variables were duplicated and non-consumers were assigned zero values for beverage categories that they did not consume. Volume and energy variables were summed to yield three measures of total consumption: ‘total sugar-sweetened beverages’, ‘taxed SSBs’, and ‘taxed sugary drinks’. Grams were converted to millilitres (ml) based on 1 gram of water equalling 1 ml of water.[48] Energy was reported in kilocalories (kcal). The dietary intake file was merged with the 2015 CCHS-Nutrition Health Survey (HS) file to examine differences by socio-economic status.

The simulation model incorporated cross-price elasticities of demand for three beverage categories associated with sugary drink price changes: 100% juice, plain milk, and diet or light beverages. Plain water was not included because consumption of water does not affect net caloric intake. Similar to the sugary drinks analysis, the volume and energy consumed from plain milk and diet or light beverages were estimated and included in the model. Diet or light beverages consisted of carbonated soft drinks, fruit drinks, sports drinks, energy drinks, coffee, tea, hot chocolate, and flavoured water described as ‘low calorie’ or containing artificial sweeteners (Appendix A, Table 2). Plain water was not considered a diet or light beverage.

SOCIO-ECONOMIC VARIABLES

The following socio-economic variables were examined: sex (variable DHH_SEX: male, female), age (DHH_AGE: continuous), ethnicity (SDCDABT: Aboriginal, not Aboriginal; SDC_43A: white, not white; SDC_43B: Chinese, not Chinese; SDC_43C: South Asian, not South Asian; SDC_43D: Black, not Black; SDC_43E: Filipino, not Filipino; SDC_43F: Latin American, not Latin American; SDC_43G: Southeast Asian, not Southeast Asian; SDC_43H: Arab, not Arab; SDC_43I: West Asian, not West Asian; SDC_43J: Japanese, not Japanese; SDC_43K: Korean, not Korean; SDC_43L: Other, not Other), total household income (INC_3: continuous), province (GEO_PRV:

Newfoundland and Labrador, Prince Edward Island, Nova Scotia, New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, British Columbia), BMI category (MHWDWHOA: underweight, normal weight, overweight, obese class I, obese class II, obese class III; MHWDWHOY: thin, normal, overweight, obese; MHWDWHOP: thin, normal, at risk of overweight, overweight, obese). Age was recoded into eight age groups used by Health Canada (1-3 years, 4-8, 9-13, 14-18, 19-30, 31-50, 51-70, 71+) and, for use in the simulation model, 10-year age groups (1-9, 10-19, 20-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80-89, 90+). Ethnicity was recoded into six categories (white only, Chinese only, South Asian only, Black only, Indigenous inclusive, mixed/other/not stated/missing). To calculate individual income, total household income was divided by the square root of the household size (DHHDHSZ). Using the square root of household size as an equivalence scale accounts for economics of scale in consumption.[242,243] With survey weights applied, individual income was separated into quintiles ranging from 1 (low income) to 5 (high income). BMI category was recoded in four groups [underweight/normal weight (includes at risk of overweight), overweight, obese, and don't know/refusal/not stated]. The variables for sex and province were not recoded.

ANALYSIS

The first component of the analysis examined volume and energy intake of 16 sugary drink types and total SSBs among population sub-groups. Data was weighted to represent the majority of the 10 provinces.[45] Since weighting methods do not incorporate variance resulting from the multi-stage, clustered nature of the sample design, known as the design effect, a bootstrap resampling method was used for all analysis. The bootstrapped weights prepared by Statistics Canada and Health Canada[43] were applied in the statistical software SAS (version 9.4; SAS Institute Inc., Cary, North Carolina, USA; 2016) using PROC SURVEYMEANS or PROC SURVEYREG with the BRR option. Use of a bootstrap resampling method widens confidence intervals by accounting for greater variance than other weights. The survey file and bootstrap weights file were matched based on the variable SAMPLEID.

Demographic characteristics for the unweighted and weighted samples were reported for: sex, age group, ethnicity, income, province, and BMI (number and percent of sample). The prevalence of sugary drink consumption among children and adults was examined by calculating the number and proportion of consumers of each of the 16 beverage categories and total SSBs. PROC SURVEYMEANS estimated mean and 95% confidence intervals of per capita daily consumption (volume, in ml; energy, in kcal) for each sugary drink category and total SSBs. Estimates were for all respondents, by sex and age sub-groups.

Consumption of 100% juice and total SSBs was examined by socio-economic variable and tested for statistically significant differences in mean consumption between sub-groups. For each socio-economic variable (sex, age category, ethnicity, income, province and BMI category), PROC SURVEYREG estimated mean per capita daily consumption (volume and energy) of 100% juice and total SSBs and used ANOVA with Wald F-test to test for a significant group effect. The procedure also applied Student's t-test to examine pair-wise differences. Statistical significance was set at $p<0.05$.

The second component of the analysis generated estimates of SSBs and sugary drinks intake for simulation modelling. Using descriptive statistics, per capita daily mean and standard errors (volume, in ml; energy, in kcal) were calculated for 'taxed SSBs' and 'taxed sugary drinks' for 10-year age and sex sub-groups. Proportional survey weights were applied in analysis; bootstrap resampling was not used. In the pilot simulation study, use of bootstrap methods for calculating mean beverage consumption produced large standard errors, translating into standard deviations and confidence intervals that were implausible from a behavioural perspective and would have influenced the simulation modelling results. Proportional weights sum to equal the final sample size, whereas scaled survey weights are the number of people that a respondent represents in the target population. Proportional weights were constructed by first computing a weight constant derived by dividing the sample size (N) by the sum of existing scaled survey weights (i.e., the sum of the weight variable WTS_M). Second, for each respondent, the weight variable WTS_M was multiplied by the weight constant to yield a proportional weight value specific to each respondent. Analysis of simulation inputs was conducted with the proportional survey weights applied in statistical software IBM SPSS Statistics (version 24.0; IBM Corp., Armonk, New York, USA; 2016) Since SPSS reports standard errors calculated from the weight variable rather than the sample size, standard errors were recalculated post-analysis from the standard deviation and the unweighted sample size for each 10-year age and sex sub-groups.

In addition to these analyses, demographic characteristics of the unweighted and proportionally weighted samples were reported for: sex, age group, ethnicity, income, province, and BMI (number and percent of sample). For all other results, only proportional sample sizes (not unweighted sample sizes) are reported.

Dietary recall data entails important assumptions and limitations. Measurement error is the difference between reported dietary intake and true intake, and consists of within-person random error and systematic error. Individuals vary in what they eat on a daily basis. Accordingly, reported dietary intake for a single day will be different from an individual's usual dietary intake over a longer time period. This within-person random error contributes variability to single day reports, whereas the population's true distribution is narrower. For research questions requiring usual intake distributions, such as what proportion of the population is above or below a dietary recommendation, within-person random error must be adjusted for. However, the current study examines mean intake for a population, and it can be assumed that group-level analysis of unadjusted means reflects the mean of the population distribution of usual intake, since data was collected throughout the year, and the days of week were evenly represented.[55,244]

Systematic error is minimized in 24-hour dietary recalls, especially in comparison to other more biased dietary assessment tools, such as food frequency questionnaires. However, some degree of intake-related bias and person-specific bias remains. Intake-related bias is related to true usual intake, such as high consumers underreporting compared to their true usual intake and low consumers overreporting compared to their true usual intake. Some misreporting is specific to individual characteristics of the respondent—person-specific bias. For example, underreporting energy intake is related to body weight.[245] Respondents could have been excluded from the current analysis on the basis of suspected energy underreporting or overreporting, but this may have introduced additional systematic bias. However, the possible implications of person-specific bias are an important consideration, especially when examining intake by BMI category.

Finally, underreporting of food consumption is a common limitation of dietary recall data. By some estimates, sugary drink intake is underreported by 30-40%.[246] Due to food and beverage underreporting, estimates of energy intake are often lower than actual energy intake since energy is found in almost all foods and beverages and underreporting as an additive effect. No standard adjustment currently exists for correcting underreporting.[247] Therefore, sugary drink intake based on CCHS data may underestimate actual intake levels, as well as energy intake from these products.

For this study component, the target population is the entire Canadian population. The sample population draws from a sampling frame that includes the majority of the population in the 10 provinces, but not the entire population, which may introduce under-coverage bias.

HEALTH AND ECONOMIC COSTS MODEL

MODEL OVERVIEW

Early in the project, a decision was made to adapt an existing model rather than create a simulation model to estimate the impact of SSB and sugary drink taxes. An inventory of published models was created and reviewed based on three main considerations: 1) whether the model simulated the physiological pathways of primary interest, 2) the model's capacity to forecast future outcomes, and 3) the data and technical complexity required to adapt and parameterize the model, recognizing that the most complex model may not be the model most suited for addressing the research question.[248] A small number of the reviewed models were microsimulations, which permit detailed examination of interactions and outcomes at the individual level, but are highly complex and data intensive. In comparison, macrosimulations were more commonly used to simulate beverage taxes and were highly feasible. In particular, the Assessing Cost-Effectiveness (ACE) model had the following key characteristics: the model simulated BMI-related disease risk from SSB consumption and the direct effects of SSBs on type 2 diabetes risk, the model included a time component, and the model could be feasibly modified for the current project. An external modelling expert was consulted regarding existing models and concurred with the choice to adapt the ACE model. This model was originally created for Australia to examine the effectiveness of key strategies to reduce health risk factors.[90,249,250] One of the model's lead researchers provided approval and expert oversight (JL Veerman) as Jones and colleagues the adapted the model for the Canadian context.[251] The current study further updated the model with several key features, including Canada's most recent estimates of SSB and sugary drink intake.

Table 2. Briggs and colleagues taxonomy of public health economic models

			A	B	C	D
			COHORT/AGGREGATE-LEVEL/COUNTS		**INDIVIDUAL-LEVEL**	
			Expected value, continuous state, deterministic	Markovian, discrete state, stochastic	Markovian, discrete state	Non-Markovian, discrete state
1	No interaction	Untimed	Decision tree rollback or comparative risk assessment	Simulation decision tree or comparative risk assessment	Individual sampling model: Simulated patient-level decision tree or comparative risk assessment	
2		Timed	Markov model (deterministic)	Simulation Markov model	Individual sampling model: Simulated patient-level Markov model	
3	Interaction between entity and environment	Discrete time	System dynamics (finite difference equations)	Discrete time Markov chain model	Discrete-time individual event history model	Discrete-time discrete event simulation
4		Continuous time	Systems dynamics (ordinary differential equations)	Continuous time Markov chain model	Continuous time individual event history model	Continuous-time discrete event simulation
5	Interaction between heterogeneous entities/spatial aspects important		x	x	x	Agent-based simulation

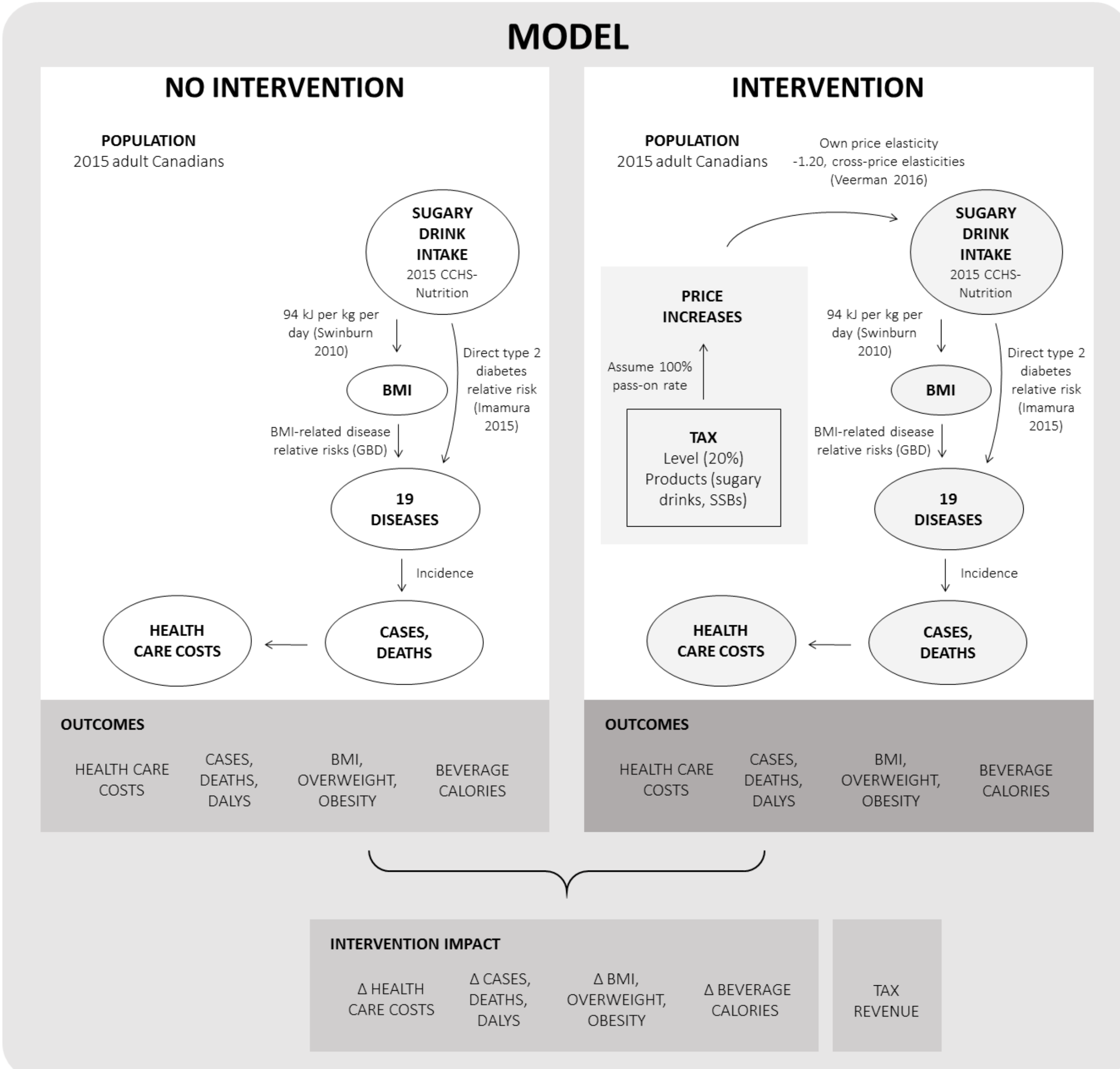
Reproduced from Briggs et al. 2016[248]

In the current study, the ACE model simultaneously simulated different trajectories for two identical populations: a counterfactual scenario of 'business as usual', and a scenario in which beverage consumption was changed through applying a tax intervention. The difference between the two scenarios shows the effect of tax intervention. Within the business as usual scenario, it is assumed that no additional interventions would have an effect on the risk factor or disease outcomes.

The ACE model is a Markov cohort macrosimulation in which the population resides in a main life table and proportions are modelled to have diseases. The ACE model simulates groups of people (cohorts) as they transition between multiple health states (hence, 'multi-state'), and does not use inputs or estimates at the individual-level like microsimulations. Markovian models have no memory (referred to as 'the Markovian assumption). Accordingly, transitions between states are based only on the cohort's current state and not previous states. In Briggs and colleagues' taxonomy of public health economic models (Table 2), the ACE model is classified as B2 "Simulation Markov model", with the addition of a multi-state life table.[248]

Population impact fractions linked the relevant diseases to the causative risk factors using two different pathways: 1) energy consumption from beverages influenced high BMI and BMI-related diseases, and 2) consumption of SSBs, sugary drinks, and 100% juice had a direct effect on type 2 diabetes risk. Own- and cross-price elasticities of demand linked the increase in price from the tax to consumer behaviour, specifically changes in the consumption of taxed, substitute, and complement beverages. Within the model, the population was limited to specific age groups depending on the outcome of interest. The model simulated health effects and health care cost savings for the Canadian adult population (age 20 and older) only due to data limitations. For example, BMI-related relative risks from the GBD Study start at age 25 years. Thus, the model assumes any disease burden before age 20 cannot be prevented and therefore underestimates the potential benefits of the tax intervention, especially for type 2 diabetes and other conditions with reported incidences during childhood and adolescence. However, to permit estimation of the tax revenue for the entire population, the model was re-run with all age cohorts included. The model's starting reference year was 2015. Results are presented for a 25-year period, from 2016-2041. The model's relational pathways, key parameters, data sources, and assumptions are summarized (Figure 5).

Figure 5. Model overview



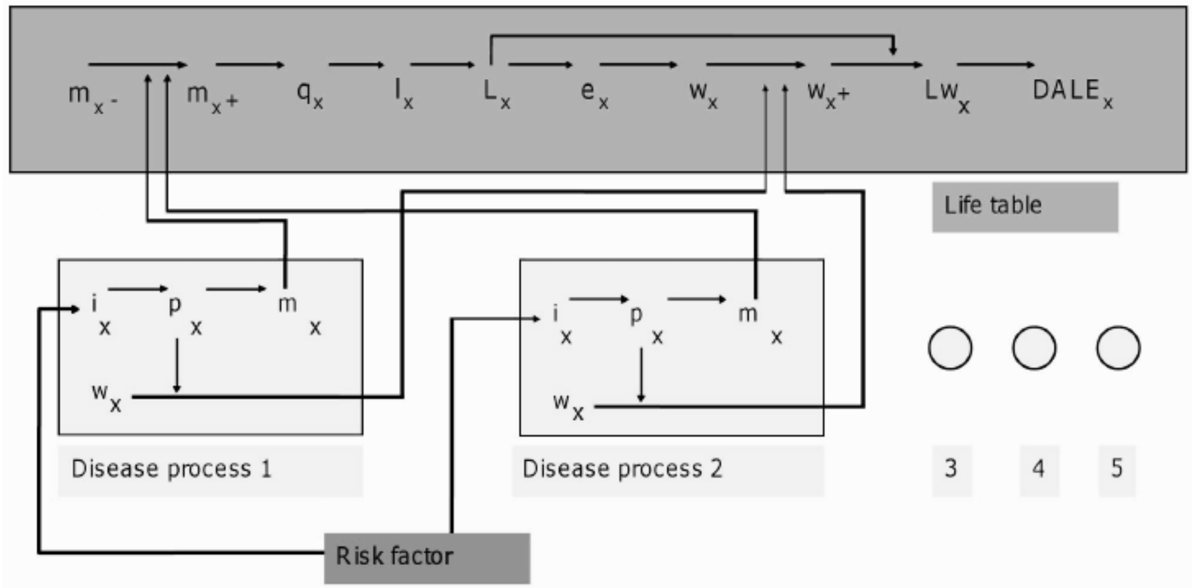
LIFE TABLE ANALYSIS

The ACE model consisted of a main life table populated with a closed cohort replicating the 2015 Canadian adult resident population, aging it over time. Due to model design, the population could not be replenished by new births or immigration. The population was disaggregated by sex and 10-year age groups, but not by additional characteristics such as income, ethnicity, or geography. It was assumed that model inputs and parameters, such as mortality rate, did not vary by these characteristics. Consistent with the design of Markov models, the population transitioned through four primary health states, based on annual transition probabilities, until death or age 95, which was the assumed standard life expectancy. The main life table incorporated all-cause mortality rates by sex and age, but assumed there was no secular trend that would vary mortality rates in the future. Running parallel to the main life table were structures for each modelled SSB- or sugary drink-related disease where proportions of the population were assigned to each disease.

The projected health impact of the tax intervention was tracked through two primary outcomes. First, the model calculated the difference in the number of years lived by the population with the intervention compared to the population without the intervention. Age-sex mortality rates, specific to each disease and from 'all other causes,' determined the number of years lived. Second, the model tracked the years of life lived in poor health due to disease or injury, called years lived with disability (YLD). The average YLD for a given age and sex was referred to as prevalent YLD (pYLD), and pertained to a specific disease or group of diseases. Like mortality, the model used these age- and sex-specific morbidity rates for each disease and all other causes of illness, and it was assumed there were not background trends in disease rates. Disability weights for each disease were used to calculate YLDs and represent the severity of health loss associated with the disease state.

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

Figure 6. Schematic of a proportional multi-state life table



Interaction between disease parameters and lifetable parameters, where x is age, i is incidence, p is prevalence, m is mortality, w is disability-adjustment, q is probability of dying, l is number of survivors, L is life years, Lw is disability-adjusted life years and DALE is disability-adjusted life expectancy, and where '-' denotes a parameter that specifically excludes modelled diseases, and '+' denotes a parameter for all diseases (i.e., including modelled diseases). Source: Lee et al. 2013[252]

If the intervention lowered the incidence of diseases, there was an improvement in disease morbidity and mortality rates. These improved disease rates were added to the all other causes rates in the main life table, thereby improving the entire population's morbidity and mortality rates (Figure 6). These improved rates translated into a reduction in years of life lost and disability.

In this study, costs are from the perspective of the health sector and are limited to downstream costs averted or incurred and not costs of implementing the intervention. The model calculated the difference in health care costs between the business as usual case and the intervention. Negative cost offsets indicated that health care costs were averted due to the tax intervention. Two types of costs were assigned: age- and sex-specific cost of having one of the modelled diseases, and age- and sex-specific annual cost for any other health care incurred by all those alive.

Table 3. Modelled diseases associated with the BMI-related and non-BMI related health effects of SSB and sugary drink consumption[a]

Type 2 diabetes[b]
Breast cancer
Colon and rectum cancer
Esophageal cancer
Gallbladder and biliary tract cancer
Kidney cancer
Leukemia
Liver cancer
Ovarian cancer
Pancreatic cancer
Thyroid cancer
Uterine cancer
Ischemic heart disease
Ischemic stroke
Hemorrhagic stroke
Hypertensive heart disease
Chronic kidney disease due to diabetes
Chronic kidney disease due to hypertension
Chronic kidney disease due to glomerulonephritis
Chronic kidney disease due to other causes
Osteoarthritis of the hip
Osteoarthritis of the knee
Low back pain

[a] BMI-related diseases were obtained from the Global Burden of Disease 2015 Study[8]
[b] Model included the non-BMI-mediated health effects of sugary drinks on type 2 diabetes[42]

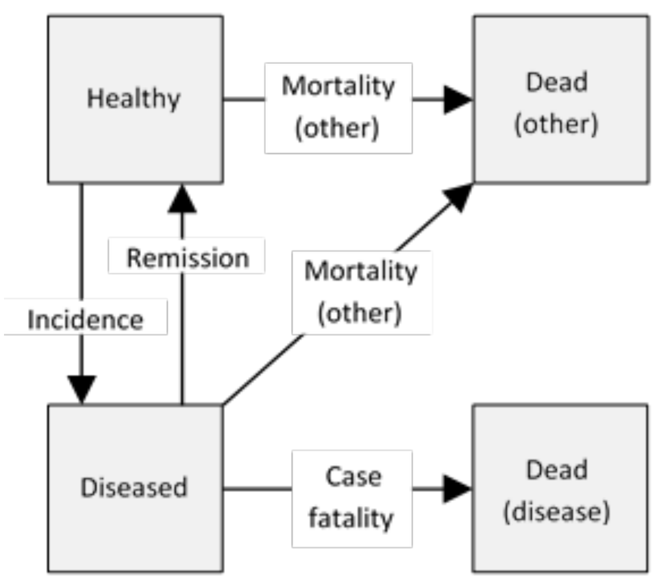
DISEASE MODELS

The ACE model included 19 diseases for which high BMI was a risk factor. The modelled BMI-related diseases paralleled those examined in the 2015 Global Burden of Disease (GBD) study (Table 3).[8] The model accounted for non-BMI-mediated health effects on type 2 diabetes from SSB, sugary drink, and 100% juice consumption. Other non-BMI-mediated risks from SSBs and sugary drinks are not included in the model, which may have underestimated the direct effects of beverage consumption on conditions such as cardiovascular disease.

Consistent with the GBD study, specific types of diseases were distinct, and modelled separately. Chronic kidney disease (CKD) was modelled as four types, by cause, and osteoarthritis was modelled as osteoarthritis of the hip and osteoarthritis of the knee. Disease definitions specified by the GBD study using International Classification of Diseases (ICD) codes guided the selection of other model inputs, enabling the greatest possible consistency in disease definitions for different data sources (Appendix B, Table 1). Osteoarthritis and low back pain were nonfatal conditions.

Each disease has a separate structure within the model, for a total of 23 disease tables. The proportion of the Canadian population assigned to each disease was determined by disease incidence (inflow) and case-fatality (outflow) rates. Together, the main life table and disease structures encompassed the ACE model's four health states: healthy, diseased, dead from the disease, and dead from all other causes (Figure 7). Cohorts transitioned between states based on annual transition probabilities: incidence, remission, case-fatality, and mortality from all other causes. Remission from disease was assumed to be generally unlikely and set to zero. As the intervention had an effect and the population aged, the incidence of diseases reduced and, subsequently, mortality and morbidity rates improved. The disease structures tracked disease health care costs, and reported outcomes of disease incidence, prevalence, and mortality.

Figure 7. Conceptual model of four health states



Each disease is modelled by a conceptual model with four states (healthy, diseased, dead from the disease, and dead from all other causes) and transition hazards between states of incidence, remission, case fatality, and mortality from all other causes. Source: Forster et al. 2011[250]

Since Markovian models have no memory, transition probabilities, morbidity, and cost for a given health state were the same regardless of previous health states or the length of time an individual was in a health state. Furthermore, though proportions of the population could coexist in more than one disease state, it was assumed that diseases were independent of one another. For example, the probability of developing ischemic heart disease did not change with a concurrent cancer diagnosis.[248] However, because type 2 diabetes is associated with increased risk of other modelled diseases (e.g., strokes and ischemic heart disease), model modifications were made, as described in later sections.

EFFECT OF RISK FACTOR EXPOSURE

In the model, the taxation intervention operated via two physiological pathways. First, the tax reduced net energy intake, thereby causing a corresponding reduction in average BMI and, subsequently, reduction in BMI-mediated diseases. Second, through a direct non-BMI mediated effect, lower SSB or sugary drink intake reduces type 2 diabetes. Additionally, 100% juice that was consumed as a substitute to SSBs, also has a direct non-BMI mediated effect on type 2 diabetes. Within these pathways, the changes in BMI and SSB, sugary drink, or 100% juice volume were linked to changes in annual transition probabilities through population impact fraction (PIF) estimates. A PIF is the percentage change in future disease incidence from a risk factor with a given disease relative risk ratio. When the intervention was applied, the intervention's effect was applied through PIFs such that the relative risk of disease incidence due to the risk factor was affected. For type 2 diabetes, PIFs for BMI- and non-BMI effects were combined in the type 2 diabetes disease structure to produce a single effect on incidence. The relationship between the change in risk factor exposure (BMI or beverage intake) and disease risk was captured in relative risk ratios for the relevant diseases.

INTERVENTION SPECIFICATION AND PARAMETERS

TYPE OF TAX

The modelled tax was an ad valorem excise tax set equal to a percentage of the pre-tax beverage price. The tax was modelled for each of the two beverage groups—SSBs and sugary drinks—and used an average pre-tax price of $2.50/litre. The price was approximated from a review of beverage prices on a Canadian grocery store website and weighted based on each beverage category's proportional contribution to Canadians' total daily per capita volume of SSB or sugary drink intake. The pre-tax price of $2.50 assumes all beverages are priced equally and does not reflect that beverage prices vary by beverage type, unit volume, retail outlet, and numerous other factors. Sensitivity analyses modeled other pre-tax beverage prices.

TAXATION LEVELS MODELLED

The ad valorem excise tax was modelled at the following levels: 10%, 20% and 30% of the beverage's pre-tax price. These tax levels were consistent with existing measures in other jurisdictions. For example, based on an average price of $2.50/litre, the 10% increase was similar to the taxes in Mexico and four Californian cities (approximately 1 cent per ounce or 34 cents per litre); the 20% tax was similar to the tax implemented in Philadelphia (1.5 cents per ounce or 51 cents a litre); and, the 30% tax was similar to the tax passed in Boulder, Colorado (2 cents per ounce or 68 cents per litre).[101,102,105,117–119,121] Note that these comparisons may vary based on actual price per litre, and that many existing taxes are designed as specific volumetric excise taxes.

PRICE ELASTICITY OF DEMAND

No Canada-specific price elasticity of demand metrics are currently available for SSBs or sugary drinks. The last time Statistics Canada collected food expenditure data that included quantity purchased was 2001.[253] Given this absence of recent national data and the prohibitive cost of proprietary data, price elasticities cannot be estimated for Canada. The model used a pooled own-price elasticity of demand for SSBs of -1.20 [95% confidence interval (CI): -1.34, -1.06], based on a meta-analysis of studies from the United States, the UK, Mexico, Brazil, France, and India.[221] The beverage category of 'sugary drinks' that specifically includes 100% juice has not been examined in previous price elasticities studies. For example, a meta-analysis of food price elasticities grouped 100% juice with fruits and vegetables in a 'fruits and vegetables' category and combined SSBs with other products in a 'sweets, confectionary and sweetened beverages' category.[254] However, an meta-analysis by Andreyeva and colleagues reports similar mean own price elasticities for 'soft drinks' and juice (-0.79 and -0.76, respectively),[94] as do Smith and colleagues using the categories ‘caloric sweetened beverages’ and juice (-1.264 and -1.012, respectively) in their meta-analysis.[196] To permit testing of the potential impacts of a tax on sugary drinks, the own price elasticity of SSBs was applied to the beverage group of sugary drinks, requiring the assumption that the elasticity for SSBs also applied to sugary drinks. Using the upper boundary for own-price elasticity of demand (-1.06), sensitivity analyses tested the impact of consumers being less responsive to price increases.

The meta-analysis estimated how changing the price of SSBs influenced the consumption of other beverage types, producing cross-price elasticities between SSBs and 100% juice [0.21 (0.14, 0.29)], milk [0.09 (0.03, 0.14)], and diet drinks [-0.30 (-0.63, 0.02)].[221] These cross-price elasticities were included in the current study and it was assumed that the SSB cross-price elasticities for milk and diet drinks could be applied to sugary drinks. When modelling sugary drinks, the cross-price elasticity for 100% juice was not used since 100% juice was included in sugary drinks and therefore could not be a substitute beverage. No known meta-analyses estimate cross-price elasticities between SSBs or sugary drinks and foods or alcohol. Experimental and econometric studies have tested whether increasing the price of SSBs was associated with increased food or alcohol consumption. The studies generally report that for SSBs, most foods are complements, not substitutes, or have no significant relationship.[125,126,219,255,256] The effects of the tax intervention are likely to not be attenuated by additional food or alcohol energy intake. However, given the potential implications of assuming no change in energy intake from food or alcohol, the effects of 50% energy compensation were examined through sensitivity analyses. Price elasticities were assumed to be the same for the entire Canadian population, and not differ by age, sex, income, beverage consumption patterns, or any other characteristic.

The intervention was assumed to be fully implemented after one year. In the model, consumption decreased when price increased. Since the price increased only once, that is, when the intervention was implemented at the start of the model, consumption decreased once and then maintained that level for the duration of the model’s 25-year timeframe. The long-term effectiveness of beverage taxes has not been reported in the academic literature. Therefore, it was assumed that the tax would maintain its effectiveness and that population's beverage intake would not increase after implementation. Sensitivity analyses examined what happened when the tax intervention was effective for only the first 10 years. A 100% tax pass-on rate was assumed; sensitivity analyses modelled 80% and 120% pass-on rates. The rate was assumed to be homogenously applied across products, venues, and geographic settings.

TAX REVENUE

For each tax intervention scenario, tax revenue estimates were calculated in model runs separate from health effects. Tax revenue was based on beverage consumption for the entire Canadian population and not limited to Canadian adults. Tax revenue calculations did not adjust for secular trends in beverage consumption or changes in population demographics. Costs were reported in 2015 Canadian dollars.[257]

BASELINE SPECIFICATION AND PARAMETERS

POPULATION

The model replicated the 2015 Canadian population through the inclusion of three parameters: population size, mortality rate, and prevalent years lived with disability (pYLD) for all causes. The model's population size was Statistics Canada's estimated 2015 population size, by sex and 1-year age groups.[258] All-cause mortality rates was calculated by dividing Statistics Canada's 2012 all-cause deaths by the 2012 population size for corresponding sex and age groups.[258,259] Using the epidemiology software DisMod II (EpiGear, Version 1.05, Brisbane, Australia), data was interpolated to obtain mortality rates by sex and 1-year age groups (0-100+). From the GBD Results Tool, the rate of 'all cause' pYLD was calculated per capita (2015 population) by sex and 5-year age groups.[260]

DISEASE RISK AND EPIDEMIOLOGY

Relative risk ratios captured the relationship between changes in an exposure and a given disease outcome. For BMI-related relative risks, the study used meta-analyses or pooled analyses of prospective observational studies reported by the GBD 2015 Risk Factors Collaborators.[1,8] For sex and age group, mean relative risks (RRs) and 95% confidence intervals (95% CIs) were reported as the relative risk of morbidity or mortality from a high-BMI-related disease, per 5 BMI-unit (5 kg/m^2) increase above a BMI of 22.5 kg/m^2. The GBD study estimated separate relative risks for pre-menopausal and post-menopausal breast cancer. Assuming an average age of 50 years for menopause, the relative risks were combined by using pre-menopausal RRs for ages >50 years and post-menopausal RRs for ages ≥50 years (Appendix B, Table 2). For all RRs, it was assumed that these parameters were uniform across countries, and therefore the RRs based on international data, such as those of the GBD study, apply to Canada.

The model accounted for direct non-BMI-mediated health effects from sugary drink consumption through the inclusion of SSB-related relative risk of type 2 diabetes. Using meta-analyses estimates from Imamura et al., the relative risk of type 2 diabetes incidence increased by 1.13 (95% CI: 1.06, 1.21) per serving (250ml/day) of beverage.[42] In the same publication, the authors identified a non-BMI-related increased relative risk of type 2 diabetes from 100% juice of 1.07 (1.01, 1.14) per serving of juice.[42] However, in the current study, the SSB-related relative risk was applied to both SSB and sugary drink consumption. Other risks from sugary drinks, independent of BMI, such as high blood pressure,[35] were not included in the model due to an absence of suitable parameter inputs.

Assumptions and limitations specific to meta-analyses must be acknowledged. The GBD Study was based upon meta-analyses, and limitations to the GBD Study have been reported and critiqued.[239] The current study used effect sizes from meta-analysis studies to simulate consumer behaviours (i.e. price elasticities of demand) and the effects of BMI and beverage intake on disease risk. Meta-analysis uses the effect sizes reported in published articles to calculate an overall effect size. The accuracy of meta-analytic results relies on the selection criteria used to

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

include or exclude publications, the quality of the included publications, and the application of appropriate statistical analysis, among other factors. Due to publication bias, available articles are more likely to report statistically significant effect sizes or effect sizes in favourable directions, which influences the findings in meta-analysis. Researchers conducting meta-analyses must identify and mitigate differences in articles' populations, settings, study designs, risk factors (e.g. how SSBs are designed), and reported outcomes.[261] Finally, the source of research funding may influence meta-analysis results and conclusions.[224]

The model used age- and sex-specific data on incidence, prevalence, mortality, and case fatality for each disease. Epidemiological data at this level of detail was limited. To yield the necessary data inputs, DisMod was used to estimate an epidemiologically- and mathematically-coherent set of parameters for each disease. DisMod used background population size and mortality, and a minimum of three input variables, to calculate epidemiologically-consistent outputs. Data were assembled and prepared in several steps. First, data on incidence, prevalence, and mortality were identified and compiled. Sources consistent with ICD disease definitions were selected. The most recent data available was used, with preference given to surveillance data from Canada. Since GBD's highest age category is '80+ years', a technique was applied to smooth data up to age 95 years. After preliminary processing, inputs were added to DisMod by 5-year age group and sex for each disease. Across diseases, remission was input as 0. Where necessary, the most reliable input parameters were weighted more heavily. DisMod outputs—incidence, prevalence, mortality and case fatality—presented by sex and 1-year age groups were added to the model (Appendix B, Table 3).

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

In the current study, Canada-specific disability weights for each disease of interest were calculated using GBD data and DisMod output. For each age and sex group, the number of years lived with disability due to a given disease was divided by the number of prevalent cases of that disease. The raw disability weights were adjusted using pYLD for 'all other causes' to fix artificially low weights for older ages. Final adjustments leveled incongruent peaks for a small number of weights. Disability weights were input by sex and 5-year age groups, and are assumed to have no variation within these groups as 95% uncertainty intervals could not be calculated.

BODY WEIGHT

To account for existing secular changes in BMI, the model incorporated predicted BMI trends using existing age- and sex-specific regression coefficients[262] derived from measured and self-reported BMI data in serial cross-sectional surveys: CCHS 2001-2010 (Appendix C, Table 1).[263–269]The predicted BMI trend was applied for 25 years into the future. Sensitivity analyses examined the implications of not applying this BMI trend.

For the current study, population estimates of BMI were calculated using Canadian Community Health Survey – Nutrition 2015 variable for measured BMI found in the Health Survey file (N=20,487).[240] Approximately 70% of respondents permitted the collection of physical measures;[240] participants who reported being pregnant or had unreported BMI were excluded. The data set included special survey weights for use with variables pertaining to measured height and weight to account for lower response rates. Similar to analysis of the model's beverage inputs, bootstrap resampling was not used. Proportional weights were calculated from the weight variable for measured height and weight (variable name WTS_MHW) using the same methods applied during beverage analysis. Mean measured BMI and standard deviation was calculated for sex-specific 10-year age groups. Analysis was conducted with the statistical software IBM SPSS Statistics (version 24.0; IBM Corp., Armonk, New York, USA; 2016) at SWO-RDC. Mean BMI estimates were input into the model with standard deviations to permit uncertainty analyses on this parameter. Within the model, BMI was modelled as lognormally distributed for the Canadian adult population and the results were exponentiated for display and reporting.

The effect of energy intake on weight was modelled using an energy equation for adults from Swinburn et al.[270,271] This formula provides empirically-derived values for the daily intake of energy [measured in kilojoules (kJ)] required for a weight change of 1 kilogram (kg): 94 kJ per kg per day (95% CI: 88.2, 99.8). Among adults, 50% of weight change is in the first year of reduced energy intake, and 95% by 3 years. Swinburn et al.'s estimate is very close to the commonly cited results from Hall et al. of 100 kJ per kg per day; however, Hall et al. do not give uncertainty around the estimate.[272] Physical activity levels were assumed stable, so as to not contribute to changes in energy intake or expenditure.

BEVERAGE CONSUMPTION

SSB and sugary drink consumption data were analyzed as described. Mean and standard error beverage intake for each sex-specific 10-year age group were converted to litres (Appendix A, Table 3 & Appendix A, Table 4). Average per capita daily intake was 195 ml (92 kcal) for SSBs and 270 ml (126 kcal) for sugary drinks; sugary drink volume was 38% greater than SSB volume due to high 100% juice consumption. Average per capita daily intake was 74 ml (34 kcal) for 100% juice, 132 ml (64 kcal) for plain milk, and 44 ml (2 kcal) for diet or low calorie beverages. Energy density from beverage consumption was calculated in kcal per litre for each sub-group, and converted into kJ (1 kcal = 4.184 kJ). No secular trend in SSB and sugary drink consumption was assumed. The model also did not account for secular trends in energy intake. However, the models used a BMI trend which reflects increasing energy imbalance.

HEALTH CARE COSTS

Direct health care costs for each disease were calculated using estimates from Canada's most recent published national disease-specific costs study, the *Economic Burden of Illness in Canada* (EBIC) 2005-2008, and the Canadian Institute for Health Information's *National Health Expenditure Database*. EBIC costs are reported according to diagnostic category, sex and age group. Health conditions are based on ICD codes and organized into diagnostic categories.[78,273,273]

The steps undertaken to estimate disease-specific costs are as follows. First, for each modelled disease, the closest-fitting EBIC diagnostic category was identified by matching the ICD codes. Using the EBIC online too, 2008 costs were generated for each required EBIC category according to sex (male, female) and age category (0-14 years, 15-34, 35-54, 55-64, 65-74, ≥75). For some diseases, the costs were adjusted to improve alignment ICD disease definitions using a proportional method (Appendix D, Table 1).

Second, unattributable direct costs were added to cost estimates. EBIC diagnostic categories do not include direct costs that could not be attributable to a specific health condition. However, EBIC does report total unattributable direct costs. Using a method developed by Krueger et al.,[79] the proportion of each disease's contribution to total attributable direct costs was calculated by sex-age group. This proportion was then applied to total unattributable direct costs. For each disease, the attributable and unattributable costs were summed to yield total direct costs. The attributable direct costs consisted of hospital care, physician care, and drugs. Unattributable direct costs consisted of other institutions, other professionals, capital, public health, administration, and other health spending. Indirect costs, such as the value of lost production due to one's illness, injury or premature death, were not included. For the modelled diseases, incidence during childhood and young adulthood was low. Accordingly, the three youngest categories (0-14, 15-34, 35-54) were collapsed into a single category (<55 years).

Third, the cost per disease case was calculated. Since EBIC reports total costs and not cost per case, each disease-specific direct cost was divided by the number of incident or prevalent cases in 2008 for a given sex-age group to yield cost per case. Incident cases were used for each cancer type. Prevalent cases were used for ischemic heart disease, ischemic stroke, hemorrhagic stroke, hemorrhagic heart disease, type 2 diabetes, chronic kidney disease, osteoarthritis, and low back pain. Some disease case data required adjustment using the proportional method to improve alignment with ICD disease definitions. Incidence and prevalence data was obtained from the Canadian Chronic Disease Surveillance System, CANSIM tables, and the GBD Results Tool.[260,274,275] Lastly, health care costs were inflated to 2015 dollars using the Statistics Canada Consumer Price Index 'health care' sub-index.[257] Costs increased by 9.13% from 2008 to 2015 (Appendix D, Table 2).

EBIC costs data is based on the most responsible diagnosis and therefore does not account for co-morbidities. The current study's analysis does include uncertainty in cost estimates since EBIC does not report 95% confidence intervals or standard errors. However, EBIC data was deemed the most suitable because it provided clear disease-specific costs for the entire Canadian population.

MODEL QUALITY CHECKS

Prior to running the modelled interventions, numerous checks were performed on the model to ensure proper design and functionality, and to support validation efforts. With each check, the model and output were inspected. These checks included examining formulae, setting consumption to zero, running extreme variations of the tax intervention, and checking that costs, relative risks, and other inputs match source documents. The model was an adaptation of an Australian model with similar structure and assumptions, thereby supporting the model's face validity.[90] The model's interval validity was achieved through an earlier review of the model by a modelling expert (JL Veerman) and model checks. As the first model of its kind for the Canadian population, the model cannot be compared to similar models and cross validity cannot be examined. External validity and predictive validity has not been widely examined in for public health simulation models and was not tested in this study.

MODEL ANALYSIS

Analyses were conducted using Microsoft Excel (Microsoft Corporation, Redmond, Washington, USA) and two add-ins: Risk Factor (EpiGearXL 5.0) calculated potential impact fractions and Ersatz (Version 1.34) performed a Monte Carlo simulation with bootstrapping (2000 iterations) while incorporating probabilistic uncertainty from model inputs. Uncertainty intervals (i.e., 95% uncertainty intervals) were calculated, reflecting uncertainties from the following parameters:

mean BMI, relative risks, effect of change in energy intake on weight, beverage intake and price elasticity of demand. Software (excluding Excel) was from EpiGear.com (Brisbane, Australia). Ethics approval was not required for this analysis.

Overall, the primary outcomes were differences in disease-specific incidence, prevalence, and mortality, DALYs, deaths, and cases of overweight and obesity. Cost outcomes showed changes in direct health care costs resulting from changes in disease morbidity and mortality, while accounting for additional health costs due to longer lives. Tax revenue were estimated. All monetary values were reported in 2015 Canadian dollars unless otherwise specified.

SENSITIVITY ANALYSES

Univariate sensitivity analyses examined the impact of modifying key assumptions and parameters. Parameters were varied as follows: 1) BMI remained at 2015 levels, thereby removing the assumed secular trend toward increased BMI; 2) by capping the effect of the tax on BMI, the intervention's effectiveness was stopped after the first 10 years; 3) by using the upper boundary for own-price elasticity of demand, simulated consumers were less responsive to beverage price increases; 5) the effects of energy compensation were examined by modelling no substitute or complement beverages, as well as a 50% compensation of avoided beverage calories; 5) the assumed 100% pass-on rate was changed to 80% and 120%; 5) pre-tax beverage price was varied to test the effect of price on revenue and other outcomes; and 6) consistent with economic practice, a discount rate was applied to DALYs, costs, and revenue to demonstrate how benefits in the future can be deemed lower value compared to benefits in the present. The current study used a 3% discount rate, but 1.5% rate may have been applied in accordance with Canada's *Guidelines for the Economic Evaluation of Health Technologies.*[276]

PILOT STUDY

The original adaptation of the ACE model for the Canadian context was conducted as part of a pilot study using sugary drink intake data from the 2004 CCHS Nutrition survey.[251] The current study built upon this preliminary research and incorporated a number of key modifications: CCHS Nutrition 2004 data was replaced with updated estimates from the CCHS Nutrition 2015 consumption data; BMI data from 2012-2013 was replaced with data from 2015; and the current model accounted for cross-price elasticities by incorporating substitute and complement beverages and their related health effects.

RESULTS

SUGARY DRINK INTAKE

SAMPLE CHARACTERISTICS

Sample characteristics are presented for unweighted and weighted samples (Table 4). For each socio-economic variable, the weighted sample's distributions were generally consistent with those of the unweighted sample. The majority of the sample was over 18 years of age. Ethnicity responses categorized as "White only" were the most frequent among respondents, followed by "Mixed/other/not stated/missing" and "Indigenous inclusive". For sex and income variables, respondents were evenly distributed between categories. Respondents from Ontario, Quebec, British Columbia, and Alberta made up a greater proportion of the sample than respondents from less populous provinces. For the variable BMI category, one-third of respondents had no reported measured BMI. Of those with reported BMI, "underweight/normal" was the most prevalent BMI category, followed by "overweight" and "obese". All subsequent results are presented for weighted samples only.

PREVALENCE OF SUGARY DRINK CONSUMPTION

A large proportion of respondents reported consuming some type of sugary drink during the previous 24-hour period (Table 5). 100% juice was the most widely consumed sugary drink for both children and adults, though consumption was twice as prevalent among children (1-18 years) as adults (19+ years). Similarly for SSBs, which include all sugary drinks except 100% juice, a greater proportion of children than adults consumed these products. Half of all children drank some type of SSB on the previous day, compared to two-fifths of all adults.

Among SSB types, both children and adults were most likely to report consuming regular fruit drinks, sugar-sweetened milk, and regular carbonated soft drinks. For other types of SSBs, consumption patterns varied by age group. For example, drinking yogurt and hot chocolate were more popular among children than adults, whereas adults more widely consumed pre-sweetened coffees and 'other SSBs'.

Table 4. Sample characteristics (N=20,176)

	Unweighted sample		Weighted sample	
	%	n	%	n
Sex				
Male	48.3	9,747	50.0	10,096
Female	51.7	10,429	50.0	10,080
Age (years)				
1-3	6.6	1,324	3.3	671
4-8	6.1	1,233	5.6	1,129
9-13	10.0	2,016	5.3	1,077
14-18	9.9	1,991	5.7	1,153
19-30	8.8	1,779	13.0	2,622
31-50	21.6	4,365	30.5	6,150
51-70	23.1	4,666	26.8	5,402
71+	13.9	2,802	9.8	1,972
Ethnicity				
White only	77.0	15,529	71.6	14,452
Chinese only	3.3	666	4.6	915
South Asian only	3.4	690	4.9	994
Black only	2.0	410	3.5	706
Indigenous inclusive	4.7	940	3.0	606
Mixed/other/not stated/missing	9.6	1,941	12.4	2,504
Income quintile				
1 (low income)	22.0	4,449	20.0	4,034
2	21.7	4,374	20.7	4,178
3	20.6	4,153	19.7	3,968
4	18.0	3,633	19.7	3,973
5 (high income)	17.7	3,567	19.9	4,022
Province				
Newfoundland and Labrador	6.4	1,288	1.5	300
Prince Edward Island	5.8	1,164	0.4	83
Nova Scotia	7.3	1,473	2.6	531
New Brunswick	6.5	1,311	2.1	421
Quebec	15.6	3,153	23.3	4,704
Ontario	20.6	4,158	38.8	7,834
Manitoba	6.8	1,377	3.5	694
Saskatchewan	7.3	1,463	3.0	613
Alberta	11.0	2,221	11.7	2,352
British Columbia	12.7	2,568	13.1	2,644
BMI category				
Underweight/normal	31.4	6,333	29.7	6,002
Overweight	21.3	4,290	21.4	4,308
Obese	16.3	3,293	15.4	3,115
DK/Refusal/NS	31.0	6,260	33.5	6,752

BMI, body-mass index; DK, don't know; NS, not stated

Table 5. Prevalence of sugary drink consumption

	Children 1-18 years %	**Adults** 19+ years %
	n=4,030	n=16,146
100% juice	**39.3**	**22.8**
Total sugar-sweetened beverages	**53.0**	**40.8**
Regular fruit drinks	15.5	7.1
Sugar-sweetened milk	15.0	7.2
Regular carbonated soft drinks	14.9	15.3
Tea pre-sweetened with sugar	5.7	4.3
Flavoured drinkable yogurt	5.5	0.7
Smoothies	4.3	4.6
Hot chocolate pre-sweetened with sugar	3.2	1.1
Coffee pre-sweetened with sugar	1.9	4.4
Other SSBs*	1.8	3.1
Regular sports drinks	1.7	0.9
Regular flavoured water	0.5	0.4
Regular energy drinks	0.1	0.5

Proportion of respondents who reported consuming a beverage type during the previous 24-hour period. N=20,176
*Due to small cell counts, five beverage types were aggregated to create 'Other SSBs': regular protein drinks, regular meal replacement beverages, coffee that was sugar-sweetened by the consumer before consumption ('coffee sugar-sweetened at the table'), tea sugar-sweetened at the table, and hot chocolate prepared from basic ingredients ('from scratch').
SSB, sugar-sweetened beverage

AVERAGE DAILY SUGARY DRINK CONSUMPTION

The average daily volume and energy intake of 16 sugary drink types and 'total SSBs' is reported for the entire Canadian sample (1+ years), and by sex and age category (Table 6). F-tests were conducted to test for differences in average per capita daily volume and energy intake of 100% juice and total SSBs by socio-economic characteristic (Table 7). For significantly different socio-economic variables, pairwise comparisons with Student's t-test are reported elsewhere (Appendix E, Table 5). Average daily sugary drink consumption is presented elsewhere for eight sex-specific age categories (Appendix E, Table 1-4).

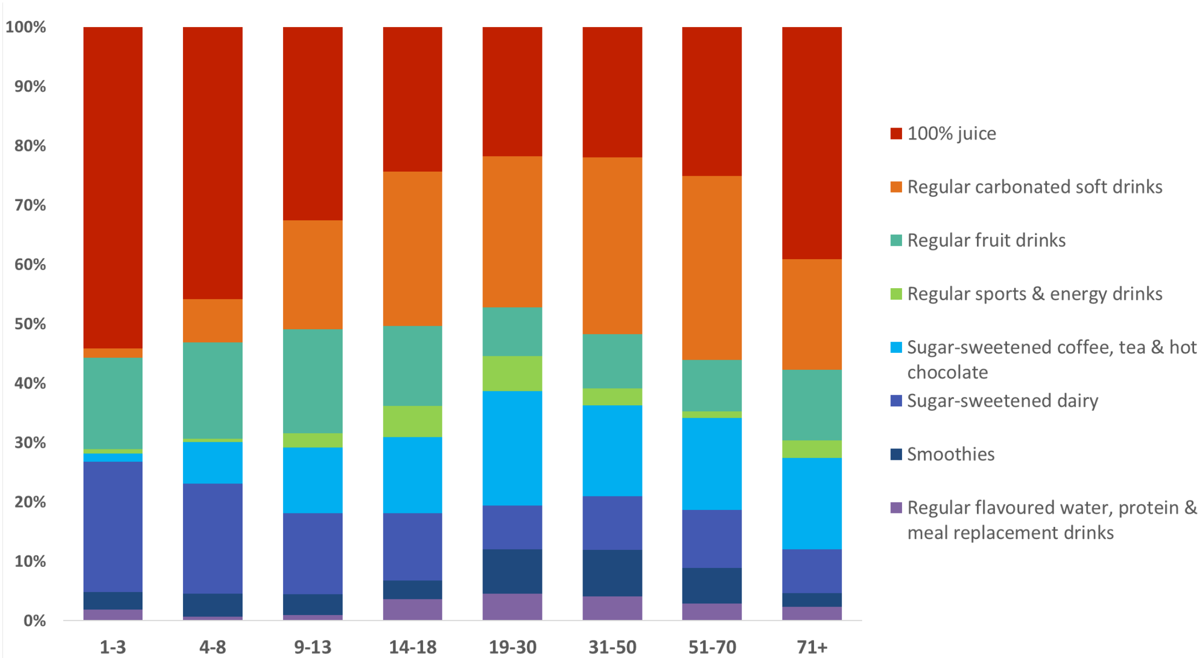
In 2015, each Canadian consumed an average of 74.3 ml (33.7 kcal) of 100% juice and 203.6 ml (98.7 kcal) of SSBs per day. Canadians consumed a wide range of sugary drinks, but a small number of beverage types contributed the vast majority of total volume. 100% juice was consumed more than any other sugary drink, followed closely by regular carbonated soft drinks. Beverages with some fruit flavour or content (regular fruit drinks and smoothies), sugary tea and coffee, and flavoured milks were the next most popular. Beverages for which consumers added their own sugar were consumed the least.

Sugary drink intake differed by sex in terms of both beverage quantity and preferred types (Table 7). Compared to females, males' consumption was significantly higher for 100% juice (37% greater volume) and total SSBs (54% greater). Males reported consumption was higher for all other beverage types, except hot chocolate pre-sweetened with sugar, flavoured drinkable yogurt, and coffee sugar-sweetened at the table.

Sugary drink intake also differed by children versus adults (Table 6). Children consumed more sugary drinks on average each day than adults: nearly double the volume of 100% juice (86% more) and 14% more SSBs. Children's daily consumption was higher for 8 of 15 SSB categories: regular fruit drinks, sugar-sweetened milk, regular sports drinks, hot chocolate pre-sweetened with sugar, flavoured drinkable yogurt, regular flavoured water, hot chocolate prepared from scratch, and tea sugar-sweetened at the table. However, for both age categories the same three beverages (carbonated soft drinks, fruit drinks, and sugar-sweetened milk) contributed the majority of SSB volume: 69% of children's SSB volume and 60% of adults' SSB volume.

Beverage intake was different when examined by eight age categories (Table 7). For 100% juice volume and energy, all pairwise comparisons were significantly different except for six comparisons: 9-13 vs 4-8, 9-13 vs 14-18, 19-30 vs 1-3, 19-30 vs 14-18, 19-30 vs 71+, and 31-50 vs 71+. For total SSBs volume and energy, all pairwise comparisons were significantly different except for two comparisons: 4-8 vs 51-70 and 14-18 vs 19-30. Energy intake was also not significantly different for 1-3 vs 71+. There were notable variations according to age category in the contributions of individual beverage types (by volume) to overall sugary drink intake (Figure 8). For children and older adults, 100% juice was the most consumed sugary drink. In contrast, carbonated soft drinks was the leading sugary drink among Canadians ages 14-70. Beverage consumption was most dispersed across beverage types during age 19-30 years.

Figure 8. Distribution of types of sugary drinks consumed, by age category



Proportion of total volume by beverage category
Sugar-sweetened coffee, tea & hot chocolate: tea pre-sweetened with sugar, coffee pre-sweetened with sugar, hot chocolate pre-sweetened with sugar, tea sugar-sweetened at the table, coffee sugar-sweetened at the table, hot chocolate prepared from scratch
Sugar-sweetened dairy: sugar-sweetened milk, flavoured drinkable yogurt

Beverage intake differed by ethnicity (Table 7). 100% juice intake among respondents with black ethnicity was significantly higher compared to Chinese (volume and energy), South Asian (volume and energy), and White (energy only). Respondents with Chinese ethnicity reported significantly lower 100% juice intake compared to white and 'Mixed/other/not stated/missing' (volume and energy for both). For SSBs, consumption among respondents with Indigenous ethnicity was significantly higher compared to white (volume and energy), South Asian, black, and 'Mixed/other/not stated/missing' (volume only for each). SSB volume and energy among respondents with Chinese ethnicity was significantly lower than the other five ethnicity categories. Consumption of 100% juice or SSBs was not statistically significant different by per person income quintile.

Beverage intake was different across provinces (Table 7). For 100% juice, residents of Quebec reported consuming significantly more than each of the nine other provinces. For SSBs, consumption was more varied between provinces. Residents of British Columbia reported consuming significantly less SSBs than each of the nine of other provinces. Alberta consumed more than PEI (volume only), Nova Scotia (volume only), Saskatchewan (energy only), and Quebec (volume and energy); Quebec consumed less than Manitoba and New Brunswick (volume and energy for both); PEI also consumed less compared to Manitoba (volume only).

For BMI category, there were differences in 100% juice intake (Table 7). Respondents with BMI in the 'underweight/normal' category consumed significantly more 100% juice volume and energy than the other three BMI categories. SSB intake differed for energy intake only for one pairwise comparison: 'underweight/normal' consumed more energy from SSBs than the 'overweight' BMI category.

Table 6. Per capita average daily sugary drink consumption

	ALL		SEX				AGE			
			Males		Females		Children 1-18 yrs		Adults 19+ yrs	
	Volume, ml mean (95% CI) **Energy**, kcal mean (95% CI)		**Volume**, ml mean (95% CI) **Energy**, kcal mean (95% CI)		**Volume**, ml mean (95% CI) **Energy**, kcal mean (95% CI)		**Volume**, ml mean (95% CI) **Energy**, kcal mean (95% CI)		**Volume**, ml mean (95% CI) **Energy**, kcal mean (95% CI)	
	N=20,176		n=10,096		n=10,080		n=4,030		n=16,146	
100% juice										
Volume, ml	74.3	(69.9, 78.7)	85.9	(78.6, 93.1)	62.7	(58.1, 67.4)	118.1	(110.8, 125.5)	63.4	(58.2, 68.5)
Energy, kcal	33.7	(31.7, 35.7)	38.7	(35.3, 42.0)	28.7	(26.6, 30.9)	55.3	(51.9, 58.8)	28.3	(25.9, 30.7)
Total sugar-sweetened beverages										
Volume, ml	203.6	(193.1, 214.0)	246.8	(229.6, 264.1)	160.2	(149.6, 170.9)	225.4	(211.9, 238.9)	198.1	(186.0, 210.3)
Energy, kcal	98.7	(93.5, 103.9)	119.9	(111.1, 128.7)	77.5	(72.1, 82.9)	117.1	(109.9, 124.3)	94.1	(88.0, 100.2)
Regular carbonated soft drinks										
Volume, ml	70.3	(64.7, 76.0)	95.2	(85.6, 104.8)	45.4	(39.6, 51.2)	59.3	(52.8, 65.8)	73.1	(66.3, 79.9)
Energy, kcal	28.6	(26.3, 30.9)	38.9	(35.0, 42.8)	18.3	(16.0, 20.6)	24.2	(21.6, 26.9)	29.7	(27.0, 32.5)
Regular fruit drinks										
Volume, ml	29.5	(25.9, 33.0)	32.0	(25.8, 38.2)	26.9	(23.7, 30.1)	53.0	(45.8, 60.3)	23.6	(19.6, 27.6)
Energy, kcal	13.7	(12.0, 15.3)	14.9	(12.0, 17.8)	12.4	(11.0, 13.9)	23.8	(20.5, 27.2)	11.1	(9.3, 13)
Sugar-sweetened milk										
Volume, ml	25.8	(22.5, 29.0)	30.7	(25.0, 36.4)	20.8	(18.0, 23.6)	42.5	(37.8, 47.2)	21.6	(17.9, 25.3)
Energy, kcal	18.5	(15.3, 21.8)	23.3	(17.4, 29.3)	13.7	(11.5, 16.0)	30.7	(27.2, 34.2)	15.5	(11.6, 19.4)
Tea pre-sweetened with sugar										
Volume, ml	20.3	(15.9, 24.8)	24.4	(16.4, 32.5)	16.2	(12.8, 19.6)	18.7	(15.2, 22.2)	20.7	(15.3, 26.1)
Energy, kcal	6.9	(5.3, 8.5)	8.4	(5.6, 11.3)	5.4	(4.3, 6.6)	6.5	(5.3, 7.7)	7.0	(5.1, 8.9)
Smoothies										
Volume, ml	16.6	(13.2, 20.0)	16.7	(11.3, 22.1)	16.4	(12.7, 20.1)	11.7	(9.6, 13.8)	17.8	(13.6, 21.9)
Energy, kcal	10.2	(8.0, 12.3)	10.3	(6.9, 13.8)	10.0	(7.8, 12.3)	7.3	(6.0, 8.7)	10.9	(8.3, 13.5)
Coffee pre-sweetened with sugar										
Volume, ml	15.9	(13.1, 18.7)	16.4	(12.5, 20.3)	15.5	(11.7, 19.2)	6.8	(4.9, 8.6)	18.2	(14.7, 21.7)
Energy, kcal	6.1	(4.9, 7.4)	6.7	(4.6, 8.8)	5.6	(4.2, 6.9)	4.3	(3.1, 5.6)	6.6	(5.0, 8.2)
Regular sports drinks										
Volume, ml	7.0	(4.5, 9.4)	11.2	(6.5, 15.9)	2.8	(1.1, 4.4)	9.5	(6.8, 12.2)	6.3	(3.3, 9.3)
Energy, kcal	1.9	(1.2, 2.5)	3.0	(1.8, 4.2)	0.7	(0.3, 1.2)	2.6	(1.9, 3.4)	1.7	(0.9, 2.5)

	ALL		SEX				AGE			
			Males		**Females**		**Children** 1-18 yrs		**Adults** 19+ yrs	
	Volume, ml mean (95% CI) **Energy**, kcal mean (95% CI)		**Volume**, ml mean (95% CI) **Energy**, kcal mean (95% CI)		**Volume**, ml mean (95% CI) **Energy**, kcal mean (95% CI)		**Volume**, ml mean (95% CI) **Energy**, kcal mean (95% CI)		**Volume**, ml mean (95% CI) **Energy**, kcal mean (95% CI)	
Regular protein drinks										
Volume, ml	5.8	(4.3, 7.4)	7.7	(4.8, 10.7)	3.9	(2.7, 5.1)	2.5	(1.0, 4.1)	6.6	(4.7, 8.5)
Energy, kcal	4.4	(2.8, 6.1)	6.3	(3.1, 9.5)	2.6	(1.8, 3.3)	2.3	(1.0, 3.7)	5	(2.9, 7.0)
Hot chocolate pre-sweetened with sugar										
Volume, ml	4.2	(3.1, 5.3)	3.2	(2.4, 4.1)	5.2	(3.1, 7.2)	8.0	(6.0, 10)	3.2	(1.9, 4.6)
Energy, kcal	3.4	(2.4, 4.5)	2.6	(1.8, 3.3)	4.3	(2.3, 6.2)	6.3	(4.6, 8.0)	2.7	(1.4, 4.0)
Flavoured drinkable yogurt										
Volume, ml	2.4	(1.9, 2.9)	2.2	(1.6, 2.9)	2.6	(1.8, 3.3)	7.8	(6.2, 9.5)	1.0	(0.6, 1.5)
Energy, kcal	1.8	(1.4, 2.1)	1.7	(1.2, 2.1)	1.9	(1.3, 2.4)	5.8	(4.6, 7.0)	0.8	(0.4, 1.1)
Regular meal replacement beverages										
Volume, ml	1.7	(1.2, 2.1)	1.7	(1.1, 2.4)	1.6	(1.0, 2.3)	2	(1.1, 3.0)	1.6	(1.1, 2.1)
Energy, kcal	1.7	(1.2, 2.1)	1.7	(1.1, 2.3)	1.6	(1.0, 2.2)	2	(1.0, 2.9)	1.6	(1.1, 2.1)
Regular energy drinks										
Volume, ml	1.7	(1.0, 2.5)	2.6	(1.2, 3.9)	0.9	(0.2, 1.6)	0.5	(0.2, 0.9)	2.0	(1.1, 3.0)
Energy, kcal	0.8	(0.4, 1.1)	1.2	(0.6, 1.8)	0.4	(0.1, 0.6)	0.2	(0.1, 0.4)	0.9	(0.5, 1.3)
Regular flavoured water										
Volume, ml	1.7	(0.9, 2.5)	2.1	(0.7, 3.5)	1.3	(0.5, 2.0)	2.3	(0.9, 3.6)	1.5	(0.6, 2.4)
Energy, kcal	0.4	(0.2, 0.6)	0.5	(0.2, 0.8)	0.3	(0.1, 0.5)	0.5	(0.2, 0.9)	0.4	(0.1, 0.6)
Coffee sugar-sweetened at the table										
Volume, ml	0.5	(0.2, 0.8)	0.36	(0.06, 0.65)	0.68	(0.10, 1.25)	0.013	(-0.015, 0.040)	0.6	(0.2, 1.1)
Energy, kcal	0.2	(0.1, 0.4)	0.15	(0.01, 0.29)	0.29	(0.02, 0.56)	0.004	(-0.004, 0.012)	0.3	(0.1, 0.5)
Hot chocolate prepared from scratch										
Volume, ml	0.177	(-0.005, 0.359)	0.3	(-0.1, 0.6)	0.069	(0.005, 0.133)	0.5	(-0.4, 1.4)	0.092	(0.016, 0.168)
Energy, kcal	0.135	(-0.004, 0.273)	0.2	(-0.1, 0.5)	0.051	(0.003, 0.100)	0.4	(-0.3, 1.0)	0.071	(0.006, 0.135)
Tea sugar-sweetened at the table										
Volume, ml	0.006	(-0.008, 0.020)	0.013	(-0.015, 0.041)	-	-	0.032	(-0.038, 0.103)	-	-
Energy, kcal	0.001	(-0.001, 0.003)	0.002	(-0.002, 0.006)	-	-	0.005	(-0.006, 0.015)	-	-

Note: Negative values in 95% confidence intervals are a result of the bootstrap resampling method and not an indication of 'negative' consumption.
95% CI, 95% confidence intervals

Table 7. Beverage consumption by socio-economic characteristics

	100% JUICE				SSBs			
	Volume (ml) mean (95% CI)		**Energy** (kcal) mean (95% CI)		**Volume** (ml) mean (95% CI)		**Energy** (kcal) mean (95% CI)	
Sex	$F_{(1,20176)}$=28.11 (P<0.001)		$F_{(1,20176)}$=24.12 (P<0.001)		$F_{(1,20176)}$=74.45 (P<0.001)		$F_{(1,20176)}$=65.94 (P<0.001)	
Male	85.9	(78.6, 93.1)	38.7	(35.3, 42.0)	246.8	(229.6, 264.1)	119.9	(111.1, 128.7)
Female	62.7	(58.1, 67.4)	28.7	(26.6, 30.9)	160.2	(149.6, 170.9)	77.5	(72.1, 82.9)
Age (years)	$F_{(7,20176)}$=30.57 (P<0.001)		$F_{(7,20176)}$=34.38 (P<0.001)		$F_{(7,20176)}$=58.53 (P<0.001)		$F_{(7,20176)}$=57.70 (P<0.001)	
1-3	95.1	(82.7, 107.6)	44.1	(38.4, 49.8)	80.7	(65.6, 95.7)	46.8	(38.4, 55.3)
4-8	134.4	(119.5, 149.2)	63.6	(56.5, 70.7)	158.8	(140.8, 176.8)	90.2	(79.4, 100.9)
9-13	119.5	(107.0, 131.9)	56.0	(50.1, 61.9)	246.9	(226.9, 266.9)	126.9	(116.7, 137.1)
14-18	114.4	(100.9, 128.0)	53.1	(46.8, 59.5)	354.8	(319.5, 390.1)	175.4	(156.6, 194.2)
19-30	91.3	(70.9, 111.7)	41.7	(32.1, 51.3)	327.1	(277.2, 377.0)	165.6	(139.0, 192.2)
31-50	60.5	(52.0, 69.0)	27.1	(23.2, 31.0)	214.4	(195.6, 233.2)	101.1	(90.3, 111.8)
51-70	49.6	(43.8, 55.4)	21.7	(19.1, 24.3)	148.1	(133.7, 162.5)	67.6	(60.4, 74.8)
71+	72.7	(63.2, 82.3)	32.5	(28.1, 36.9)	113.1	(100.0, 126.2)	49.9	(44.2, 55.6)
Ethnicity	$F_{(5,20176)}$=3.36 (P=0.0054)		$F_{(5,20176)}$=2.92 (P=0.0132)		$F_{(5,20176)}$=10.57 (P<0.001)		$F_{(5,20176)}$=13.15 (P<0.001)	
White only	74.2	(69.0, 79.4)	33.3	(30.9, 35.7)	203.9	(190.9, 216.9)	97.7	(91.4, 104.0)
Chinese only	51.3	(36.8, 65.7)	23.9	(17.2, 30.7)	116.4	(88.5, 144.3)	53.2	(40.8, 65.6)
South Asian only	64.0	(49.5, 78.6)	30.5	(23.4, 37.5)	197.4	(158.1, 236.7)	103.5	(78.4, 128.7)
Black only	97.5	(72.1, 123.0)	46.0	(33.6, 58.4)	221.7	(182.7, 260.7)	107.0	(85.4, 128.6)
Indigenous inclusive	79.3	(52.4, 106.2)	36.9	(23.9, 49.9)	303.4	(241.0, 365.9)	141.6	(112.6, 170.7)
Mixed/other/not stated/missing	79.5	(67.0, 92.1)	36.6	(30.9, 42.4)	206.8	(178.8, 234.9)	106.5	(82.2, 130.8)
Income quintile	$F_{(4,20176)}$=1.15 (P=0.3314)		$F_{(4,20176)}$=1.27 (P=0.2795)		$F_{(4,20176)}$=0.05 (P=0.5590)		$F_{(4,20176)}$=1.15 (P=0.9948)	
1 (low income)	82.1	(69.2, 95.0)	37.9	(31.7, 44.0)	201.8	(179.8, 223.7)	100.4	(85.7, 115.2)
2	77.3	(67.8, 86.8)	34.8	(30.3, 39.2)	208.5	(188.9, 228.1)	97.3	(88.1, 106.4)
3	75.2	(67.0, 83.5)	34.1	(30.5, 37.7)	213.4	(187.1, 239.7)	100.0	(88.2, 111.7)
4	68.7	(60.6, 76.9)	31.2	(27.5, 34.9)	207.6	(188.1, 227.2)	98.1	(88.4, 107.9)
5 (high income)	67.9	(57.9, 78.0)	30.5	(26.0, 35.0)	186.6	(163.9, 209.4)	97.8	(83.9, 111.7)
Province	$F_{(9,20176)}$=8.13 (P<0.001)		$F_{(9,20176)}$=7.51 (P<0.001)		$F_{(9,20176)}$=8.00 (P<0.001)		$F_{(9,20176)}$=6.33 (P<0.001)	
Newfoundland and Labrador	68.5	(55.4, 81.6)	32.2	(25.9, 38.4)	233.5	(192.7, 274.3)	110.2	(90.6, 129.8)
Prince Edward Island	75.7	(56.2, 95.2)	35.1	(26.0, 44.2)	207.7	(181.6, 233.8)	104.1	(90.9, 117.3)
Nova Scotia	63.3	(52.1, 74.4)	28.9	(23.8, 34.1)	208.2	(178.2, 238.2)	99.4	(85.4, 113.4)
New Brunswick	66.9	(54.8, 78.9)	30.6	(25.1, 36.0)	234.3	(201.3, 267.2)	114.9	(97.7, 132.2)

Quebec	116.9	(103.5, 130.2)	52.5	(46.2, 58.8)	192.9	(171.0, 214.7)	90.5	(80.0, 101.0)
Ontario	64.1	(57.7, 70.5)	29.4	(26.4, 32.4)	208.5	(189.3, 227.8)	102.8	(92.2, 113.5)
Manitoba	61.5	(49.8, 73.3)	28.3	(23.1, 33.4)	249.5	(217.5, 281.6)	112.9	(97.6, 128.2)
Saskatchewan	61.5	(49.1, 73.9)	28.7	(22.8, 34.6)	204.7	(172.3, 237.1)	96.0	(81.5, 110.6)
Alberta	54.9	(45.4, 64.5)	24.7	(20.4, 28.9)	246.6	(219.6, 273.6)	123.0	(106.1, 139.9)
British Columbia	56.3	(47.0, 65.6)	25.2	(20.8, 29.5)	148.1	(131.5, 164.6)	72.2	(63.5, 80.9)
BMI category	$F_{(3,20176)}$=10.51 (P<0.001)		$F_{(3,20176)}$=10.64 (P<0.001)		$F_{(3,20176)}$=1.35 (P=0.2567)		$F_{(3,20176)}$=3.10 (P=0.0265)	
Underweight/normal	92.6	(84.4, 100.9)	41.9	(38.1, 45.7)	213.5	(196.3, 230.8)	109.0	(99.2, 118.8)
Overweight	67.3	(59.1, 75.6)	30.9	(26.8, 35.0)	194.2	(178.0, 210.3)	89.7	(82.2, 97.2)
Obese	61.3	(52.0, 70.6)	27.1	(23.0, 31.2)	217.9	(187.5, 248.3)	97.9	(84.2, 111.7)
DK/Refusal/NS	68.4	(60.7, 76.2)	31.3	(27.7, 34.8)	194.2	(175.3, 213.0)	95.6	(84.3, 106.9)

N=20,176

95% CI, 95% confidence intervals; BMI, body-mass index; DK, don’t know; NS, not stated; SSB, sugar-sweetened beverage

SSB AND SUGARY DRINK TAXES

The potential health and economic impacts of a 20% tax on SSBs or sugary drinks were estimated for the Canadian adult population over a 25 year period (2016-2041) using the simulation model.

HEALTH BENEFITS

ENERGY INTAKE

The simulated 20% tax on SSBs produced a one-time -19.6% reduction in the volume of SSB intake that was carried over the 25 years examined in the model. Three substitute and complement beverages were modelled: 100% juice, plain milk, and diet beverages. The tax resulted in a 4.0% and 1.6% increase in the intake volumes of 100% juice and plain milk, respectively, and a -5.4% decrease in diet beverage intake. These shifts in beverage intake produced changes in beverage energy intake (Appendix E, Table 7 & Appendix E, Table 8). Among Canadian adult males (≥20 years), per capita daily energy intake of SSBs decreased by an average of -21.3 kcal (95% uncertainty intervals [UI]: -23.6, -19.0), 100% juice increased by 1.3 kcal (0.8, 1.7), plain milk increased by 0.9 kcal (0.3, 1.4), and diet beverages decreased by a negligible -0.1 kcal (-0.2, 0.0). Among Canadian adult females, per capita daily energy intake of SSBs decreased by -13.5 kcal (-12.0, -15.0), 100% juice increased by 1.0 kcal (0.6, 1.3), plain milk increased by 0.7 kcal (0.3, 1.1), and diet beverages decreased by a negligible -0.1 kcal (-0.1, 0.0). The net change in per capita daily energy intake was a reduction of -19.3 kcal (-16.8, -21.8) for males and -11.9 kcal (-10.3, -13.5) for females.

Similar to the SSB tax, the simulated 20% tax on sugary drinks produced a one-time -19.6% reduction in the volume of sugary drink intake that was carried over a 25-year period. Since 100% juice was included within the sugary drinks category, 100% juice was not modelled as a substitute beverage (Appendix E, Table 9 & Appendix E, Table 10). Plain milk intake increased by 1.6% and diet beverage intake decreased by -5.4%. Among Canadian adult males, per capita daily energy intake of sugary drinks decreased by -27.6 kcal (-30.4, -24.6), plain milk increased by 0.9 kcal (0.3, 1.4), and diet beverages decreased by a negligible -0.1 kcal (-0.2, 0.0). Among Canadian adult females, per capita daily energy intake of sugary drinks decreased by -18.2 kcal (-20.0, -16.2), plain milk increased by 0.7 kcal (0.3, 1.2), and diet beverages decreased by a negligible -0.1

kcal (-0.1, 0.0). The net change in per capita daily energy intake was a reduction of -26.8 kcal (-29.7, -23.8) for males and -17.5 kcal (-19.5, -15.5) for females.

For both tax scenarios, adult males had a larger absolute change in energy intake compared to women of the same age for all ages except 70-79 years. Across age groups, the absolute change in energy intake was highest for ages 20-29 years.

BODY MASS

Among adults, the change in energy intake from a 20% SSB tax produced an average reduction in BMI of -0.28 (-0.32, -0.24) for males and -0.20 (-0.23, -0.17) for females (Appendix E, Table 11). The tax intervention shifted the prevalence of overweight and obesity (overweight=25≤30, obesity=BMI>30) among adults from 63.3% to 61.7%. The change in prevalence equates to the prevention of 398,668 (343,264, 457,695) cases of obesity and 51,334 (42,820, 60,558) cases of overweight among Canadian adults in the next 25 years (Appendix E, Table 12).

The 20% sugary drink tax produced an average reduction in BMI of -0.38 (-0.43, -0.33) for males and -0.30 (-0.34, -0.26) for females (Appendix E, Table 11). Overweight and obesity prevalence moved from 63.7% to 61.0%, equating to the prevention of 567,807 (496,088, 641,127) cases of obesity and 75,129 (63,781, 87,212) cases of overweight (Appendix E, Table 12).

For both taxes, the changes in the prevalence of obesity and overweight were greatest among males and young adults. Though overall overweight prevalence decreased, overweight prevalence increased slightly for some male age categories. However, this is still a beneficial outcome. Due to the tax intervention, some males with obesity shifted to having overweight. Movement of males from overweight to normal weight also occurred, but was not sufficiently large enough to offset the movement of males from obesity to overweight in select age categories.

Rates of overweight and obesity in the intervention population were as follows. Overweight was more prevalent among males than females (males 38.08%, females 29.50%), as was obesity (males 31.05%, females 27.75%). This pattern holds across all age groups except: males and females ages 30-39 (rates were equivalent); females ages 20-29 and ≥80 years (females were higher than males). The sugary drink tax intervention produced similar patterns. Overweight was more prevalent among males than females (males 38.02%, females 29.40%), as was obesity (males 28.51%, females 26.21%). This is consistent for all ages groups except females ages 20-39 and ≥80 years (females were higher than males).

DISEASE REDUCTIONS

By reducing mean BMI, the beverage taxes prevented disease incident cases, prevalent cases, and deaths over the next 25 years (Table 8; Figure 9; see Appendix E, Tables 7-23 for more results). The largest reductions in incidence rates occurred early in the modelled 25-year time period. Conversely, the largest reductions in prevalence rates and mortality rates occurred later in the modelled timeframe (Appendix E, Table 24).

Over the next 25 years, the tax on SSBs was projected to prevent 144,074 new cases of type 2 diabetes among the 2015 adult population, averaging more than 5,700 cases annually. Incidence rates decreased between -4.1% to -5.9%, depending on the year. In the year 2041, the prevalence of type 2 diabetes was projected to decrease by 122,772 cases (-4.0% reduction in prevalence rate). The tax on sugary drinks prevented an estimated 203,778 news cases of type 2 diabetes, averaging more than 8,100 new cases annually. Incidence rates decreased between -6.0% to -8.3%. In the year 2041, the prevalence of type 2 diabetes was projected to decrease by an estimated 172,084 cases (-5.5% reduction in prevalence rate).

The simulated tax prevented an estimated 12,801 new cancer cases associated with 11 cancer types. Females benefited more than males: the two most common prevented incident cancers were specific to females (i.e., female breast and uterus) and constituted half of new cancer cases (53%). Four cancer types contributed three-quarters (77%) of prevented new cancers: breast, uterine, colon and rectum, and kidney. The largest reductions in cancer incidence rates were for uterine cancer (-1.4% to -1.5%). Compared to the SSB tax, the sugary drink tax was projected to prevent substantially more (70%) new cancer cases, for a total of 21,809 prevented incidence cases. Cancers prevented by the sugary drink tax followed similar patterns as those prevented by the SSB tax, but in greater numbers.

The SSB tax prevented an estimated 2,893 cancer deaths. Five cancers contributed to more than three-quarters (78%) of prevented cancer deaths: colon and rectum (21% of deaths), breast (20%), esophageal (17%), liver (10%), and uterine (10%). The largest reductions in cancer mortality rates were for uterine cancer (-0.1% to -1.3%). The sugary drink tax prevented an estimated 4,906 cancer deaths, 70% more than the SSB tax. Prevented cancer deaths due to the sugary drink tax followed similar patterns as those prevented by the SSB tax, but in greater numbers.

The simulated taxes on SSBs and sugary drinks prevented new cases and prevalent cases of ischemic heart disease (IHD), ischemic stroke, and hemorrhagic stroke, as well as deaths due to these conditions. Prevented prevalent cases of hypertensive heart disease (HHD) were also estimated. Changes in disease rates varied by condition, with hemorrhagic stroke having the greatest reductions in incidence rates and mortality rates (-0.8% to -1.8%; -0.1% to -1.1%, respectively) and HHD having the greatest reduction in prevalence rates (-1.7% in the year 2041). Over the next 25 years, the SSB tax prevented an estimated 6,444 cardiovascular disease deaths and the sugary drink tax prevented an estimated 10,394 deaths. Consistent with other conditions, prevented cases of cardiovascular disease were substantially higher for the sugary drink tax than the SSB tax. For example, prevented new cases of IHD from the sugary drink tax were 57% higher, equating to 21,085 additional prevented cases.

The SSB tax was estimated to decrease the prevalence of other chronic conditions: chronic kidney disease (CKD), osteoarthritis (OA) and low back pain. For the year 2041, the prevalent cases prevented by the SSB tax were estimated to be 57,278 for CKD, 15,385 for OA, and 2,125 for low back pain. The prevalent cases prevented by the sugary drinks tax were estimated to be 88,114 for CKD, 22,151 for OA, and 2,733 for low back pain. The SSB tax prevented 712 deaths from CKD and the sugary drink tax prevented 1,443 deaths from CKD over a 25-year period. CKD due to hypertension constituted the highest proportion of prevented CKD deaths (SSB tax: 52%;

sugary drink tax: 45%). Of these chronic conditions, the greatest reductions in prevalence rates and mortality rates were for CKD due to glomerulonephritis (-1.7% for the year 2041; 0.0% to 1.2%, respectively).

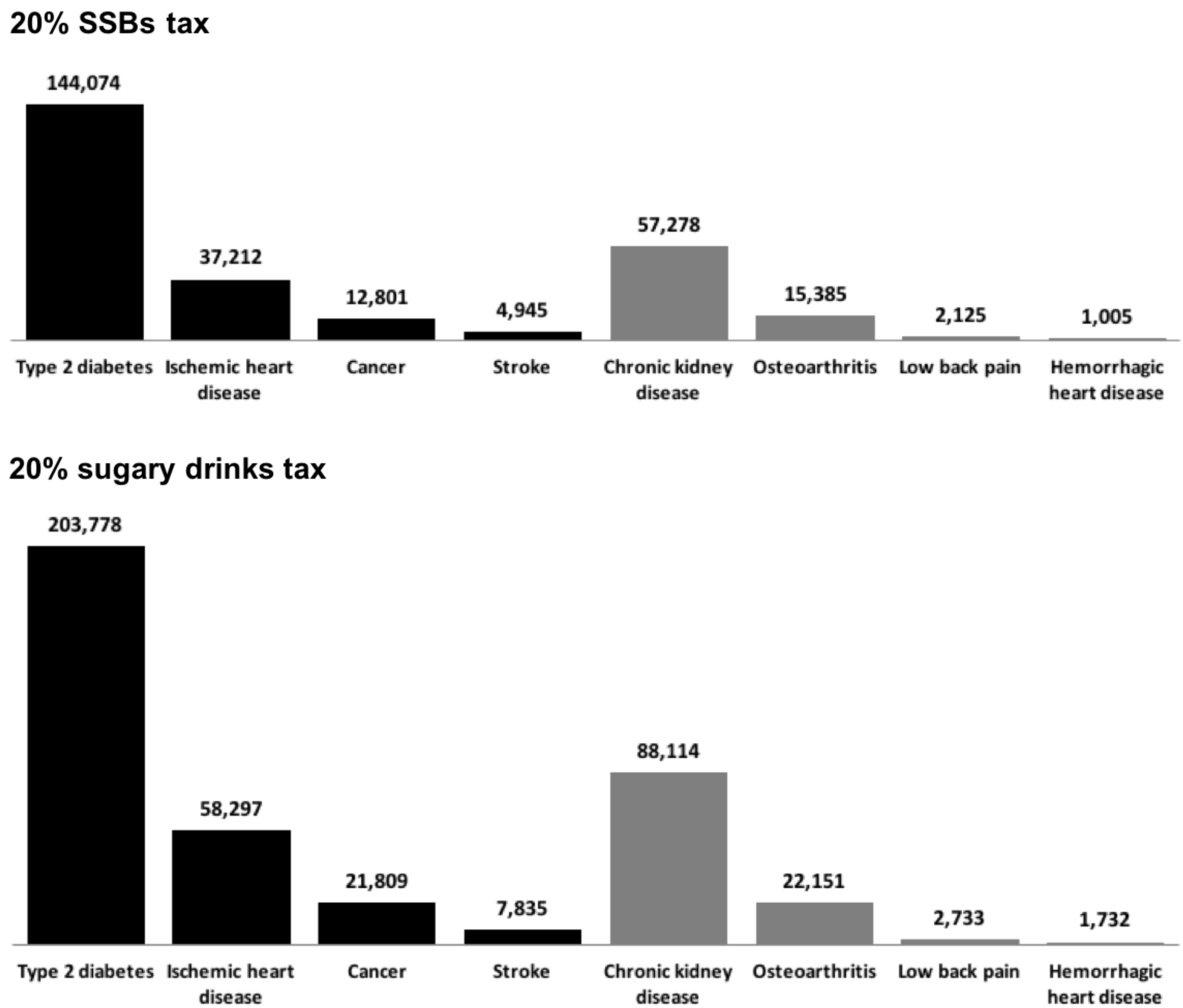
Table 8. Prevented disease incident cases, prevalent cases, and deaths due to 20% beverage taxes[a]

	INCIDENT CASES 2016-2041				**PREVALENT CASES** 2041				**DEATHS** 2016-2041			
	SSBs		**Sugary drinks**		**SSBs**		**Sugary drinks**		**SSBs**		**Sugary drinks**	
	Mean	(95% UI)	Mean	(95% UI)	Mean	(95% UI)	Mean	(95% UI)	Mean	(95% UI)	Mean	(95% UI)
Type 2 diabetes												
Type 2 diabetes	144,074	(111,012, 180,560)	203,778	(161,815, 251,368)	122,772	(94,685, 153,721)	172,084	(136,593, 212,432)				
Cancer												
Breast cancer	4,414	(1,504, 8,123)	7,537	(2,583, 13,700)					574	(180, 1,072)	946	(296, 1,739)
Colon and rectum cancer	1,967	(1,530, 2,473)	3,444	(2,712, 4,202)					615	(477, 775)	1,034	(805, 1,274)
Esophageal cancer	607	(211, 1,060)	1,069	(341, 1,906)					496	(157, 881)	882	(261, 1,586)
Gallbladder and biliary tract cancer	333	(204, 482)	622	(389, 893)					70	(43, 101)	120	(74, 174)
Kidney cancer	1,104	(830, 1,416)	1,851	(1,461, 2,294)					226	(168, 295)	373	(290, 467)
Leukemia	377	(230, 542)	678	(430, 961)					117	(66, 174)	209	(121, 305)
Liver cancer	586	(266, 937)	990	(440, 1,570)					299	(135, 476)	497	(221, 786)
Ovarian cancer	60	(-13, 139)	102	(-24, 235)					19	(-10, 52)	32	(-20, 87)
Pancreatic cancer	256	(92, 457)	474	(157, 817)					188	(64, 336)	349	(111, 605)
Thyroid cancer	667	(434, 935)	1,000	(652, 1,379)					10	(4, 16)	14	(5, 24)
Uterine cancer	2,430	(1,988, 2,924)	4,042	(3,356, 4,743)					279	(229, 335)	448	(373, 526)
Cardiovascular disease												
Ischemic heart disease	37,212	(28,565, 47,137)	58,297	(45,942, 71,959)	25,772	(19,807, 32,588)	39,021	(30,656, 48,240)	4,466	(3,364, 5,745)	7,166	(5,518, 9,016)
Ischemic stroke	2,902	(2,151, 3,767)	4,690	(3,426, 6,094)	1,555	(1,196, 1,977)	2,354	(1,804, 2,961)	855	(595, 1,157)	1,482	(994, 2,022)
Hemorrhagic stroke	2,043	(1,413, 2,774)	3,145	(2,103, 4,316)	759	(533, 1,014)	1,118	(772, 1,494)	1,123	(780, 1,525)	1,746	(1,166, 2,396)
Hypertensive heart disease					1,005	(483, 1,675)	1,732	(823, 2,902)				
Other conditions												
CKD diabetes mellitus					17,800	(5,988, 32,495)	27,744	(9,931, 49,861)	219	(-151, 679)	593	(-28, 1404)
CKD hypertension					9,583	(3,553, 17,273)	14,689	(5,221, 26,504)	370	(128, 681)	643	(202, 1,168)
CKD glomerulonephritis					16,172	(5,739, 29,115)	24,659	(9,009, 43,789)	112	(40, 204)	188	(68, 333)
CKD other causes					13,723	(4,994, 24,976)	21,022	(7,127, 37,916)	11	(3, 20)	19	(4, 36)
Osteoarthritis of the hip					1,639	(950, 2,413)	2,330	(1,305, 33,61)				
Osteoarthritis of the knee					13,746	(8,738, 19,721)	19,821	(12,183, 27,943)				
Low back pain					2,125	(1,391, 2,956)	2,733	(1,702, 3,808)				

CKD, chronic kidney disease; SSBs, sugar-sweetened beverages; 95% UI, 95% uncertainty intervals

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

Figure 9. Disease cases prevented by 20% beverage taxes, 2016-2041



SSBs, sugar-sweetened beverages
Black bars represent prevented incident cases in 2016-2041 due to beverage taxes. Grey bars represent prevented prevalent cases in 2041 due to beverage taxes.

OVERALL DEATHS POSTPONED AND DALYS AVERTED

Overall, in a 25-year period, the simulated 20% SSB tax postponed an estimated 8,083 (6,660, 9,665) deaths and a 20% sugary drink tax postponed an estimated 12,734 (10,648, 14,948) deaths among the 2015 adult population. These estimates are lower than the sum of prevented disease-specific deaths (SSB tax: 10,049; sugary drinks tax: 16,741) because, over the simulated timeframe, some of the population avoided a sugary-drink related death but eventually died from other causes. The majority of postponed deaths were due to reductions in ischemic heart disease or cancer mortality. A 20% SSB tax averted 314,326 (256,268, 376,504) DALYs and a 20% sugary drink tax averted 460,812 (390,171, 535,277) DALYs over a 25-year period.

ECONOMIC BENEFITS

HEALTH CARE COSTS SAVINGS

The direct health care savings from a 20% SSB tax were estimated at $7.5 billion ($7,532,685,334 [95% UI: $6,161,778,552, $ 8,982,807,845)) over 25 years. These estimates account for health care costs due to unrelated diseases that would occur in additional years of life. The health care savings from a 20% sugary drink tax were estimated at almost $10.9 billion ($10,886,361,809 [$9,199,719,561, $12,700,899,203]).

TAX REVENUE

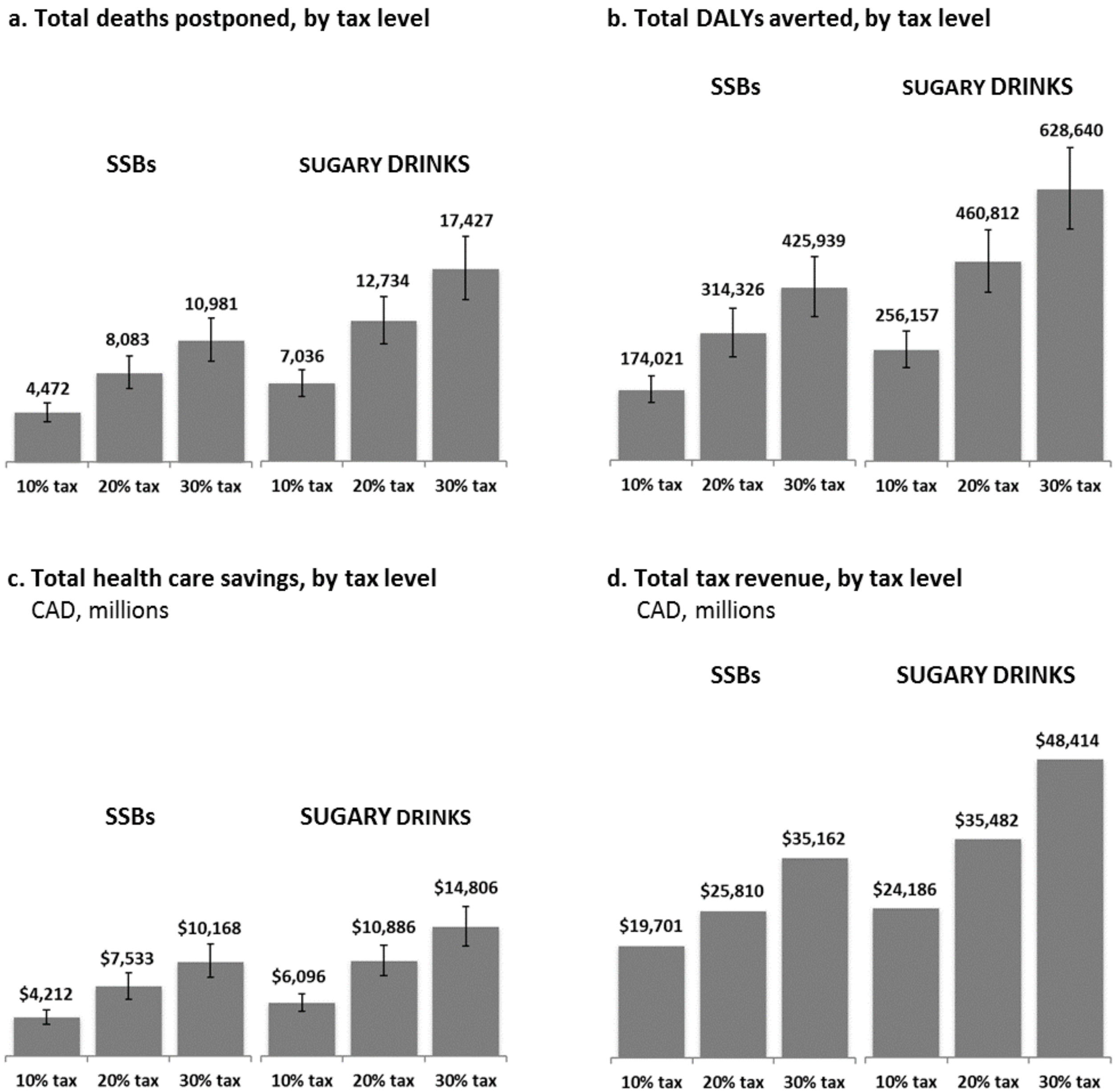
Annual SSB tax revenue was projected to be $1.0 billion ($1,032,395,974 [$999,323,908, $1,065,318,498]), assuming an average pre-tax price of $2.50 per litre. The 25-year total tax revenue was an estimated $25.8 billion ($25,809,899,350), not adjusting for any secular trends in beverage consumption or changes in population demographics. Sugary drink tax revenue was estimated at $1.4 billion ($1,419,265,323; [$1,377,467,447, $1,462,623,693]) per year, and almost $35.5 billion ($35,481,633,075) over 25 years.

The combined health care savings and revenue over this period from a 20% SSB tax or sugary drink tax was an estimated $33.3 billion ($33,342,584,684) or almost $46.4 billion ($46,367,994,884), respectively.

IMPACT OF DIFFERENT TAX LEVELS

The impacts of 10% and 30% tax rates were modelled for SSBs and sugary drinks and compared to 20% tax outcomes (Figure 10). For each beverage classification, the 10% tax was estimated to avert approximately 55% of the DALYs that the 20% tax averted. A 30% tax was estimated to avert an additional 35% of DALYs, compared to the 20% tax. The absolute differences varied by beverage classification. For the SSB tax, the combined savings and revenue from the 10% tax were estimated at $23.9 billion, and $45.3 billion for the 30% tax. For the sugary drinks tax, the combined savings and revenue from the 10% tax were almost $30.3 billion, and $63.2 billion for the 30% tax.

Figure 10. Health and economic impact of different taxation levels, 2016-2041



SSBs, sugar-sweetened beverages; DALYs, disability-adjusted life years

Error bars represent 95% uncertainty intervals. Tax revenue was annual estimates multiplied by 25 years and therefore does not have 95% uncertainty intervals and error bars.

SENSITIVITY ANALYSIS

Univariate sensitivity analyses were conducted on the 20% SSB tax and the 20% sugary drink tax simulations, with comparisons to each beverage tax's base case (Table 9). There were similar patterns for SSB taxes and sugary drink taxes. When the underlying upward trend in the population's BMI was removed, the health benefits and health care savings declined minimally; revenue remained the same (Scenario 1). Reducing the intervention's long-term effectiveness led to sizable decreases in projected health benefits and health care savings; revenue was unaffected (Scenario 2). A more conservative own-price elasticity of demand minimally reduced health and costs outcomes; revenue increased slightly (Scenario 3).

The effects of energy compensation were examined. When the intervention was modelled to have no substitute or complement beverages, the project health benefits and health care savings increased minimally. This increase was larger for the SSB tax than the sugary drink tax since the SSB base case included more calorie compensation than the sugary drink base case (Scenario 4a). Revenue was unaffected. Compensating half (50%) the avoided beverage calories (partial) with energy from other sources (e.g. other beverages and foods), produced a large reduction in the health and costs outcomes, though this reduction was less than 50% of the base case outcomes since improved disease rates produced overall improvements in the broader population (Scenario 4b). Revenue was unaffected.

When the price increase was incompletely passed on to consumers, the intervention's health gains and costs savings were slightly lower; revenue was higher since consumption decreased to a lesser extent than the base case (Scenario 5a). Passing on more than the tax's price increase (tax 'overshifting') increased health gains and costs savings; revenue decreased (Scenario 5b). Due to the nature of an ad valorem excise tax, varying the pre-tax beverage price had little impact on health outcomes and health care savings; however, tax revenue was affected (Scenarios 6a and 6b). Discounting DALYs, costs, and revenue by 3% annually decreased these outcomes by a sizable amount, but still left an impact (Scenario 7). Discounting was not applied to deaths.

Table 9. Sensitivity analyses for 20% beverage taxes, 2016-2041

SCENARIO[a]	DEATHS		DALYS		HEALTH CARE COSTS SAVINGS (CAD)		TAX REVENUE (CAD)	
20% SSB TAX								
Base case	8,083		314,326		$7,532,685,334		$25,809,899,350	
1) BMI remains at 2015 levels	6,799	-16%	285,801	-9%	$7,031,392,535	-7%	$25,806,022,407	0%
2) Effect of tax on health capped at 10 years	3,939	-51%	194,304	-38%	$4,150,464,686	-45%	$25,817,004,902	0%
3) Upper boundary of own-price elasticity of demand	7,079	-12%	276,631	-12%	$6,647,321,933	-12%	$26,475,371,094	2.6%
4a) No substitute or complement beverages	9,444	17%	353,597	12%	$8,435,268,360	12%	$25,809,015,287	0%
4b) 50% energy compensation	4,722	-42%	199,084	-37%	$4,765,143,116	-37%	$25,799,426,527	0%
5a) Tax pass-on 80%	6,740	-17%	262,215	-17%	$6,300,930,956	-16%	$26,872,671,488	4%
5b) Tax pass-on 120%	9,313	15%	362,457	15%	$8,674,206,145	15%	$24,820,775,175	-4%
6a) Pre-tax beverage price 25% lower	8,094	0%	314,302	0%	$7,535,093,203	0%	$19,193,971,592	-26%
6b) Pre-tax beverage price 25% higher	8,058	0%	312,657	0%	$7,494,282,490	0%	$32,310,357,476	25%
7) Health gain, costs and revenue discounted by 3%	8,105	0%	198,784	-37%	$4,923,959,190	-35%	$18,509,642,311	-28%
20% SUGARY DRINK TAX								
Base case	12,734		460,812		$10,886,361,809		$35,481,633,075	
1) BMI remains at 2015 levels	11,191	-12%	425,342	-8%	$10,185,051,470	-6%	$35,492,802,547	0%
2) Effect of tax on health capped at 10 years	5,897	-54%	284,875	-38%	$5,910,649,536	-46%	$35,491,329,159	0%
3) Upper boundary of own-price elasticity of demand	11,369	-11%	412,489	-10%	$9,757,418,075	-10%	$36,423,014,254	3%
4a) No substitute or complement beverages	13,315	5%	478,054	4%	$11,276,576,197	4%	$35,499,066,977	0%
4b) 50% energy compensation	6,696	-47%	269,537	-42%	$6,378,516,992	-41%	$35,493,167,349	0%
5a) Tax pass-on 80%	10,574	-17%	384,387	-17%	$9,094,095,520	-16%	$36,963,959,606	4%
5b) Tax pass-on 120%	14,735	16%	532,655	16%	$12,571,345,348	15%	$34,125,923,047	-4%
6a) Pre-tax beverage price 25% lower	12,784	0%	462,920	0%	$10,924,563,403	0%	$26,403,730,090	-26%
6b) Pre-tax beverage price 25% higher	12,777	0%	462,931	0%	$10,933,462,333	0%	$44,442,499,641	25%
7) Health gain, costs and revenue discounted by 3%	12,801	0%	291,728	-37%	$7,137,430,515	-34%	$25,464,721,559	-28%

DALYs, disability-adjusted life years; CAD, Canadian dollars; SSBs, sugar-sweetened beverages; BMI, body-mass index
[a]Results for each sensitivity analysis scenario were compared to each beverage tax's base case.
*See Appendix E for 95% uncertainty intervals

DISCUSSION

CONSUMPTION OF SUGAR-SWEETENED BEVERAGES

The current study reports the first known estimates of Canadians' sugary drink consumption based on 2015 nationally representative nutrition data. Canadians reported consuming an average of 278 ml (132 kcal) of sugary drinks per person per day: 74 ml 100% juice and 204ml SSBs from 15 different drinks containing added sugar. Compared to published estimates of 2004 consumption, 2015 intake of sugary drinks appears to have declined,[48,49] consistent with trends reported for the US.[60–62] The reduction in sugary drink intake may be due to shifting consumer preferences, increased public concern for the dietary causes of widespread obesity, and public health interventions that have discouraged consumption of sugary drinks.[277] Further research should compare 2004 and 2015 consumption of sugary drinks, as well as consumption of other beverage types.

Though sugary drink consumption appears to have declined from what may be historic peak intake, consumption remains high and still a substantial source of free sugar for Canadians. The WHO recommends limiting the consumption of free sugar to no more than 10% of total energy intake, with further benefits from reducing to less than 5%.[47] As an approximation, 132 kcal from sugary drinks equates to 7% of a 2,000 kcal Health Canada reference diet,[278] suggesting that as a population, Canadians' average free sugar intake from sugary drinks alone may exceed WHO limits. Since this is average intake, in actuality a substantial proportion of Canadians exceed these recommend limits. No studies report overall added sugar or free sugar intake for 2015, so it is unknown how sugary drink intake compares relative to other sources of free sugar. However, estimates for 2004 reported SSBs as contributing more added sugar than any other source, including confectionary, refined sugar, and products such as honey.[52] For Canadians, SSBs and free sugars remain an important risk factor for excess weight gain, type 2 diabetes, and cardiovascular disease, and warrant continued efforts to reduce exposure to this dietary risk.[28,29,35,279]

CONSUMPTION OF 100% JUICE AND DIFFERENT TYPES OF SUGARY DRINKS

The current study provides important characterization of what sugary drinks are consumed by Canadians. Consumption was differentiated by 16 types of sugary drinks. However, four types made up the majority of consumed volume: 100% juice, regular carbonated soft drinks, regular fruit drinks, and sugar-sweetened milk (which included flavoured plant-based beverages). Canadians reported consuming 100% juice more widely and in greater volume than any other sugary drink. The government of Canada is re-examining the place of 100% juice in national dietary guidance. Canada's 2007 food guide lists 125 mL of 100% juice as a serving of fruit and vegetables; although the food guide recommends consuming juice less often than consuming than fruit and vegetables, it does not list 100% juice among foods to 'limit'.[56] In comparison, recent draft guidelines released ahead of a new Canada food guide advise avoidance of processed or prepared beverages high in sugars, and explicitly list 100% juice among beverages to avoid.[280] The new guidance is consistent with positions of the WHO and the Heart and Stroke Foundation of Canada, both of which recommend limiting 100% juice based on the free sugar content.[47,281] Similar scrutiny is also necessary for flavoured milk. Draft guidelines advise consumption of 'plain milk' and avoidance of flavoured milk. 100% juice and flavoured milk are perceived by Canadians as 'healthier' than other sugary drink types, which may lead to increased consumption.[282] Likewise, drinkable yogurt and smoothies contain vitamins and minerals which may lead beverage companies to market these products as health-promoting, despite high sugar content.

Although the majority of sugary drink volume is from only a few beverage types, sugary drink consumption was still quite dispersed across different types of products, reflecting the growing array of beverage products offered to Canadians.[283] Policies aimed at reducing sugar intake should be designed with consideration for the existing wide range of sugary drinks, as well as future product innovations. The current study presents the first nationally representative data on certain types of sugary drinks, specifically: smoothies, protein drinks, flavoured water, and meal replacement beverages. Notably, the study found very low consumption of beverages sweetened by the consumer. Coffee and tea sugar-sweetened by the consumer and hot chocolate prepared from scratch contributed to 0.2% of total intake. The vast majority of sugary drink intake consists of beverages sweetened during the manufacturing process. Canadians would benefit from policy measures that stimulate reformulation to reduce the sugar content of beverages and foods, such as beverage taxation.[93] After the UK adopted a national tax on SSBs, several UK beverage companies announced reformulation efforts to reduce sugar content.[113,114] Hashem and colleagues recently reported a 10% reduction in the average sugar content of energy drinks in the UK since the tax was accepted.[284]

Further research could be undertaken to examine factors and patterns associated with intake of specific beverage types. For example, the consumption of energy drinks, especially among youth, has been the target of recent review, and some jurisdictions have considered novel polices to reduce consumption.[285] Though the current study found mean per capita daily consumption of regular energy drinks to be low (children, 0.5mL; adults, 2.0 mL), only 0.1% of children and 0.5% of adults reported consuming this beverage during the previous 24-hour period. Accordingly, energy drink consumption is isolated to a small segment of the population that consumes large amounts. The intake of protein drinks and meal replacement beverages could also be examined in more depth. These beverages are consumed in greater quantities than products that have received greater health scrutiny, such as energy drinks and flavoured water. Dietary supplement beverages is an area of substantial market growth with continued development of new products.[286] However, research reports consumers using these high-energy products for nutritional deficiencies that are generally non-existent, and to the detriment of other health goals, such as weight loss.[67,287]

DIFFERENCES BY SOCIO-ECONOMIC STATUS

Children and youth remain the highest consumers of sugary drinks, drinking almost double the 100% juice volume of adults and 14% more SSBs than adults. The highest mean 100% juice consumption occurred among ages 4-8 years, whereas peak SSB consumption occurred among ages 14-18 years, consistent with the study's hypothesis. In addition to drinking more 100% juice than adults, children also consumed more fruit drinks, sugar-sweetened milk, sports drinks, hot chocolate, drinkable yogurt, and flavoured water. These results are alarming given children's lower energy requirements and the potential for lifelong adverse effects from early onset obesity and type 2 diabetes. High sugary drink consumption among these vulnerable age groups reinforces the need for effective and progressive policy measures that discourage consumption.

The current study adds to the limited Canadian literature examining differences in beverage consumption across socio-economic groups. As expected, males consume more sugary drinks than females. However, females had a greater preference than males for pre-sweetened hot chocolate, flavoured drinkable yogurt, and coffee sugar-sweetened at the table. For ethnicity, income, province of residence, and BMI category, results were not consistent with a priori hypotheses: 100% juice and SSB consumption was highest among some non-white ethnicities (black and Indigenous, respectively); however, other non-white ethnicities had the lowest consumptions of 100% juice and SSBs (Chinese for both 100% juice and SSBs). There were some differences by geography. 100% juice and SSB consumption was highest for residents of Quebec and Manitoba, and lowest for Alberta and British Columbia. These findings varied from the hypothesis that the highest consumption would be among the Atlantic provinces, as reported previously.[49] BC's low SSB consumption was expected given the province's history of superior performance on numerous health behaviour indicators.[288] Very few differences were observed in sugary drink consumption by income quartile, similar to previous research.[50,51,73,289]

The study found statistically significant differences by BMI category, especially for 100% juice. Respondents in the underweight/normal BMI category consumed more 100% juice than other BMI categories. For SSB energy only, underweight/normal BMI category consumed more than the overweight BMI category. Authors using 2004 data found minimal evidence of an association between patterns of beverage consumption and obesity and overweight among children and adults: for women who predominately consumed fruit drinks, overweight and obesity was more prevalent.[290,291] It is well established that individuals with higher BMI tend to underreport energy intake.[245] This may have attenuated an association between BMI category and sugary drink intake. Another plausible explanation is that in an effort to lose weight, individuals who have overweight or obesity have made dietary modifications and have reduced sugary drink consumption from previously high levels, although this was not examined in the current study. Future research might examine socio-demographic correlates in greater detail, including variables such as food security status and education level.

HEALTH AND ECONOMIC IMPACT OF A TAX ON SSBS

The current study provides the first estimates of the potential health and economic impacts of a tax on SSBs based on 2015 national dietary recall data for Canada. Not surprisingly, the simulated tax reduced energy intake from beverages, and produced reductions in disease cases among the simulated Canadian adult population over a 25-year period. The results suggest that a 20% SSB tax would eliminate nearly 204 billion kcal from Canadians' diets annually. Decreased BMI would lower the prevalence of obesity and overweight by 2.5% (from 63.3% to 61.7%) and lead to reduced incidence, prevalence, and mortality of 19 BMI-related diseases. Additionally, the SSB tax would also reduce the direct effects of SSBs on type 2 diabetes risk. A 20% SSB tax would not eliminate all of the 1,598 deaths and 45,474 estimated by the GBD study to be attributable to SSB consumption in 2010. However, the current study's results suggest sizable reductions over a 25-year period: 8,033 deaths postponed (323 annually) and 314,326 DALYs averted (12,573 annually). Though the reported reductions in disease rates may appear low (e.g., -1.2% reduction in ischemic heart disease incidence), when applied to the entire Canadian population, equate to sizable reductions in morbidity and mortality. This is consistent with Rose's population approach which depicts the large-scale impacts of small shifts in population risk.[292] Indeed, it is precisely small increases in energy intake across entire populations that have contributed to the global obesity crisis.[293] Reducing the prevalence of obesity, type 2 diabetes, and other chronic diseases will require the implementation of strategies such as SSB taxation that achieve large population health gains through small changes in many individuals over an extended period of time.[86,272]

The model's estimates show that the simulated SSB tax would have sizable economic benefits: health care savings of almost $7.5 billion CAD over 25 years, or $301 million annually, and revenue of $25.8 billion CAD, or $1.0 billion annually. When 3% discounting was applied, these values reduced by 28%-35%, but were still substantial. As expected, the health care savings equate to a small proportion of Canada's overall health care spending ($219.1 billion CAD in 2015[78]). However, they are an important contribution toward reducing the alarming costs of obesity in Canada ($6.8 billion CAD in 2013).[79] The costs examined in the current study were from the perspective of the health sector and were limited to downstream costs averted or incurred, and not costs of implementing the intervention. In other settings, simulations which modelled implementation costs report that SSB taxation is a highly cost-effective strategy.[137,181] Given the revenue-generating nature of a SSB tax, similar benefits are expected for the Canadian context. The current study's health care costs did not account for nonfatal conditions (e.g., amputations due to diabetes). Other excluded costs were indirect costs (e.g., decreased work productivity) and out-of-pocket expenditures, which can average $2,300 annually (CAD 2010) for diabetes. Chronic disease indirect costs may be as high as five times greater than direct costs, depending on the calculation approach[26,79] Altogether, inclusion of these additional costs may have increased the net cost savings of the intervention. Health-related food taxes are not a panacea for obesity, but these measures are among the most cost-effective diet-related disease prevention strategies.[142,143] Furthermore, the health care savings and tax revenue can aid in funding a more comprehensive nutrition strategy that reduces health disparities.[138]

The study findings are consistent with outcomes reported in reviews of tax simulations[222] and studies on existing SSB taxes, such as Mexico's tax.[212] Comparison of tax simulation models is challenging due to differences in populations, risk factor exposure, model architecture, and simulated diseases. However, models are similar in demonstrating an overall decrease in SSB intake that lowers population-level mean BMI and reduces cases of the diverse range of diseases directly and indirectly associated with SSB intake.[90,122,124,126,134,142,182,183,183–185,187,188,190–212,215–220,294–296] For example, compared to Australian SSB tax simulations,[90,181] the current study reported a greater number of DALYs averted, which is reasonable given Canada's larger population and the inclusion of a wider range of BMI-related diseases. The current study uses a simulation model that consists of what could be considered the most comprehensive selection of

BMI-related diseases, while also accounting for type 2 diabetes direct effects. Previous studies modelled fewer BMI-related diseases or did not include type 2 diabetes direct effects.[90,142,182,204] Other non-BMI mediated risks from sugary drinks, such as high blood pressure,[35] were not included in the model due to an absence of suitable parameter inputs. Thus, the model does not capture all the effects of SSBs documented within the scientific literature.

HEALTH AND ECONOMIC IMPACT OF A TAX ON SUGARY DRINKS

Modelling a 'sugary drink' tax that included 100% juice as a taxed beverage yield greater potential health and economic benefits than a SSB tax. This represents an important extension of previous work given that no published simulation studies have applied this definition to a beverage tax. A simulation model conducted in the UK found greater health benefits when beverage reformulation efforts included reductions in 100% juice sugar content rather than only SSBs.[297] The inclusion of 100% juice increased the taxed beverage volume by 38%. Notably, the simulated benefits were proportionally even greater: reductions in energy intake, DALYs averted, and health care costs were 39%-47% higher for a sugary drink tax compared to a SSB tax. The inclusion of 100% juice was based on the fact that free sugars contribute to the overall energy density of beverages and are metabolized the same way as 'added' sugars.[47] The consumption of free sugars is a determinant of body weight and influences cardiometabolic factors independent of weight.[29,35] This evidence on free sugars and the level of 100% juice consumption should be considered when examining prospective taxation measures.[42] This application of a 'sugary drinks' definition to examining beverage taxation is timely given Health Canada's forthcoming revised food guide.[280]

The body of evidence examining the associations between sugary drinks and adverse health outcomes is less than for SSBs. For 100% juice specifically, recent meta-analysis of longitudinal studies reports an association between 100% juice in young children and weight gain.[224] There are several challenges inherent to exploring these relationships. Epidemiological evidence may have confounding between healthy behaviours and 100% juice consumption because many consumers perceive 100% juice as a 'healthy' beverage. In addition, much of the existing evidence on 100% juice has been funded or is associated with the fruit juice industry. These conflicts of interests may bias results, as has been demonstrated for experimental research on SSBs.[298]

Given the novelty of including 100% juice as a taxed beverage, additional assumptions were undertaken in the model. Due to a lack of Canadian data, the model assumed that 100% fruit juice had the same own-price elasticity of demand as SSBs. It was also assumed that the cross-price elasticities with plain milk and diet drinks also applied to 100% fruit juice. It is unknown how the elasticities vary.[221] In addition, the model assumed that 100% juice had the same BMI-mediated health effects as SSB,[47] though it remains unclear whether macronutrients other than sugar in 100% juice may alter the disease-specific risks attributable to SSBs. For this reason, the study reports all primary health and economic outcomes separately for SSBs and sugary drinks. In addition, when estimating the non-BMI-mediated effects of SSBs and sugary drinks on type 2 diabetes cases, the model assumed that 100% juice had the same effects as SSBs. However, the effect of 100% juice on type 2 diabetes may be slightly lower than for SSBs.[42] Therefore, the current analysis may have overestimated the direct of effect of 100% juice on type 2 diabetes. Future modelling would benefit from new research that addresses key gaps: econometric studies that estimate own- and cross-price elasticities for sugary drinks, and ideally the Canadian population; experimental studies on the outcomes to sugary drink taxation; and rigourous meta-analyses of 100% juice consumption and health outcomes, with particular attention to any influence from potential financial conflicts.

ROLE OF ENERGY COMPENSATION

The current study accounted for the effects of complement and substitute beverages by using cross-price elasticities between SSBs and other beverage types. The results show minimal effects from compensatory beverage intake. For the SSB tax, 100% juice and plain milk were substitute beverages and diet drinks were complementary. For the sugary drink tax, only plain milk and diet drinks were examined. The differences in energy intake from the SSB tax compared to the sugary drink tax were due to two reasons. First, 100% juice was a substitute beverage to SSBs and increased caloric intake by 1.0-1.3 kcal per person per day. Second, and more importantly, inclusion of 100% juice in a sugary drink tax led to a larger reduction in consumed beverage volume, with an additional reduction of 4.7-6.3 kcal compared to the SSB tax. There were also additional benefits: lower 100% juice intake reduced direct type 2 diabetes risk. Thus, taxing 100% juice has multiple benefits. The results can be interpreted to suggest that if 100% juice is not included in a beverage tax, Canadians will shift consumption to 100% juice due to the comparatively lower price. Furthermore, exclusion of 100% juice from the tax may send an implicit or explicit health message that 100% juice is 'healthy' and lead to higher consumption.

It is plausible that if a beverage tax is applied, some consumers may switch to sugary foods. Elasticity studies suggest that if this does occur, it will be to a small degree.[125,126,219,255,256] No known meta-analysis calculates cross-price elasticities between SSB or sugary drinks and any substitute or complement food. The impact of food cross-price elasticities on health outcomes is unknown. Studies of real-world beverage taxes have focused on identifying non-alcoholic beverage substitution, not food substitution.[129,140,165,168,299] Switching to foods has not been explicitly examined, and may not be feasible given the complex nature of diet and the food system. Additionally, Mexico has implemented a tax on 'junk food' to limit consumption and discourage switching in this direction. Even with some energy compensation, unless the number of calories from the substitute beverage exceeds the tax-induced reduction, there is still some degree of health benefit. Sensitivity analysis in the current study examined if the energy reduced by taxes was compensated by 50% and found health and economic effects decreased, though by less than 50%.

As for diet beverages, the current study modelled a cross-price elasticity that led to reductions in diet or lower calorie beverages. Given that this cross-price elasticity was from an international meta-analysis, there may be country-specific differences in the direction of the change.[221] For example, diet beverage consumption may increase in some settings. However, Canadians have an unfavourable view of diet beverages and consider diet carbonated soft drinks just as unhealthy as regular versions.[282] Consensus has not emerged on whether consumption of diet beverages supports or inhibits weight loss. Canada's draft food guidelines offer no guidance on foods and beverages containing artificial and other non-nutritive sweeteners.[280]

ADDITIONAL LIMITATIONS

The study contains other limitations and assumptions. Most notably, 24-hour dietary recall is subject to error, especially due to underestimation of energy intake. As noted above, individuals with higher BMI are more likely to underreport energy intake. Care was taken when assigning beverage codes to specific beverage categories; however, the code descriptions were limited and misclassification is possible.

The model assumed that changes in consumption and weight would occur equally within a given sex and age group. In actuality, not all Canadians consume sugary drinks and, among consumers, some drink significantly less or more than the average.[50,51] Based on the tax simulation framework, high sugary drink consumers stand to benefit the most as their consumption can decline more in response to a tax intervention. Though lower income groups do not have statistically different intake from other income groups, lower income groups are more responsive to price changes and may disproportionately benefit in terms of health outcomes.[134] Reviews of simulated pricing policies have found beverage taxes to be slightly fiscally regressive, but can reduce health disparities through their 'progressive for health' nature.[96,97,136]

The study assumed no secular change in sugary drink consumption. The results of this analysis of 2015 data indicate that consumption has decreased since 2004. However, this decrease was preceded by decades of increasing soft drink consumption. For example, from 1938 to 2001, soft drinks and sweetened juices changed from 0.1% to 6.3% of total household energy.[300] Therefore, it is unclearly whether the changes observed in sugary drink consumption between 2004 and 2015 will continue, and how a secular trend should be represented in future models.

The model did not include protein drinks and meal replacement beverages as taxed beverages, though these products are typically sweetened during manufacturers and would have increased

SSB and sugary drink volumes by 4% and 3%, respectively. In addition, the non-alcoholic portion of mixed alcoholic drinks (e.g. the regular cola in a rum and Coke) was not counted as SSB and sugary drink volume. Accordingly, consumed volume from these mixed drinks means sugary drink volume was higher than was modelled here. This could be re-examined in future work, as well as the role of the sugars found in alcoholic drinks.

The primary scenarios used a 100% pass-on rate, although the sensitivity analysis illustrated the implications of a lower or higher pass-on rate. Evidence from France and Mexico, settings with a national excise tax on SSBs, show pass-on rates equal to or almost equal to 100%, with some heterogeneity by product, outlet, and region.[128,164] The model did not capture any effects from product reformulation that may result from a SSB or sugary drink tax.

Ages 0-19 were not included due to an absence of suitable parameters: the Global Burden of Disease BMI-related relative risks start at age 25 years, reflectively the occurrence of these conditions later in life. The current model assumes any disease burden before age 20 cannot be prevented, and therefore underestimates the tax intervention's impact, especially for type 2 diabetes and other conditions with reported incidences during childhood and adolescence. Future health technologies, which were assumed to be stable in the model, may contribute to extended lifespan, thereby reducing deaths from sugary drinks and increasing years lived with a disability and health care costs.

An important strength of the current study was accounting for these key parameters and other unknowns by estimating uncertainty from price elasticity, BMI, beverage intake, and relative risks. The study also tested the sensitivity of the results to varying key assumptions, including model inputs, beverage prices, intervention effectiveness, and physiological responses.[97] Future studies could examine the potential impact of a 'tiered' tax based on beverage sugar content, as well as the effects of a tax relative to other nutrition interventions.

CONCLUSIONS

Consumption of sugary drinks remains an important disease risk factor among the Canadian population. Average intake of sugary drinks in 2015 is lower than 2004 estimates, but remains high, especially among children and youth. The federal government's proposed front-of-package labelling on prepackaged foods and restriction on marketing of unhealthy foods and beverages to kids are encouraging steps in discouraging sugary drink consumption.[235,236] Taxation of sugary beverages is a powerful policy lever that has not yet been proposed at the federal level. However, policymakers are increasingly examining the feasibility and benefits of a sugary drink tax. The current study suggests that a beverage tax in Canada has the potential to substantially reduce the health burden while generating health care savings and tax revenue, especially if 100% juice is among taxed beverages. Given Canadians' high 100% juice consumption, the mounting evidence on adverse effects associated with free sugar consumption, and the role of 100% juice as a substitute beverage to SSBs, there is a strong rationale for its inclusion as a taxed beverage.

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APPENDIX A: DRINK SPECIFICATION AND MODEL INPUTS

Appendix A, Table 1. Sugary drink food codes

Code	Description
Regular carbonated soft drinks	
5293	Carbonated drinks, chocolate
5288	Carbonated drinks, cola
4980	Carbonated drinks, cola, decaffeinated
2920	Carbonated drinks, cola, fast-food cola
2854	Carbonated drinks, cream soda
2855	Carbonated drinks, ginger ale
2856	Carbonated drinks, grape soda
2857	Carbonated drinks, lemon-lime soda
7429	Carbonated drinks, lemon-lime soda, with caffeine
2858	Carbonated drinks, orange soda
2859	Carbonated drinks, pepper type
2861	Carbonated drinks, root beer
2860	Carbonated drinks, tonic water (quinine)
504686	Carbonated citrus juice drink
505188	Carbonated juice drink, NS as to type of juice
505189	Carbonated noncitrus juice drink
Regular fruit drinks	
1694	Apricot nectar, canned
5628	Cocktail mix, non-alcoholic, concentrated, frozen
5424	Drink, breakfast type, orange, ready-to-drink
7055	Drink, fruit flavour, vitamin C added, ready-to-drink
2981	Drink, fruit punch flavour, powder, water added
2958	Drink, fruit punch flavour, vitamin C added, powder, water added
6437	Drink, fruit punch, frozen concentrate, water added
2959	Drink, fruit punch, vitamin C added, ready-to-drink
2961	Drink, grape, vitamin C added, canned
2983	Drink, lemonade flavour, powder, water added
2965	Drink, lemonade flavour, vitamin C added, powder, water added
2972	Drink, orange flavour, vitamin C added, powder, water added
2967	Drink, orange, vitamin C added, canned
2974	Drink, orange, vitamin C added, frozen concentrate, water added
1720	Grape juice, frozen concentrate, sugar and vitamin C added, diluted
1570	Grapefruit juice, canned, sweetened
1717	Grapefruit juice, frozen concentrate, diluted
6204	Guava, nectar, canned
2889	Juice drink, citrus fruit, frozen concentrate, water added

2885	Juice drink, cranberry and apricot, bottled
2954	Juice drink, cranberry-apple, vitamin C added, bottled
2922	Juice drink, fruit punch, frozen concentrate, water added
7070	Juice drink, fruit, ready-to-drink
404292	Juice drink, fruit, without added vitamin C, ready-to drink
2960	Juice drink, grape, vitamin C added, canned
6470	Juice drink, orange
2968	Juice drink, pineapple and grapefruit, vitamin C added, canned
2969	Juice drink, pineapple and orange, vitamin C added, canned
2956	Juice, cocktail, cranberry, vitamin C added, bottled
2976	Juice, cocktail, cranberry, vitamin C added, frozen concentrate, water added
2868	Juice, tomato clam cocktail, canned
2893	Lemonade, white, frozen concentrate, water added
2895	Limeade, frozen concentrate, water added
6205	Mango, nectar, canned
1629	Papaya nectar, canned
1644	Peach nectar, canned
1652	Pear nectar, canned
1625	Tangerine (mandarin) juice, canned, sugar added
501936	Banana nectar
501937	Cantaloupe nectar
502472	Citrus fruit juice drink, frozen concentrate, diluted (40-50% fruit juice)
504387	Daiquiri mix, frozen concentrate, diluted
502464	Fruit punch, made with fruit juice and soda
502465	Fruit punch, made with soda, fruit juice, and sherbet or ice cream
502479	Fruit-flavoured drink, made from powdered mix (lemonade)
501853	Grapefruit and orange juice, fresh, with sugar
505134	Grapefruit juice, frozen (reconstituted with water)
504733	Juice drink, fruit punch, frozen concentrate, diluted with 3.5 parts water
504734	Juice drink, fruit punch, frozen concentrate, diluted with 4 parts water
504735	Juice drink, fruit punch, frozen concentrate, diluted with 5 parts water
502480	Lemonade, drink, powder, with sugar and vitamin C added, water added
502468	Lemonade, frozen, diluted with water
502469	Lemon-limeade
502470	Limeade, frozen concentrate, diluted
501940	Passion fruit nectar
504510	Pina Colada, non-alcoholic
501935	Prune juice, with sugar
504558	Shirley Temple
501941	Soursop (Guanabana) nectar
Regular sports drinks	
5962	Sports drink, fruit flavour, ready-to-drink

5963	Sports drink, lemon-lime flavour, ready-to-drink
Regular energy drinks	
7179	Energy drink, caffeine free
7173	Energy drink, coffee flavours
7176	Energy drink, coffee flavours, light
7180	Energy drink, tea flavoured
7175	Energy drink, various flavours
7178	Energy drink, with fruit juice
Sugar-sweetened coffee	
505183	Blended coffee beverage, decaffeinated coffee, sweetened, with whipped cream
504722	Blended coffee beverage, decaffeinated coffee, sweetened
504729	Blended coffee beverage, regular coffee, sweetened
504386	Blended coffee beverage, regular coffee, sweetened, with whipped cream
502440	Coffee and cocoa (mocha), instant, with whitener, pre-sweetened, powder, water added
502439	Coffee, instant, pre-sweetened, no whitener, powder, water added
2928	Coffee, instant, sweetened, cappucino flavour, powder, water added
2929	Coffee, instant, sweetened, French flavour, powder, water added
2930	Coffee, instant, sweetened, mocha flavour, powder, water added
504363	Coffee, mocha, with whipped cream
504847	Coffee, mocha, without whipped cream
502441	Coffee, regular, presweetened with sugar, pre-lightened
Sugar-sweetened tea	
504730	Tea, chai latte
4908	Tea, iced, lemon flavour, ready-to-drink
2915	Tea, instant, sweetened, lemon flavour, powder, water added
502456	Tea, made from powdered instant, presweetened with sugar (NS as to sweetener, iced tea)
502452	Tea, NS as to type, presweetened with sugar
502453	Tea, NS as to type, sweetened, NS as to sweetener (Lemon-flavoured)
502454	Tea, NS as type, sweetened, NS as to sweetener, decaffeinated
Hot chocolate (non-diet)	
504779	Hot chocolate, made from dry mix, milk added
500028	Hot chocolate, made from dry mix, water added
Flavoured water (non-diet)	
7185	Vitamin water, all flavours, sweetened
7237	Vitamin water, flavours not lemon/orange, sweetened
7187	Vitamin water, lemon/orange flavours, sweetened
7189	Vitamin water, tropical citrus flavour, sweetened, with caffeine
Smoothies	
504145	Fruit smoothie drink, made with fruit or fruit juice only (no dairy products)
504981	Fruit smoothie drink, NFS
504171	Milk fruit drink (Smoothie)

Sugar-sweetened milk	
5589	Chocolate flavour drink, whey and milk based
502759	Chocolate flavour mix beverage, powder, 2% milk added
500027	Chocolate flavour mix beverage, skim milk added
500025	Chocolate flavour mix beverage, whole milk added
500024	Chocolate flavour mix bevrage, powder, milk added, NS as to type of milk
504695	Chocolate syrup, 1% milk added
502760	Chocolate syrup, 2% milk added
504976	Chocolate syrup, milk added, NS as to type of milk
504359	Chocolate syrup, skim milk added
504696	Chocolate syrup, whole milk added
500026	Chocolate, flavour mix beverage, powder, 1% milk added
55	Eggnog, 7% M.F., Canadian product, 4% to 8% M.F.
500038	Eggnog, made with 2% milk
500036	Malted milk, chocolate, enriched, powder, milk added
500035	Malted milk, natural flavour, enriched, powder, 2% milk added
500037	Malted milk, NS as to flavour, enriched, powder, milk added
500041	Milk shake with malt (Malted milk with ice cream)
75	Milk shake, chocolate, thick
504172	Milk shake, homemade or fountain-type, chocolate
504173	Milk shake, homemade or fountain-type, flavours other than chocolate
500040	Milk shake, homemade or fountain-type, NS as to flavour
500039	Milk shake, NS as to flavour or type
502783	Milk shake, restaurant type, chocolate, thick
500042	Milk shake, restaurant type, NS as to flavour (Thick shake mix, milk added)
502784	Milk shake, restaurant type, vanilla, thick
76	Milk shake, vanilla, thick
504974	Milk, chocolate, NFS
504979	Milk, flavors other than chocolate, 1% milk-based (strawberry, vanilla, powder and syrup)
502770	Milk, flavors other than chocolate, 2% milk-based (strawberry, vanilla, powder and syrup)
504977	Milk, flavors other than chocolate, NFS (strawberry, vanilla, powder and syrup)
504980	Milk, flavors other than chocolate, skim-milk based (strawberry, vanilla, powder and syrup)
504978	Milk, flavors other than chocolate, whole milk-based (strawberry, vanilla, powder and syrup)
4711	Milk, fluid, chocolate, partly skimmed, 1% M.F.
70	Milk, fluid, chocolate, partly skimmed, 2% M.F.
69	Milk, fluid, chocolate, whole
500043	Milk-based fruit drink
7226	Plant-based beverage, almond, enriched, sweetened, chocolate flavoured
7225	Plant-based beverage, almond, enriched, sweetened, vanilla flavoured
7480	Plant-based beverage, cashew, enriched, sweetened
7478	Plant-based beverage, coconut, enriched, sweetened, all flavours
6720	Plant-based beverage, soy, enriched, all flavours

6329	Plant-based beverage, soy, enriched, chocolate
Sugar-sweetened drinkable yogurt	
6993	Yogourt beverage, fruit flavoured
7119	Yogourt beverage, fruit flavoured, with added Vitamin D
6994	Yogourt beverage, vanilla flavoured
7120	Yogourt beverage, vanilla flavoured, with added Vitamin D
100% juice	
1485	Acerola juice, raw
504002	Apple cider
1752	Apple juice, canned or bottled, added vitamin C
7419	Apple juice, canned or bottled, unsweetened, calcium and Vitamin C and D added
1495	Apple juice, canned or bottled, without added vitamin C
1754	Apple juice, frozen concentrate, diluted, added vitamin C
1497	Apple juice, frozen concentrate, diluted, without added vitamin C
7411	Babyfood, juice, apple and prune
7410	Babyfood, juice, apple, all stages
7412	Babyfood, juice, pear, all stages
7224	Beverage, coconut water, unsweetened, ready-to-drink
5389	Blackberry juice, canned
2312	Carrot juice, canned
5593	Cranberry juice, unsweetened
504388	Fruit juice blend, 100% juice, with added Vitamin C
404283	FRUIT JUICE BLEND, 100% JUICE, WITH VITAMINS AND MINERALS
501927	Fruit juice, NFS (Mixed fruit juices)
6642	Grains, wheat flour, white, all purpose, unbleached
6660	Grape juice, canned or bottled, unsweetened, with added vitamin C
1576	Grape juice, canned or bottled, without added vitamin C
1716	Grapefruit juice, canned, no added sugar
6440	Grapefruit juice, pink, raw
1572	Grapefruit juice, white, raw
2955	Juice drink, cranberry-grape, vitamin C added, bottled
5287	Juice drink, mixed vegetable and fruit
2904	Juice drink, orange and apricot, canned
6662	Juice, apple and grape, with added vitamin C
5586	Juice, tomato and vegetable, low sodium
2464	Juice, tomato, canned
6287	Juice, tomato, canned, no salt added
1590	Lemon juice, canned or bottled
1591	Lemon juice, frozen
1589	Lemon juice, raw
1595	Lime juice, canned or bottled
1594	Lime juice, raw

502123	Mixed vegetable juice (vegetables other than tomato)
501855	Orange and banana juice
1622	Orange grapefruit juice, canned
1723	Orange juice, canned
1620	Orange juice, chilled, includes from concentrate
6203	Orange juice, chilled, includes from concentrate, fortified with added calcium and vitamin D
1725	Orange juice, frozen concentrate, diluted
504732	Orange juice, frozen concentrate, diluted with 3.5 parts water
504731	Orange juice, frozen concentrate, diluted with 4 parts water
7573	Orange juice, frozen concentrate, diluted, with added calcium and Vitamin D
504477	Orange juice, frozen concentrate, unsweetened, diluted
504478	Orange juice, frozen concentrate, with calcium and vit. D added, diluted
505135	Orange juice, NFS
1619	Orange juice, raw
7051	Orange pineapple juice
5472	Orange-strawberry-banana juice
1631	Passion fruit juice, purple, raw
1632	Passion fruit juice, yellow, raw
1657	Pineapple juice, canned, added vitamin C
1659	Pineapple juice, frozen concentrate, diluted
504189	Pineapple juice-non-citrus juice blend, unsweetened, with added vitamin C
504190	Pineapple, orange and banana juice
501857	Pineapple-grapefruit juice, fresh
501866	Pineapple-orange juice, frozen, diluted with water
501862	Pineapple-orange juice, NFS, includes from concentrate
6661	Pomegranate juice, ready-to-drink
1673	Prune juice, canned
1624	Tangerine (mandarin) juice, raw
2473	Vegetable juice cocktail, canned
7421	Vegetable juice cocktail, canned, low sodium

Source: Food Description file, 2015 Canadian Community Health Survey-Nutrition (Variables FID_CDE, FDC_DEN)[240]

Appendix A, Table 2. Milk and diet drink food codes

Code	Description
Milk, plain	
5483	Beverage, bean
124	Milk, fluid, buttermilk, cultured, 1% M.F.
5487	Milk, fluid, buttermilk, cultured, 2% M.F.
7024	Milk, fluid, buttermilk, cultured, whole
72	Milk, fluid, goat, enriched, whole
6353	Milk, fluid, goat, unenriched, whole
404108	Milk, fluid, partly skimmed, 0.5% M.F.
63	Milk, fluid, partly skimmed, 1% M.F.
404021	MILK, FLUID, PARTLY SKIMMED, 1% M.F., WITH 35% MORE CALCIUM
61	Milk, fluid, partly skimmed, 2% M.F.
404020	MILK, FLUID, PARTLY SKIMMED, 2%, WITH 35% MORE CALCIUM
74	Milk, fluid, sheep, whole
114	Milk, fluid, skim
404036	MILK, FLUID, SKIM, WITH 35% MORE CALCIUM
113	Milk, fluid, whole, pasteurized, homogenized, 3.25% M.F.
123	Milk, fluid, whole, producer, 3.7% M.F.
504448	Milk, NFS
7531	Plant-based beverage, cashew, enriched, unsweetened
4780	Plant-based beverage, rice, enriched
6330	Plant-based beverage, soy, enriched, all flavours, unsweetened
78	Whey, acid, dry
77	Whey, acid, fluid
80	Whey, sweet, dry
79	Whey, sweet, fluid
Carbonated soft drinks, diet or light	
2853	Carbonated drinks, club soda
2926	Carbonated drinks, cola with aspartame
4979	Carbonated drinks, cola with aspartame, decaffeinated
2938	Carbonated drinks, non cola with aspartame
Fruit drinks, diet or light	
403953	CRANBERRY JUICE COCKTAIL, + VITAMIN C, + ASPARTAME, BOTTLED
6328	Drink, breakfast type, orange, reduced sugar
505190	Fruit drink, low calorie
505191	Fruit flavored drink, made from powdered mix, low calorie
502481	Fruit-flavoured drink, made from powdered mix, low calorie, with vitamin C added
5603	Juice drink, cranberry-apple low calorie, with vitamin C added
7230	Juice drink, orange, Calorie-reduced
2963	Lemonade with artificial sweetener, powder, water added
Sports drinks, diet or light	

5292	Sports drink, fruit flavour, low calorie, ready-to-drink
Energy drinks, diet or light	
7174	Energy drink, shot, sugar free
7177	Energy drink, sugar free/low calorie
7184	Energy drink, with electrolytes, sugar free/low calorie
Coffee, with low calorie sweetener	
505185	Coffee and cocoa (mocha), made from powdered instant mix, with whitener and low calorie sweetener, decaffeinated
Tea, diet or light	
504757	Tea, made from powdered instant, with artificial sweetener (iced tea)
504765	Tea, NS as to type, presweetened with low calorie sweetener (Ready-to-drink)
Hot chocolate, diet or light	
500029	Hot chocolate, made from dry mix with low calorie sweetener, water added
Flavoured water, diet or light	
7186	Vitamin water, all flavours, low Calorie
7238	Vitamin water, flavours not lemon/orange, low Calorie
7188	Vitamin water, lemon/orange flavours, low Calorie
6327	Water, fruit flavour, sweetened with artificial sweetener

Source: Food Description file, 2015 Canadian Community Health Survey-Nutrition (Variables FID_CDE, FDC_DEN)[240]

Appendix A, Table 3. Consumption and energy density of SSBs and sugary drinks, 2015 CCHS-Nutrition

	SSBs			Sugary drinks		
	Consumption (SE)		**Energy density**	**Consumption (SE)**		**Energy density**
Age group	mL/person/day		Kcal/L	mL/person/day		Kcal/L
Males						
0-9	146.4	(5.8)	561.6	275.3	(7.2)	518.0
10-19	367.2	(11.1)	475.9	518.7	(11.7)	470.0
20-29	373.7	(18.3)	473.9	468.6	(19.5)	469.5
30-39	303.0	(14.2)	516.4	379.7	(15.1)	502.0
40-49	227.7	(11.3)	431.5	290.5	(12.1)	436.1
50-59	178.0	(9.4)	433.9	238.3	(10.0)	435.9
60-69	163.9	(10.1)	433.5	227.1	(10.8)	432.4
70-79	103.7	(7.3)	410.3	167.8	(8.9)	421.4
80-89	128.5	(13.1)	466.1	214.5	(19.5)	452.1
90+	119.3	(34.3)	481.7	233.7	(40.2)	466.4
Females						
0-9	126.2	(4.9)	560.6	237.0	(6.3)	520
10-19	251.3	(7.1)	503.0	349.9	(8.0)	493
20-29	233.1	(12.4)	487.8	291.9	(12.9)	484.7
30-39	163.9	(9.1)	468.4	228.1	(10.1)	465.1
40-49	145.8	(8.1)	436.6	184.9	(8.6)	439.0
50-59	131.8	(7.8)	466.0	175.1	(8.5)	459.6
60-69	113.0	(6.8)	443.2	156.1	(7.5)	442.5
70-79	102.8	(6.6)	413.5	163.2	(7.6)	428.8
80-89	98.1	(8.5)	437.2	176.0	(9.8)	442.8
90+	78.5	(12.7)	496.7	191.8	(19.5)	462.0

SE, standard error; SSBs, sugar-sweetened beverages

Appendix A, Table 4. Consumption and energy density of 100% juice, plain milk, and diet or light beverages, 2015 CCHS-Nutrition

	100% juice			Plain milk			Diet or light beverages		
	Consumption (SE)		Energy density	Consumption (SE)		Energy density	Consumption (SE)		Energy density
Age group	mL/person/day		Kcal/L	mL/person/day		Kcal/L	mL/person/day		Kcal/L
Males									
0-9	128.9	(4.7)	468.4	300.8	(7.6)	525.6	4.4	(1.1)	30.8
10-19	151.4	(5.9)	455.6	221.9	(7.0)	480.8	20.8	(2.8)	39.4
20-29	95.0	(7.4)	452.4	133.9	(8.7)	523.3	21.6	(4.9)	29.8
30-39	76.7	(5.8)	445.3	102.5	(7.3)	468.8	42.3	(5.3)	36.5
40-49	62.8	(4.4)	452.5	93.8	(5.9)	478.4	81.3	(9.1)	19.9
50-59	60.3	(3.8)	441.9	101.4	(5.4)	467.8	66.3	(5.8)	32.8
60-69	63.3	(4.0)	429.4	114.8	(6.6)	461.2	58.4	(6.1)	20.1
70-79	64.0	(4.4)	439.4	142.7	(6.3)	473.2	82.9	(8.7)	27.2
80-89	86.0	(12.8)	431.2	136.8	(9.5)	474.8	20.9	(4.4)	25.3
90+	114.4	(25.9)	450.4	188.3	(32.0)	530.1	0	(0)	0
Females									
0-9	110.8	(4.4)	473.7	257.4	(6.6)	516.5	7.3	(1.6)	61.8
10-19	98.6	(4.4)	467.6	176.3	(6.0)	475.6	13.7	(2.0)	37.9
20-29	58.8	(4.7)	472.5	90.0	(7.3)	509.7	29.4	(4.8)	31.2
30-39	64.2	(4.7)	456.7	88.5	(4.4)	486.1	55.7	(6.0)	20.9
40-49	39.2	(3.2)	447.8	99.3	(5.0)	477.4	52.9	(5.7)	27.3
50-59	43.3	(3.2)	440.3	79.6	(4.4)	460.5	56.1	(6.9)	15.4
60-69	43.1	(3.5)	440.7	103.4	(4.7)	460.5	50.0	(4.8)	26.8
70-79	60.5	(4.1)	454.8	106.9	(5.4)	447.4	38.8	(4.3)	25.6
80-89	77.9	(5.6)	449.9	109.2	(6.4)	457.6	16.4	(4.2)	23.3
90+	113.3	(19.0)	438.0	110.7	(12.3)	481.1	7.8	(5.6)	10.0

SE, standard error

APPENDIX B: DISEASE SPECIFICATIONS AND DATA SOURCES

Appendix B, Table 1. ICD codes for modelled diseases

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

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

ICD, International Classification of Diseases
Source: Global Burden of Disease 2015 Study[8]

Appendix B, Table 2. Relative risks for diseases associated with high BMI

Males

Unit: 5 kg/m^2 Age

Risk - Outcome	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80+
Esophageal cancer												
Input RR - mean	1.391	1.391	1.391	1.391	1.391	1.391	1.391	1.391	1.391	1.391	1.391	1.391
Interval (LL)	1.076	1.076	1.076	1.076	1.076	1.076	1.076	1.076	1.076	1.076	1.076	1.076
Interval (UL)	1.758	1.758	1.758	1.758	1.758	1.758	1.758	1.758	1.758	1.758	1.758	1.758
Colon and rectum cancer												
Input RR - mean	1.177	1.177	1.177	1.177	1.177	1.177	1.177	1.177	1.177	1.177	1.177	1.177
Interval (LL)	1.145	1.145	1.145	1.145	1.145	1.145	1.145	1.145	1.145	1.145	1.145	1.145
Interval (UL)	1.208	1.208	1.208	1.208	1.208	1.208	1.208	1.208	1.208	1.208	1.208	1.208
Liver cancer												
Input RR - mean	1.289	1.289	1.289	1.289	1.289	1.289	1.289	1.289	1.289	1.289	1.289	1.289
Interval (LL)	1.109	1.109	1.109	1.109	1.109	1.109	1.109	1.109	1.109	1.109	1.109	1.109
Interval (UL)	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491	1.491
Gallbladder and biliary track cancer												
Input RR - mean	1.155	1.155	1.155	1.155	1.155	1.155	1.155	1.155	1.155	1.155	1.155	1.155
Interval (LL)	1.033	1.033	1.033	1.033	1.033	1.033	1.033	1.033	1.033	1.033	1.033	1.033
Interval (UL)	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282	1.282
Pancreatic cancer												
Input RR - mean	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071
Interval (LL)	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999
Interval (UL)	1.154	1.154	1.154	1.154	1.154	1.154	1.154	1.154	1.154	1.154	1.154	1.154
Kidney cancer												
Input RR - mean	1.240	1.240	1.240	1.240	1.240	1.240	1.240	1.240	1.240	1.240	1.240	1.240
Interval (LL)	1.171	1.171	1.171	1.171	1.171	1.171	1.171	1.171	1.171	1.171	1.171	1.171
Interval (UL)	1.313	1.313	1.313	1.313	1.313	1.313	1.313	1.313	1.313	1.313	1.313	1.313
Thyroid cancer												
Input RR - mean	1.221	1.221	1.221	1.221	1.221	1.221	1.221	1.221	1.221	1.221	1.221	1.221
Interval (LL)	1.067	1.067	1.067	1.067	1.067	1.067	1.067	1.067	1.067	1.067	1.067	1.067
Interval (UL)	1.382	1.382	1.382	1.382	1.382	1.382	1.382	1.382	1.382	1.382	1.382	1.382
Leukemia												
Input RR - mean	1.086	1.086	1.086	1.086	1.086	1.086	1.086	1.086	1.086	1.086	1.086	1.086
Interval (LL)	1.053	1.053	1.053	1.053	1.053	1.053	1.053	1.053	1.053	1.053	1.053	1.053
Interval (UL)	1.119	1.119	1.119	1.119	1.119	1.119	1.119	1.119	1.119	1.119	1.119	1.119
Ischemic heart disease												
Input RR - mean	2.274	2.018	1.724	1.599	1.567	1.520	1.466	1.414	1.364	1.319	1.274	1.170
Interval (LL)	1.257	1.296	1.532	1.418	1.457	1.417	1.372	1.324	1.287	1.242	1.187	1.091
Interval (UL)	3.686	3.109	1.932	1.785	1.680	1.631	1.557	1.504	1.448	1.400	1.365	1.253
Ischemic stroke												
Input RR - mean	2.472	2.235	1.979	1.826	1.733	1.635	1.543	1.455	1.380	1.304	1.228	1.068
Interval (LL)	1.399	1.454	1.694	1.600	1.581	1.479	1.441	1.345	1.310	1.233	1.159	0.992
Interval (UL)	3.980	3.334	2.313	2.076	1.898	1.796	1.653	1.566	1.458	1.376	1.305	1.143
Hemorrhagic stroke												
Input RR - mean	3.066	2.913	2.597	2.389	2.199	1.996	1.805	1.665	1.523	1.410	1.295	1.070
Interval (LL)	1.750	1.860	1.974	1.869	1.821	1.625	1.573	1.437	1.377	1.265	1.162	0.928
Interval (UL)	5.337	4.399	3.387	3.002	2.673	2.419	2.060	1.933	1.684	1.571	1.439	1.220
Hypertensive heart disease												
Input RR - mean	3.122	3.000	2.769	2.573	2.407	2.281	2.159	2.035	1.955	1.860	1.792	1.697
Interval (LL)	1.588	1.748	1.814	1.741	1.716	1.597	1.499	1.451	1.342	1.296	1.169	1.067
Interval (UL)	5.502	4.912	4.217	3.647	3.296	3.189	3.039	2.822	2.700	2.617	2.553	2.620
Type 2 diabetes												
Input RR - mean	3.547	3.455	3.349	3.160	2.864	2.624	2.417	2.215	2.046	1.896	1.740	1.461

Males

Unit: 5 kg/m^2 Age

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

Females

Unit: 5 kg/m^2 Age

Risk - Outcome	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80+
Esophageal cancer												
Input RR - mean	1.351	1.351	1.351	1.351	1.351	1.351	1.351	1.351	1.351	1.351	1.351	1.351
Interval (LL)	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012
Interval (UL)	1.745	1.745	1.745	1.745	1.745	1.745	1.745	1.745	1.745	1.745	1.745	1.745
Colon and rectum cancer												
Input RR - mean	1.059	1.059	1.059	1.059	1.059	1.059	1.059	1.059	1.059	1.059	1.059	1.059
Interval (LL)	1.031	1.031	1.031	1.031	1.031	1.031	1.031	1.031	1.031	1.031	1.031	1.031
Interval (UL)	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083
Liver cancer												
Input RR - mean	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176	1.176
Interval (LL)	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030
Interval (UL)	1.334	1.334	1.334	1.334	1.334	1.334	1.334	1.334	1.334	1.334	1.334	1.334
Gallbladder and biliary track cancer												
Input RR - mean	1.344	1.344	1.344	1.344	1.344	1.344	1.344	1.344	1.344	1.344	1.344	1.344

Females

Unit: 5 kg/m^2 Age

Risk - Outcome	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80+
Interval (LL)	1.223	1.223	1.223	1.223	1.223	1.223	1.223	1.223	1.223	1.223	1.223	1.223
Interval (UL)	1.478	1.478	1.478	1.478	1.478	1.478	1.478	1.478	1.478	1.478	1.478	1.478
Pancreatic cancer												
Input RR - mean	1.092	1.092	1.092	1.092	1.092	1.092	1.092	1.092	1.092	1.092	1.092	1.092
Interval (LL)	1.037	1.037	1.037	1.037	1.037	1.037	1.037	1.037	1.037	1.037	1.037	1.037
Interval (UL)	1.144	1.144	1.144	1.144	1.144	1.144	1.144	1.144	1.144	1.144	1.144	1.144
Breast cancer												
Input RR - mean	0.890	0.890	0.890	0.890	0.890	1.345	1.345	1.345	1.345	1.345	1.345	1.345
Interval (LL)	0.868	0.868	0.868	0.868	0.868	1.121	1.121	1.121	1.121	1.121	1.121	1.121
Interval (UL)	0.914	0.914	0.914	0.914	0.914	1.601	1.601	1.601	1.601	1.601	1.601	1.601
Uterine cancer												
Input RR - mean	1.613	1.613	1.613	1.613	1.613	1.613	1.613	1.613	1.613	1.613	1.613	1.613
Interval (LL)	1.543	1.543	1.543	1.543	1.543	1.543	1.543	1.543	1.543	1.543	1.543	1.543
Interval (UL)	1.681	1.681	1.681	1.681	1.681	1.681	1.681	1.681	1.681	1.681	1.681	1.681
Ovarian cancer												
Input RR - mean	1.038	1.038	1.038	1.038	1.038	1.038	1.038	1.038	1.038	1.038	1.038	1.038
Interval (LL)	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998
Interval (UL)	1.077	1.077	1.077	1.077	1.077	1.077	1.077	1.077	1.077	1.077	1.077	1.077
Kidney cancer												
Input RR - mean	1.320	1.320	1.320	1.320	1.320	1.320	1.320	1.320	1.320	1.320	1.320	1.320
Interval (LL)	1.254	1.254	1.254	1.254	1.254	1.254	1.254	1.254	1.254	1.254	1.254	1.254
Interval (UL)	1.395	1.395	1.395	1.395	1.395	1.395	1.395	1.395	1.395	1.395	1.395	1.395
Thyroid cancer												
Input RR - mean	1.136	1.136	1.136	1.136	1.136	1.136	1.136	1.136	1.136	1.136	1.136	1.136
Interval (LL)	1.094	1.094	1.094	1.094	1.094	1.094	1.094	1.094	1.094	1.094	1.094	1.094
Interval (UL)	1.178	1.178	1.178	1.178	1.178	1.178	1.178	1.178	1.178	1.178	1.178	1.178
Leukemia												
Input RR - mean	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131	1.131
Interval (LL)	1.061	1.061	1.061	1.061	1.061	1.061	1.061	1.061	1.061	1.061	1.061	1.061
Interval (UL)	1.208	1.208	1.208	1.208	1.208	1.208	1.208	1.208	1.208	1.208	1.208	1.208
Ischemic heart disease												
Input RR - mean	2.274	2.018	1.724	1.599	1.567	1.520	1.466	1.414	1.364	1.319	1.274	1.170
Interval (LL)	1.257	1.296	1.532	1.418	1.457	1.417	1.372	1.324	1.287	1.242	1.187	1.091
Interval (UL)	3.686	3.109	1.932	1.785	1.680	1.631	1.557	1.504	1.448	1.400	1.365	1.253
Ischemic stroke												
Input RR - mean	2.472	2.235	1.979	1.826	1.733	1.635	1.543	1.455	1.380	1.304	1.228	1.068
Interval (LL)	1.399	1.454	1.694	1.600	1.581	1.479	1.441	1.345	1.310	1.233	1.159	0.992
Interval (UL)	3.980	3.334	2.313	2.076	1.898	1.796	1.653	1.566	1.458	1.376	1.305	1.143
Hemorrhagic stroke												
Input RR - mean	3.066	2.913	2.597	2.389	2.199	1.996	1.805	1.665	1.523	1.410	1.295	1.070
Interval (LL)	1.750	1.860	1.974	1.869	1.821	1.625	1.573	1.437	1.377	1.265	1.162	0.928
Interval (UL)	5.337	4.399	3.387	3.002	2.673	2.419	2.060	1.933	1.684	1.571	1.439	1.220
Hypertensive heart disease												
Input RR - mean	3.122	3.000	2.769	2.573	2.407	2.281	2.159	2.035	1.955	1.860	1.792	1.697
Interval (LL)	1.588	1.748	1.814	1.741	1.716	1.597	1.499	1.451	1.342	1.296	1.169	1.067
Interval (UL)	5.502	4.912	4.217	3.647	3.296	3.189	3.039	2.822	2.700	2.617	2.553	2.620
Type 2 diabetes												
Input RR - mean	3.547	3.455	3.349	3.160	2.864	2.624	2.417	2.215	2.046	1.896	1.740	1.461
Interval (LL)	2.308	2.509	2.803	2.694	2.450	2.224	2.086	1.865	1.724	1.596	1.444	1.207
Interval (UL)	5.228	4.693	3.919	3.700	3.314	3.038	2.779	2.608	2.382	2.229	2.079	1.760
Chronic kidney disease due to diabetes												

Females

Unit: 5 kg/m^2 Age

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

BMI, body mass index; kg, kilogram; LL, lower limit; m, metre; RR, relative risk; UL, upper limit
Source: Global Burden of Disease 2015 Study[8]

Appendix B, Table 3. Disease data sources and processing notes

Disease	Data Sources	Pre-DisMod II Processing	DisMod II Manipulation
Esophageal cancer	**Incidence rates:** CANSIM Table 103-0500 (2013)[275] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[301] **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	Mortality rates calculated using 2012 population. Prevalence rates calculated using 2015 population. GBD provided data (prevalent cases) in 5-year age groups up to age 80+ only. Prevalence rates were extrapolated to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.
Colon and rectum cancer	**Incidence rates:** CANSIM Table 103-0500 (2013)[275] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[301] **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	Mortality rates calculated using 2012 population. Prevalence rates calculated using 2015 population. Extrapolated prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.
Liver cancer	**Incident cases:** GBD Results Tool (2015)[260] **Disease-specific deaths:** GBD Results Tool (2015)[260] **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	Incidence, mortality and prevalence rates calculated using 2015 population. Extrapolated incidence, mortality and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.
Gallbladder and biliary track cancer	**Incident cases:** GBD Results Tool (2015)[260] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[301] **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	Mortality rates calculated using 2012 population. Incidence and prevalence rates calculated using 2015 population. Extrapolated incidence and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.
Pancreatic cancer	**Incidence rates:** CANSIM Table 103-0500 (2013)[275] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[301] **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	Mortality rates calculated using 2012 population. Prevalence rates calculated using 2015 population. Extrapolated prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.
Breast cancer	**Incidence rates:** CANSIM Table 103-0500 (2013)[275] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[301] **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	Mortality rates calculated using 2012 population. Prevalence rates calculated using 2015 population. Extrapolated prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.
Uterine cancer	**Incidence rates:** CANSIM Table 103-0500 (2013)[275] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[301] **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	Mortality rates calculated using 2012 population. Prevalence rates calculated using 2015 population. Extrapolated prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.
Ovarian cancer	**Incidence rates:** CANSIM Table 103-0500 (2013)[275] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[301] **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	Mortality rates calculated using 2012 population. Prevalence rates calculated using 2015 population. Extrapolated prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.

Disease	Data Sources	Pre-DisMod II Processing	DisMod II Manipulation
Kidney cancer	**Incidence rates:** CANSIM Table 103-0500 (2013)[275] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[301] **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	Mortality rates calculated using 2012 population. Prevalence rates calculated using 2015 population. Extrapolated prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.
Thyroid cancer	**Incidence rates:** CANSIM Table 103-0500 (2013)[275] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[301] **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	Mortality rates calculated using 2012 population. Prevalence rates calculated using 2015 population. Extrapolated prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.
Leukemia	**Incidence rates:** CANSIM Table 103-0500 (2013)[275] **Disease-specific deaths:** CANSIM Table 102-0522 (2012)[301] **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	Mortality rates calculated using 2012 population. Prevalence rates calculated using 2015 population. Extrapolated prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence weighted lightly, mortality weighted heavily, prevalence set to Ignore and remission set to Exact.
Ischemic heart disease	**Incident cases:** CCDSS (2011)[274] **Disease-specific deaths:** CANSIM Table 102-0529 (2012)[302] **Prevalent cases:** CCDSS (2011)[274] **Remission:** Inputted as 0	Incidence and prevalence rates calculated using 2011 population. Mortality rates calculated using 2012 population. CCDSS provided data (incident and prevalent cases) in 5-year age groups up to age 85+ only. Incidence and prevalence rates were extrapolated to age 100+ using a polynomial trend line.	Lowest weighting for incidence, mortality and prevalence. Remission set to Exact.
Ischemic stroke	**Incident cases:** GBD Results Tool (2015)[260] **Disease-specific deaths:** GBD Results Tool (2015)[260] **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	Incidence, mortality and prevalence rates calculated using 2015 population. Extrapolated incidence, mortality and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Lowest weighting for incidence, mortality and prevalence. Remission set to Exact.
Hemorrhagic stroke	**Incident cases:** GBD Results Tool (2015)[260] **Disease-specific deaths:** GBD Results Tool (2015)[260] **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	Incidence, mortality and prevalence rates calculated using 2015 population. Extrapolated incidence, mortality and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Lowest weighting for incidence, mortality and prevalence. Remission set to Exact.
Hypertensive heart disease	**Incident cases:** CCDSS (2011)[274] **Disease-specific deaths:** CANSIM Table 102-0529 (2012)[302] **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	CCDSS incident cases rescaled using GBD data to improve alignment with disease definition. Incidence, mortality and prevalence rates calculated using 2011, 2012 and 2015 populations, respectively. Extrapolated incidence and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence set to Ignore and remission set to Exact.
Type 2 diabetes	**Incident cases:** GBD Results Tool (2015)[260] **Disease-specific deaths:** CANSIM Tables: 102-0524, 102-0536 & 102-0538 (2012)[303–305] **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	Incidence and prevalence rates calculated using 2015 population. Mortality rates calculated using 2012 population. Determined type 2 diabetes from diabetes data by assuming that among individuals <20 years of age, 10% of diabetes cases were type 2 diabetes and among individuals ≥20 years,	Lowest weighting for incidence, mortality and prevalence. Remission set to Exact.

Disease	Data Sources	Pre-DisMod II Processing	DisMod II Manipulation
		90% of diabetes cases were type 2 diabetes. Extrapolated incidence and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	
Chronic kidney disease due to diabetes	**Incident cases:** GBD Results Tool (2015)[260] **Disease-specific deaths:** GBD Results Tool (2015)[260] **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	Incidence, mortality and prevalence rates calculated using 2015 population. Extrapolated incidence, mortality and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence has lowest weighting, mortality weighted mid-level, prevalence weighted heavily and remission set to Exact.
Chronic kidney disease due to hypertension	**Incident cases:** GBD Results Tool (2015)[260] **Disease-specific deaths:** GBD Results Tool (2015)[260] **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	Incidence, mortality and prevalence rates calculated using 2015 population. Extrapolated incidence, mortality and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence has lowest weighting, mortality weighted mid-level, prevalence weighted heavily and remission set to Exact.
Chronic kidney disease due to glomerulonephritis	**Incident cases:** GBD Results Tool (2015)[260] **Disease-specific deaths:** GBD Results Tool (2015)[260] **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	Incidence, mortality and prevalence rates calculated using 2015 population. Extrapolated incidence, mortality and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence has lowest weighting, mortality weighted mid-level, prevalence weighted heavily and remission set to Exact.
Chronic kidney disease due to other causes	**Incident cases:** GBD Results Tool (2015)[260] **Disease-specific deaths:** GBD Results Tool (2015)[260] **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	Incidence, mortality and prevalence rates calculated using 2015 population. Extrapolated incidence, mortality and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence has lowest weighting, mortality weighted mid-level, prevalence weighted heavily and remission set to Exact.
Osteoarthritis of the hip	**Incidence:** No data inputted **Disease-specific mortality:** Inputted as 0 **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	GBD prevalence data does not differentiate between hip OA and knee OA. Split data based on Cross et al: for males 66% of OA is knee OA; for females 70% of OA is knee OA.[306] Prevalence rates calculated using 2015 population. Extrapolated prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Remission set to Exact.
Osteoarthritis of the knee	**Incidence:** No data inputted **Disease-specific mortality:** Inputted as 0 **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	GBD prevalence data does not differentiate between hip OA and knee OA. Split data based on Cross et al: for males 66% of OA is knee OA; for females 70% of OA is knee OA.[Error! Bookmark not defined.] Prevalence rates calculated using 2015 population. Extrapolated prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Remission set to Exact.
Low back pain	**Incident cases:** GBD Results Tool (2015)[260] **Disease-specific mortality:** Inputted as 0 **Prevalent cases:** GBD Results Tool (2015)[260] **Remission:** Inputted as 0	Incidence and prevalence rates calculated using 2015 population. Extrapolated incidence and prevalence rates from age 80+ to age 100+ using a polynomial trend line.	Incidence set to Ignore and remission set to Exact.

CANSIM, Canadian Socio-Economic Information Management System; CCDSS, Canadian Chronic Disease Surveillance System; GBD, Global Burden of Disease

APPENDIX C: TREND IN BMI

Appendix C, Table 1. Trend in BMI (Canadian ACE-BMI)[262]

Age	**Males** kg/m^2 per year	**Females** kg/m^2 per year
20-24	0.017	0.010
25-29	0.027	0.018
30-34	0.036	0.026
35-39	0.044	0.033
40-44	0.051	0.039
45-49	0.057	0.044
50-54	0.063	0.049
55-59	0.068	0.054
60-64	0.072	0.057
65-69	0.075	0.060
70-74	0.078	0.063
75-79	0.080	0.065
80+	0.082	0.066

ACE, Assessing Cost-Effectiveness; BMI, body mass index; kg, kilogram; m, metre
Source: Lau et al. 2013[262]

APPENDIX D: HEALTH CARE COSTS

Appendix D, Table 1. Data sources and analysis of health care costs inputs

Disease	Data Sources and Analysis	Direct Costs* CAD 2008	Disease Cases
Esophageal cancer	All costs were obtained from the Economic Burden of Illness in Canada 2008 study.[273] For esophageal cancer, the most suitable EBIC category was Esophagus Cancer (E06.2). In the current study's analysis, the ICD codes used to define esophageal cancer was C15. As part of calculating the cost per incident case (new case) of esophageal cancer, the number of new cases was obtained from CANSIM Table 103-0550 (ICD codes C15.0-C15.9) for the year 2008.[275]	$107,520,940	1,625
Colon and rectum cancer	All costs were obtained from the Economic Burden of Illness in Canada 2008 study.[273] For colon and rectum cancer, the most suitable EBIC category was Colorectal Cancer (E06.4), defined by ICD codes C18-C21, C26.0. As part of calculating the cost per incident case (new case) of colon and rectum cancer, the number of new cases was obtained from CANSIM Table 103-0550 (ICD codes C18.0-C18.9, C19.9, C20.9, C26.0) for the year 2008.[275]	$1,102,445,097	21,210
Liver cancer	All costs were obtained from the Economic Burden of Illness in Canada 2008 study.[273] To accommodate sub-optimal alignment between data sources, additional analytic steps were taken. For liver cancer, the most suitable EBIC category was Liver Cancer (E06.5), defined by ICD codes C22.0, C22.2-C22.7. As part of calculating the cost per incident case (new case) of liver cancer, the number of new cases was obtained from CANSIM Table 103-0550 (ICD codes C22.0) for the year 2008.[275] Since the incidence data included disease codes not used in the EBIC costs data (i.e., C22.1, C22.9), incidence data was reduced using sex-specific ratios obtained by comparing deaths from different types of liver cancer (source: CANSIM Table 102-0522;[301] this data is more detailed than incident case data).	$37,280,145	705
Gallbladder and biliary track cancer	All costs were obtained from the Economic Burden of Illness in Canada 2008 study.[273] Additional analytic steps were taken to address two issues: 1) there is no EBIC category specifically for gallbladder and biliary track cancer (this cancer type is reported in a heterogeneous category); 2) there is no CANSIM incidence data specifically for biliary track cancer (it is reported in a heterogeneous category). For the first issue, cost data was obtained by applying sex-specific ratios to the EBIC category Other Malignant Neoplasms (E06.26). The ratios were obtained by comparing deaths from different types of cancer (source: CANSIM Table 102-0522).[301] For the second issue, incidence data for biliary track cancer was estimating by apply a different sex-specific ratios to CANSIM incidence data for Other Digestive Disorders for the year 2008 (source: CANSIM Table 103-0550).[275] These ratios were obtained by comparing deaths from different digestive cancers (source: CANSIM Table 102-0522).[301] The analysis aimed to define the disease by ICD codes C23, C24.	$71,061,099	778

Disease	Data Sources and Analysis	Direct Costs* CAD 2008	Disease Cases
Pancreatic cancer	All costs were obtained from the Economic Burden of Illness in Canada 2008 study.[273] For pancreatic cancer, the most suitable EBIC category was Pancreas Cancer (E06.6), defined by ICD codes C25. As part of calculating the cost per incident case (new case) of pancreatic cancer, the number of new cases was obtained from CANSIM Table 103-0550 (ICD codes C25.0-25.9) for the year 2008.[275]	$169,383,333	3,950
Breast cancer	All costs were obtained from the Economic Burden of Illness in Canada 2008 study.[273] For breast cancer, the most suitable EBIC category was Breast Cancer (E06.12), defined by ICD codes C50. As part of calculating the cost per incident case (new case) of breast cancer, the number of new cases was obtained from CANSIM Table 103-0550 (ICD codes C50.0-C50.9) for the year 2008.[275]	$905,463,578	21,200
Uterine cancer	All costs were obtained from the Economic Burden of Illness in Canada 2008 study.[273] For uterine cancer, the most suitable EBIC category was Body of Uterus Cancer (E06.14), defined by ICD codes C54-C55. As part of calculating the cost per incident case (new case) of uterine cancer, the number of new cases was obtained from CANSIM Table 103-0550 (ICD codes C54.0-C54.9, C55.9) for the year 2008.[275]	$108,109,570	4,590
Ovarian cancer	All costs were obtained from the Economic Burden of Illness in Canada 2008 study.[273] For ovarian cancer, the most suitable EBIC category was Ovary Cancer (E06.4), defined by ICD codes C56. As part of calculating the cost per incident case (new case) of ovarian cancer, the number of new cases was obtained from CANSIM Table 103-0550 (ICD codes C56.9) for the year 2008.[275]	$115,780,221	2,465
Kidney cancer	All costs were obtained from the Economic Burden of Illness in Canada 2008 study.[273] For kidney cancer, the most suitable EBIC category was Kidney Cancer (E06.19), defined by ICD codes C65-C65. As part of calculating the cost per incident case (new case) of kidney cancer, the number of new cases was obtained from CANSIM Table 103-0550 (ICD codes C64.9, C65.9) for the year 2008.[275]	$134,074,106	4,780
Thyroid cancer	All costs were obtained from the Economic Burden of Illness in Canada 2008 study.[273] For thyroid cancer, the most suitable EBIC category was Thyroid Cancer (E06.21), defined by ICD codes C73. As part of calculating the cost per incident case (new case) of thyroid cancer, the number of new cases was obtained from CANSIM Table 103-0550 (ICD codes C73.9) for the year 2008.[275]	$85,096,594	4,560
Leukemia	All costs were obtained from the Economic Burden of Illness in Canada 2008 study.[273] For leukemia, the most suitable EBIC category was Leukemia (E06.25), defined by ICD codes C90.1, C91-C95. As part of calculating the cost per incident case (new case) of leukemia, the number of new cases was obtained from CANSIM Table 103-0550 for the year 2008.[275] New cases of leukemia were presented according to five types of leukemia. All were included – acute lymphocytic leukemia (M-9826, M-9835-	$341,146,202	4,775

Disease	Data Sources and Analysis	Direct Costs* CAD 2008	Disease Cases
	9836; C42.0, M-9811-9818, M-9837; C42.1, M-9811-9818, M-9837; C42.4, M-9811-9818, M-9837), chronic lymphocytic leukemia (C42.0, M-9823; C42.1, M-9823; C42.4, M-9823), acute myeloid leukemia (M-9840, M-9861, M-9865, M-9866, M-9867, M-9869, M-9871-M-9874, M-9895-M-9897, M-9898, M-9910, M-9911, M-9920), chronic myeloid leukemia (M-9863, M-9875, M-9876, M-9945, M-9946), other leukemia (M-9733, M-9742, M-9800, M-9801, M-9805, M-9806 to M-9809, M-9820, M-9831, M-9832 to M-9834, M-9860, M-9870, M-9891, M-9930, M-9931, M-9940, M-9948, M-9963, M-9964; C42.0, M-9827; C42.1, M-9827; C42.4, M-9827). M- refers to International Classification of Diseases for Oncology.		
Ischemic heart disease	All costs were obtained from the Economic Burden of Illness in Canada 2008 study.[273] For IHD, the most suitable EBIC categories were Myocardial Infarction (E12.1) and Other Ischemic Heart Diseases (E12.2), defined by ICD codes I20-I25. As part of calculating the cost per prevalent case of IHD, the number of prevalent cases was obtained from the Canadian Chronic Disease Surveillance System (ICD codes I20, I21, I22, I23, I24, I25) for the year 2008.[274]	$7,144,671,677	2,178,050
Stroke	All costs were obtained from the Economic Burden of Illness in Canada 2008 study.[273] Two issues arose. First, each relevant EBIC category for stroke contained a mix of ICD codes applicable to either type of stroke. As a result, it was not possible to separate cost data by type of stroke. For ischemic stroke and hemorrhagic stroke, the most suitable EBIC categories were Cerebral Infarction (E12.6), Subarachnoid Haemorrhage (E12.7), Acute but Ill-defined Stroke (E12.9), Other Cerebrovascular Disease (E12.10), collectively representing I60-I69. The second issue was that no Canadian source offered prevalence data that fit the disease code definition. To calculate the cost per prevalent case, we used prevalence data for Canada from the GBD Study (year 2010).[260] Using a ratio obtained by comparing GBD deaths and CANSIM deaths (CANSIM Table 102-0529),[302] GBD prevalence data was reduced to adjust for systematically higher estimations of prevalence. The number of cases was then decreased to adjust for population growth from 2008 to 2010. GBD uses ICD codes to define ischemic stroke (G45-G46.8, I63-I63.9, I65-I66.9, I67.2-I67.3, I67.5-I67.6, I69.3-I69.398) and hemorrhagic stroke (I60-I61.9, I62.0-I62.03, I67.0-I67.1, I68.1-I68.2, I69.0-I69.298).[260]	$2,391,456,171	131,913
Hypertensive heart disease	All costs were obtained from the Economic Burden of Illness in Canada 2008 study.[273] Several issues arose. There is no EBIC category specifically for HHD. Cost data was obtained by applying sex-specific ratios to the EBIC category Other Hypertensive Diseases. The ratios were obtained by comparing deaths from other hypertensive diseases (source: CANSIM Table 102-0529).[302] There was no Canadian source offering prevalence data that fit the necessary ICD codes. To calculate the cost per prevalent case, we used prevalence data for Canada from the Global Burden of Disease Study (year 2010).[260] Using a ratio obtained by comparing GBD deaths and CANSIM deaths (CANSIM Table 102-0529), GBD	$647,578,063	21,385

Disease	Data Sources and Analysis	Direct Costs* CAD 2008	Disease Cases
	prevalence data was reduced to adjust for systematically higher estimations of prevalence. The number of cases was then decreased to adjust for population growth from 2008 to 2010. GBD uses ICD codes to define HHD (I11-I11.9).[260] The current study's analysis aimed to adhere to this definition.		
Type 2 diabetes	All costs were obtained from the Economic Burden of Illness in Canada 2008 study.[273] An issue is that cost data and disease epidemiology data was presented by combining all types of disease. For type 2 diabetes, the most suitable EBIC category was Diabetes Mellitus (E08) defined by ICD codes E10-E14. To determine what costs were from type 2 diabetes, age/sex-specific ratios were applied. The ratios were obtained by comparing deaths from different types of diabetes (source: CANSIM Table 102-0529).[302] To obtain prevalence data for only type 2 diabetes, it was assumed that 10% of diabetes cases in persons less than 20 years of age were type 2 diabetes and 90% of diabetes cases in persons over 20 years of age were type 2 diabetes. Prevalence data was from the Canadian Chronic Disease Surveillance System, year 2008.[274]	$3,584,624,219	1,941,147
Chronic kidney disease	All costs were obtained from the Economic Burden of Illness in Canada 2008 study.[273] In the simulation, chronic kidney disease (CKD) is disaggregated into four types (CKD due to diabetes, CKD due to hypertension, CKD due to glomerulonephritis, CKD due to other causes). There is no EBIC cost data for each type of CKD. Accordingly, only one set of CKD costs could be calculated. For CKD, the most suitable EBIC category was Chronic Renal Failure (E15.2), defined by ICD codes N18. No Canadian source offered prevalence data that fit the disease code definition. To calculate the cost per prevalent case, we used prevalence data for Canada from the GBD Study (year 2010).[260] Using a ratio obtained by comparing GBD deaths and CANSIM deaths (CANSIM Table 102-0534),[303] GBD prevalence data was reduced to adjust for systematically higher estimations of prevalence. The number of cases was then decreased to adjust for population growth from 2008 to 2010.	$674,608,632	670,556
Osteoarthritis	All costs were obtained from the Economic Burden of Illness in Canada 2008 study.[273] In the simulation, osteoarthritis is disaggregated into two types (osteoarthritis of the hip and osteoarthritis of the knee). There is no EBIC cost data for each type of osteoarthritis. Accordingly, only one set of costs could be calculated. For osteoarthritis, the most suitable EBIC category was Osteoarthritis (E17.2), defined by ICD codes M15-M19. No Canadian source offered prevalence data that fit the disease code definition. To calculate the cost per prevalent case, we used prevalence data for Canada from the GBD Study (year 2010).[260] The number of cases was decreased to adjust for population growth from 2008 to 2010. GBD uses ICD codes to define osteoarthritis (M16-M16.7, M16.9, M17-M17.5, M17.9).[260]	$2,613,364,178	1,772,650

Disease	Data Sources and Analysis	Direct Costs* CAD 2008	Disease Cases
Low back pain	All costs were obtained from the Economic Burden of Illness in Canada 2008 study.[273] For low back pain, the most suitable EBIC category was Low Back Pain (E17.4), defined by ICD codes M45-M48, M54 (minus M54.2). No Canadian source offered prevalence data that fit the disease code definition. To calculate the cost per prevalent case, we used prevalence data for Canada from the GBD Study (year 2010).[260] The number of cases was decreased to adjust for population growth from 2008 to 2010. GBD uses ICD codes to define low back pain (G54.4, M47-M47.2, M47.8, M48-M48.5, M49.8, M51-M51.4, M51.8, M53.3, M53.8, M54-M54.1, M54.3-M54.5, M99-M99.8).[260]	$2,154,102,094	3,996,535

CAD, Canadian dollars; CANSIM, Canadian Socio-Economic Information Management System; CKD; chronic kidney disease; EBIC, Economic Burden of Illness in Canada; GBD, Global Burden of Disease; ICD, International Classification of Diseases

*Hospital care, physician care, drugs, other institutions, other professionals, capital, public health, administration, other health spending

Appendix D, Table 2. Health care costs inputs

Direct Costs (CAD 2015)

Sex	Age	Esophageal cancer	Colon & rectum cancer	Liver cancer	Gallbladder & biliary tract cancer	Pancreatic Cancer	Breast cancer	Uterine cancer	Ovarian cancer
		$/incident case	$/incident case	$/incident case	$/incident case	$/incident case	$/incident case	$/incident case	$/incident case
Male	<55	63,754	59,774	56,634	150,016	44,953			
	55–64	87,918	53,653	61,775	84,677	48,328			
	65–74	74,570	56,237	59,393	101,543	66,060			
	75+	59,595	63,757	42,221	60,082	39,147			
Female	<55	85,829	50,675	130,296	189,784	51,874	47,032	24,369	48,174
	55–64	115,665	53,092	61,495	162,926	53,575	66,321	23,859	65,690
	65–74	85,443	56,533	64,106	100,028	49,926	38,518	27,755	59,132
	75+	53,009	54,838	55,737	63,970	36,018	30,021	28,093	37,876

Sex	Age	Kidney cancer	Thyroid cancer	Leukemia	Ischemic heart disease	Ischemic stroke	Hemorrhagic stroke	Hypertensive heart disease	Type 2 diabetes
		$/incident case	$/incident case	$/incident case	$/prevalent case	$/prevalent case	$/prevalent case	$/prevalent case	$/prevalent case
Male	<55	28,278	20,068	149,341	4,706	13,106	13,106	34,675	3,191
	55–64	28,539	25,098	66,858	4,794	17,148	17,148	37,757	2,037
	65–74	34,637	23,232	43,909	4,577	18,933	18,933	46,984	1,954
	75+	29,055	34,401	28,204	3,382	29,453	29,453	23,601	1,661
Female	<55	29,004	18,511	184,406	2,501	10,627	10,627	59,030	2,080
	55–64	23,834	19,405	123,800	2,961	10,815	10,815	87,501	2,017
	65–74	38,468	23,479	52,874	3,153	15,517	15,517	46,967	2,049
	75+	33,141	26,127	30,098	2,436	29,214	29,214	14,382	1,388

Sex	Age	CKD due to diabetes	CKD due to hypertension	CKD due to glomerulonephr itis	CKD due to other causes	Osteoarthritis of the hip	Osteoarthritis of the knee	Low back pain	Direct costs for all other conditions
		$/prevalent case	$/prevalent case	$/prevalent case	$/prevalent case	$/prevalent case	$/prevalent case	$/prevalent case	$/person
Male	<55	1,668	1,668	1,668	1,668	1,010	1,010	682	2,762
	55–64	1,563	1,563	1,563	1,563	1,444	1,444	655	6,152
	65–74	1,338	1,338	1,338	1,338	1,900	1,900	579	10,369
	75+	1,785	1,785	1,785	1,785	2,020	2,020	709	17,320
Female	<55	973	973	973	973	1,137	1,137	532	3,871

55–64	589	589	589	589	1,483	1,483	415	6,354
65–74	724	724	724	724	1,900	1,900	471	8,986
75+	942	942	942	942	2,047	2,047	736	14,613

CAD, Canadian dollars; CKD, chronic kidney disease

APPENDIX E: ADDITIONAL RESULTS

SUGARY DRINK INTAKE

Appendix E, Table 1. Children's per capita average daily sugary drink consumption, males by age group

	MALES							
	1-3 yrs **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**4-8 yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**9-13 yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**14-18 yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)	
	n=343		n=538		n=552		n=595	
100% juice								
Volume, ml	102.6	(84.1, 121.2)	147.2	(126.6, 167.7)	117.1	(101.8, 132.4)	146.9	(124.1, 169.7)
Energy, kcal	47.0	(38.6, 55.5)	69.4	(59.6, 79.2)	54.8	(47.6, 62.0)	68.5	(57.6, 79.3)
Total sugar-sweetened beverages								
Volume, ml	79.5	(56.4, 102.5)	182.7	(156.1, 209.3)	259.8	(232.7, 287.0)	434.4	(372.9, 495.9)
Energy, kcal	44.6	(33.1, 56.0)	104.9	(89.0, 120.8)	133.9	(120.2, 147.6)	210.5	(178.3, 242.7)
Regular carbonated soft drinks								
Volume, ml	1.5	(0.4, 2.7)	28.5	(17.5, 39.6)	81.1	(59.0, 103.2)	160.9	(130.9, 190.9)
Energy, kcal	0.6	(0.1, 1.1)	11.8	(7.2, 16.3)	33.0	(24.2, 41.7)	65.4	(53.2, 77.6)
Regular fruit drinks								
Volume, ml	31.7	(11.5, 51.9)	51.9	(37.9, 65.8)	57.9	(45.2, 70.7)	74.0	(39.5, 108.5)
Energy, kcal	14.3	(5.2, 23.4)	24.6	(17.7, 31.4)	26.0	(20.2, 31.7)	33.3	(16.7, 49.9)
Sugar-sweetened milk								
Volume, ml	27.0	(18.1, 35.9)	46.2	(32.3, 60.0)	44.2	(33.7, 54.6)	59.3	(38.1, 80.5)
Energy, kcal	17.2	(11.5, 22.9)	34.7	(23.4, 45.9)	34.1	(25.6, 42.6)	42.1	(27.7, 56.5)
Tea pre-sweetened with sugar								
Volume, ml	3.220	(0.004, 6.436)	15.3	(2.0, 28.7)	28.9	(20.0, 37.9)	28.0	(18.2, 37.9)
Energy, kcal	1.115	(-0.017, 2.247)	5.0	(0.5, 9.5)	10.2	(7.1, 13.4)	10.0	(6.4, 13.5)
Smoothies								
Volume, ml	5.2	(1.3, 9.1)	13.3	(5.3, 21.3)	15.6	(9.6, 21.5)	13.6	(8.6, 18.6)
Energy, kcal	3.5	(0.8, 6.1)	7.1	(2.7, 11.4)	9.9	(6.2, 13.7)	8.4	(5.4, 11.4)
Coffee pre-sweetened with sugar								
Volume, ml	-	-	1.0	(-0.8, 2.8)	2.9	(0.2, 5.6)	16.0	(7.0, 25.1)

	MALES							
	1-3 yrs **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**4-8 yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**9-13 yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**14-18 yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)	
Energy, kcal	-	-	0.5	(-0.4, 1.4)	2.5	(0.3, 4.6)	10.4	(4.0, 16.8)
Regular sports drinks								
Volume, ml	0.9	(-0.8, 2.6)	1.8	(-0.9, 4.4)	7.5	(2.4, 12.7)	39.3	(23.0, 55.5)
Energy, kcal	0.2	(-0.2, 0.7)	0.5	(-0.2, 1.2)	2.1	(0.6, 3.5)	10.9	(6.4, 15.5)
Regular protein drinks								
Volume, ml	-	-	0.06	(-0.07, 0.20)	0.3	(-0.1, 0.7)	15.3	(5.2, 25.3)
Energy, kcal	-	-	0.05	(-0.06, 0.15)	0.3	(-0.1, 0.7)	14.0	(4.9, 23.1)
Hot chocolate pre-sweetened with sugar								
Volume, ml	0.3	(-0.3, 0.9)	8.6	(2.7, 14.5)	10.4	(5.2, 15.6)	9.0	(4.0, 14.0)
Energy, kcal	0.3	(-0.3, 0.8)	8.4	(2.4, 14.3)	8.7	(4.0, 13.4)	6.8	(3.0, 10.5)
Flavoured drinkable yogurt								
Volume, ml	7.9	(4.3, 11.5)	13.4	(7.9, 18.8)	6.6	(4.0, 9.1)	2.3	(0.5, 4.2)
Energy, kcal	5.9	(3.2, 8.5)	9.9	(5.9, 13.9)	4.9	(3.0, 6.8)	1.7	(0.4, 3.1)
Regular meal replacement beverages								
Volume, ml	1.4	(-0.1, 2.9)	2.68	(-0.05, 5.42)	1.7	(-0.5, 3.8)	1.6	(-1.0, 4.3)
Energy, kcal	1.4	(-0.1, 2.8)	2.53	(-0.06, 5.11)	1.6	(-0.5, 3.6)	1.5	(-1.0, 4.1)
Regular energy drinks								
Volume, ml	-	-	-	-	0.04	(-0.07, 0.15)	2.6	(0.3, 5.0)
Energy, kcal	-	-	-	-	0.02	(-0.03, 0.07)	1.2	(0.2, 2.3)
Regular flavoured water								
Volume, ml	0.3	(-0.4, 1.0)	-	-	2.2	(-2.2, 6.5)	8.9	(1.3, 16.5)
Energy, kcal	0.1	(-0.1, 0.2)	-	-	0.5	(-0.5, 1.5)	2.1	(0.3, 3.9)
Coffee sugar-sweetened at the table								
Volume, ml	-	-	-	-	-	-	0.08	(-0.10, 0.27)
Energy, kcal	-	-	-	-	-	-	0.02	(-0.03, 0.08)
Hot chocolate prepared from scratch								
Volume, ml	-	-	-	-	0.2	(-0.2, 0.6)	3.3	(-2.6, 9.2)
Energy, kcal	-	-	-	-	0.1	(-0.2, 0.4)	2.5	(-2.0, 7.0)
Tea sugar-sweetened at the table								

	MALES							
	1-3 yrs **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**4-8 yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**9-13 yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**14-18 yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)	
Volume, ml	-	-	-	-	0.24	(-0.28, 0.75)	-	-
Energy, kcal	-	-	-	-	0.04	(-0.04, 0.11)	-	-

Note: Negative values in 95% confidence intervals are a result of the bootstrap resampling method and not an indication of 'negative' consumption.
95% CI, 95% confidence intervals

Appendix E, Table 2. Children's per capita average daily sugary drink consumption, females by age group

	FEMALES							
	1-3 yrs **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**4-8 yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**9-13 yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**14-18 yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)	
	n=328		n=591		n=525		n=558	
100% juice								
Volume, ml	87.3	(70.9, 103.7)	122.7	(100.8, 144.6)	122.0	(100.8, 143.2)	79.8	(64.1, 95.5)
Energy, kcal	41.1	(33.4, 48.7)	58.3	(47.8, 68.8)	57.3	(47.2, 67.5)	36.8	(29.5, 44.0)
Total sugar-sweetened beverages								
Volume, ml	82.0	(62.1, 101.8)	137.0	(116.0, 158.0)	233.2	(205.8, 260.7)	270.0	(236.9, 303.1)
Energy, kcal	49.2	(36.1, 62.3)	76.7	(63.9, 89.5)	119.6	(105.4, 133.8)	138.0	(119.9, 156.0)
Regular carbonated soft drinks								
Volume, ml	4.0	(1.4, 6.6)	15.1	(8.3, 22.0)	52.5	(40.5, 64.4)	80.4	(64.5, 96.4)
Energy, kcal	1.5	(0.6, 2.5)	6.1	(3.4, 8.9)	21.6	(16.6, 26.7)	33.2	(26.6, 39.9)
Regular fruit drinks								
Volume, ml	22.3	(13.1, 31.5)	43.5	(32.0, 54.9)	70.8	(53.9, 87.7)	51.5	(35.6, 67.5)
Energy, kcal	10.0	(6.0, 13.9)	19.1	(14.0, 24.2)	31.6	(24.2, 39.0)	22.6	(15.5, 29.8)
Sugar-sweetened milk								
Volume, ml	25.2	(15.1, 35.2)	38.6	(26.1, 51.1)	43.3	(32.0, 54.5)	42.6	(31.4, 53.8)
Energy, kcal	15.9	(9.1, 22.7)	27.1	(18.5, 35.8)	31.8	(23.8, 39.9)	30.9	(22.5, 39.4)
Tea pre-sweetened with sugar								
Volume, ml	1.2	(-0.3, 2.7)	11.0	(4.5, 17.5)	21.3	(14.4, 28.3)	27.5	(19.2, 35.8)
Energy, kcal	0.4	(-0.1, 0.9)	3.8	(1.6, 6.1)	7.4	(5.0, 9.9)	9.7	(6.8, 12.7)
Smoothies								
Volume, ml	5.1	(1.8, 8.4)	9.2	(4.3, 14.1)	10.3	(5.9, 14.7)	16.3	(9.7, 22.8)
Energy, kcal	3.4	(1.2, 5.6)	6.1	(2.8, 9.5)	6.8	(3.8, 9.8)	10.3	(6.1, 14.6)
Coffee pre-sweetened with sugar								
Volume, ml	-	-	0.12	(-0.15, 0.40)	4.6	(-0.8, 10.1)	23.4	(14.8, 32.0)
Energy, kcal	-	-	0.03	(-0.04, 0.11)	3.0	(-0.4, 6.5)	14.4	(9.0, 19.8)
Regular sports drinks								
Volume, ml	1.8	(-1.2, 4.7)	1.0	(-0.3, 2.4)	9.5	(2.3, 16.8)	6.1	(1.1, 11.1)
Energy, kcal	0.5	(-0.3, 1.2)	0.3	(-0.1, 0.7)	2.5	(0.6, 4.4)	1.7	(0.3, 3.1)

	FEMALES							
	1-3 yrs Volume (ml) mean (95% CI) Energy (kcal) mean (95% CI)		**4-8 yrs** Volume (ml) mean (95% CI) Energy (kcal) mean (95% CI)		**9-13 yrs** Volume (ml) mean (95% CI) Energy (kcal) mean (95% CI)		**14-18 yrs** Volume (ml) mean (95% CI) Energy (kcal) mean (95% CI)	
Regular protein drinks								
Volume, ml	0.5	(-0.6, 1.6)	-	-	0.34	(-0.09, 0.77)	1.1	(-0.8, 3.0)
Energy, kcal	0.2	(-0.3, 0.7)	-	-	0.24	(-0.03, 0.51)	1.3	(-1.0, 3.5)
Hot chocolate pre-sweetened with sugar								
Volume, ml	0.1	(-0.1, 0.4)	5.5	(-0.5, 11.4)	12.0	(6.8, 17.1)	12.4	(6.2, 18.6)
Energy, kcal	0.1	(-0.1, 0.2)	4.3	(-1.1, 9.7)	8.8	(4.9, 12.8)	8.5	(4.3, 12.7)
Flavoured drinkable yogurt								
Volume, ml	17.3	(4.7, 29.8)	11.2	(6.7, 15.7)	6.2	(3.2, 9.1)	2.0	(0.2, 3.8)
Energy, kcal	12.8	(3.4, 22.2)	8.3	(4.9, 11.6)	4.5	(2.3, 6.7)	1.5	(0.1, 2.8)
Regular meal replacement beverages								
Volume, ml	4.5	(-0.6, 9.7)	1.3	(-1.1, 3.8)	0.8	(-0.7, 2.2)	3.1	(-0.3, 6.5)
Energy, kcal	4.5	(-0.6, 9.6)	1.4	(-1.0, 3.8)	0.7	(-0.7, 2.1)	2.9	(-0.3, 6.1)
Regular energy drinks								
Volume, ml	-	-	0.2	(-0.3, 0.7)	0.3	(-0.4, 1.0)	0.427	(-0.019, 0.872)
Energy, kcal	-	-	0.1	(-0.1, 0.3)	0.1	(-0.1, 0.3)	0.165	(-0.007, 0.338)
Regular flavoured water								
Volume, ml	0.020	(-0.022, 0.062)	0.15	(-0.15, 0.44)	1.413	(0.020, 2.807)	3.1	(-0.6, 6.8)
Energy, kcal	0.005	(-0.005, 0.015)	0.03	(-0.03, 0.10)	0.325	(0.005, 0.646)	0.7	(-0.1, 1.6)
Coffee sugar-sweetened at the table								
Volume, ml	-	-	-	-	-	-	-	-
Energy, kcal	-	-	-	-	-	-	-	-
Hot chocolate prepared from scratch								
Volume, ml	-	-	0.016	(-0.022, 0.054)	-	-	-	-
Energy, kcal	-	-	0.010	(-0.013, 0.032)	-	-	-	-
Tea sugar-sweetened at the table								
Volume, ml	-	-	-	-	-	-	-	-
Energy, kcal	-	-	-	-	-	-	-	-

Note: Negative values in 95% confidence intervals are a result of the bootstrap resampling method and not an indication of 'negative' consumption.
95% CI, 95% confidence intervals

Appendix E, Table 3. Adults' per capita average daily sugary drink consumption, males by age group

	MALES							
	19-30 yrs **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**31-50 yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**51-70 yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**71+ yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)	
Sample size	n=1,434		n=3,093		n=2,670		n=872	
100% juice								
Volume, ml	111.3	(78.1, 144.5)	70.2	(56.5, 83.8)	59.3	(49.8, 68.8)	75.3	(59.6, 91.1)
Energy, kcal	49.6	(34.2, 65.0)	31.4	(25.1, 37.6)	25.8	(21.7, 30.0)	33.0	(25.8, 40.1)
Total sugar-sweetened beverages								
Volume, ml	400.6	(321.4, 479.9)	267.1	(236.5, 297.7)	171.0	(149.1, 192.9)	123.8	(103.0, 144.7)
Energy, kcal	203.7	(162.0, 245.4)	127.8	(108.2, 147.4)	76.2	(66.2, 86.2)	55.7	(46.5, 65.0)
Regular carbonated soft drinks								
Volume, ml	135.4	(103.1, 167.7)	116.4	(94.5, 138.3)	79.3	(63.6, 95.0)	45.1	(31.3, 58.9)
Energy, kcal	56.5	(43.1, 70.0)	47.3	(38.4, 56.2)	32.3	(25.9, 38.6)	18.2	(12.7, 23.8)
Regular fruit drinks								
Volume, ml	41.2	(14.4, 68.1)	26.9	(13.0, 40.7)	18.8	(13.8, 23.7)	18.4	(13.2, 23.6)
Energy, kcal	18.9	(6.6, 31.1)	12.8	(6.2, 19.5)	8.8	(6.5, 11.1)	9.2	(6.7, 11.8)
Sugar-sweetened milk								
Volume, ml	37.6	(22.0, 53.2)	32.1	(16.7, 47.5)	19.8	(13.5, 26.1)	11.9	(6.9, 16.9)
Energy, kcal	27.6	(16.0, 39.2)	27.9	(9.8, 46.0)	12.7	(8.0, 17.4)	8.2	(4.6, 11.8)
Tea pre-sweetened with sugar								
Volume, ml	60.1	(10.5, 109.7)	22.3	(13.3, 31.4)	16.1	(9.3, 22.9)	7.3	(3.4, 11.2)
Energy, kcal	21.5	(3.6, 39.4)	7.8	(4.6, 10.9)	5.1	(3.1, 7.1)	2.3	(1.0, 3.5)
Smoothies								
Volume, ml	33.9	(13.4, 54.5)	19.9	(6.7, 33.2)	10.8	(5.0, 16.7)	4.2	(1.5, 6.9)
Energy, kcal	20.7	(7.2, 34.2)	12.4	(4.1, 20.7)	6.8	(2.9, 10.8)	2.7	(0.9, 4.6)
Coffee pre-sweetened with sugar								
Volume, ml	27.7	(11.2, 44.2)	20.6	(11.9, 29.2)	13.9	(8.3, 19.5)	15.1	(8.5, 21.6)
Energy, kcal	20.3	(6.6, 34.0)	6.4	(3.9, 8.8)	6.4	(3.9, 8.8)	3.3	(1.8, 4.9)
Regular sports drinks								
Volume, ml	23.6	(-5.5, 52.7)	9.8	(4.6, 15.1)	3.8	(1.6, 6.1)	10.8	(1.1, 20.4)
Energy, kcal	6.3	(-1.3, 13.9)	2.6	(1.2, 4.0)	1.0	(0.4, 1.6)	2.8	(0.3, 5.3)

	MALES							
	19-30 yrs **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**31-50 yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**51-70 yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**71+ yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)	
Regular protein drinks								
Volume, ml	23.0	(7.0, 39.0)	10.0	(4.2, 15.8)	1.7	(0.6, 2.9)	0.3	(-0.3, 0.9)
Energy, kcal	23.1	(1.7, 44.6)	5.8	(2.4, 9.2)	1.4	(0.5, 2.4)	0.2	(-0.2, 0.6)
Hot chocolate pre-sweetened with sugar								
Volume, ml	0.773	(-0.064, 1.610)	2.0	(0.8, 3.2)	2.4	(0.6, 4.2)	3.2	(0.2, 6.3)
Energy, kcal	0.546	(-0.006, 1.099)	1.4	(0.4, 2.4)	2.1	(0.4, 3.9)	2.0	(0.2, 3.8)
Flavoured drinkable yogurt								
Volume, ml	1.7	(-0.8, 4.3)	0.42	(0.01, 0.83)	0.7	(-0.4, 1.8)	2.3	(-0.2, 4.7)
Energy, kcal	1.3	(-0.6, 3.2)	0.31	(0.01, 0.62)	0.5	(-0.3, 1.3)	1.7	(-0.1, 3.5)
Regular meal replacement beverages								
Volume, ml	0.7	(-0.4, 1.9)	1.2	(0.2, 2.3)	1.9	(0.4, 3.3)	4.6	(1.7, 7.5)
Energy, kcal	0.7	(-0.4, 1.8)	1.2	(0.2, 2.1)	1.9	(0.4, 3.4)	4.6	(1.8, 7.5)
Regular energy drinks								
Volume, ml	12.0	(3.4, 20.7)	2.1	(0.5, 3.7)	0.12	(-0.06, 0.30)	0.04	(-0.03, 0.12)
Energy, kcal	5.6	(1.6, 9.7)	1.0	(0.3, 1.7)	0.05	(-0.03, 0.13)	0.02	(-0.01, 0.05)
Regular flavoured water								
Volume, ml	2.8	(-0.7, 6.2)	2.6	(-0.8, 5.9)	1.0	(-0.5, 2.5)	-	-
Energy, kcal	0.6	(-0.2, 1.4)	0.6	(-0.2, 1.4)	0.2	(-0.1, 0.6)	-	-
Coffee sugar-sweetened at the table								
Volume, ml	-	-	0.7	(-0.1, 1.5)	0.4	(-0.1, 1.0)	0.5	(-0.5, 1.5)
Energy, kcal	-	-	0.3	(-0.1, 0.7)	0.1	(-0.1, 0.3)	0.2	(-0.3, 0.7)
Hot chocolate prepared from scratch								
Volume, ml	-	-	0.1	(-0.1, 0.3)	0.14	(-0.18, 0.45)	0.19	(-0.06, 0.44)
Energy, kcal	-	-	0.1	(-0.1, 0.4)	0.04	(-0.05, 0.12)	0.14	(-0.05, 0.33)
Tea sugar-sweetened at the table								
Volume, ml	-	-	-	-	-	-	-	-
Energy, kcal	-	-	-	-	-	-	-	-

Note: Negative values in 95% confidence intervals are a result of the bootstrap resampling method and not an indication of 'negative' consumption.
95% CI, 95% confidence intervals

Appendix E, Table 4. Adults' per capita average daily sugary drink consumption, females by age group

	FEMALES							
	19-30 yrs **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**31-50 yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**51-70 yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**71+ yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)	
	n=1,188		n=3,058		n=2,732		n=1,100	
100% juice								
Volume, ml	67.2	(48.4, 86.0)	50.7	(41.5, 60.0)	40.2	(33.3, 47.0)	70.7	(58.4, 83.0)
Energy, kcal	32.1	(22.9, 41.3)	22.7	(18.6, 26.9)	17.7	(14.5, 20.9)	32.1	(26.2, 38.0)
Total sugar-sweetened beverages								
Volume, ml	238.3	(193.4, 283.2)	161.1	(141.7, 180.6)	125.7	(105.9, 145.5)	104.7	(87.7, 121.7)
Energy, kcal	119.7	(95.3, 144.1)	74.1	(65.1, 83.0)	59.2	(48.5, 69.8)	45.3	(37.8, 52.8)
Regular carbonated soft drinks								
Volume, ml	70.9	(50.3, 91.5)	46.8	(35.7, 57.9)	43.5	(29.6, 57.4)	26.3	(17.6, 34.9)
Energy, kcal	28.8	(20.4, 37.2)	18.6	(14.4, 22.8)	17.6	(11.9, 23.3)	10.4	(7.0, 13.8)
Regular fruit drinks								
Volume, ml	26.4	(15.3, 37.4)	23.2	(16.3, 30.0)	15.7	(10.1, 21.3)	24.9	(17.2, 32.7)
Energy, kcal	12.5	(7.0, 17.9)	10.6	(7.6, 13.7)	7.6	(4.8, 10.4)	12.3	(8.4, 16.2)
Sugar-sweetened milk								
Volume, ml	19.2	(9.7, 28.8)	15.1	(10.1, 20.2)	17.7	(12.1, 23.3)	13.1	(7.6, 18.5)
Energy, kcal	11.9	(5.3, 18.5)	9.1	(5.4, 12.8)	12.3	(6.6, 18.1)	6.8	6.8 (4.2, 9.5)
Tea pre-sweetened with sugar								
Volume, ml	33.7	(10.6, 56.8)	18.0	(12.7, 23.3)	8.6	(5.0, 12.1)	10.6	(6.0, 15.2)
Energy, kcal	10.8	(2.9, 18.8)	6.2	(4.4, 8.0)	2.6	(1.5, 3.7)	3.5	(2.0, 5.0)
Smoothies								
Volume, ml	27.7	(11.8, 43.6)	23.3	(13.9, 32.7)	12.9	(8.9, 17.0)	4.3	(1.8, 6.8)
Energy, kcal	16.0	(6.3, 25.7)	13.8	(8.4, 19.3)	8.4	(5.3, 11.4)	2.5	(1.0, 3.9)
Coffee pre-sweetened with sugar								
Volume, ml	19.4	(10.5, 28.3)	17.0	(10.0, 24.0)	17.3	(7.3, 27.4)	16.5	(9.0, 24.0)
Energy, kcal	12.6	(6.2, 19.0)	5.3	(3.1, 7.5)	4.4	(1.4, 7.3)	3.2	(1.7, 4.6)
Regular sports drinks								
Volume, ml	5.37	(0.08, 10.66)	3.2	(-1.4, 7.7)	0.24	(-0.10, 0.58)	1.4	(-0.2, 3.0)
Energy, kcal	1.40	(0.02, 2.77)	0.8	(-0.4, 2.0)	0.06	(-0.02, 0.15)	0.4	(-0.1, 0.8)

	FEMALES							
	19-30 yrs **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**31-50 yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**51-70 yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)		**71+ yrs** **Volume** (ml) mean (95% CI) **Energy** (kcal) mean (95% CI)	
Regular protein drinks								
Volume, ml	4.9	(0.5, 9.2)	6.1	(3.4, 8.8)	4.5	(2.2, 6.8)	1.3	(-0.8, 3.4)
Energy, kcal	2.9	(0.4, 5.5)	4.2	(2.5, 6.0)	2.8	(1.3, 4.3)	0.8	(-0.4, 2.0)
Hot chocolate pre-sweetened with sugar								
Volume, ml	18.3	(2.8, 33.9)	1.7	(0.8, 2.6)	1.9	(0.4, 3.5)	2.9	(0.8, 5.0)
Energy, kcal	16.9	(1.9, 31.9)	1.5	(0.4, 2.6)	1.4	(0.1, 2.6)	2.3	(0.5, 4.2)
Flavoured drinkable yogurt								
Volume, ml	1.0	(-0.4, 2.5)	1.9	(0.6, 3.3)	0.6	(0.1, 1.2)	0.4	(-0.1, 0.9)
Energy, kcal	0.7	(-0.2, 1.6)	1.3	(0.4, 2.2)	0.5	(0.1, 0.9)	0.3	(-0.1, 0.6)
Regular meal replacement beverages								
Volume, ml	2.3	(-0.5, 5.0)	1.1	(0.2, 2.0)	1.2	(0.3, 2.2)	2.6	(1.0, 4.2)
Energy, kcal	2.1	(-0.4, 4.7)	1.1	(0.1, 2.1)	1.2	(0.3, 2.0)	2.7	(1.0, 4.3)
Regular energy drinks								
Volume, ml	5.7	(-0.1, 11.5)	0.60	(0.05, 1.15)	-	-	-	-
Energy, kcal	2.3	(0.1, 4.5)	0.23	(0.01, 0.45)	-	-	-	-
Regular flavoured water								
Volume, ml	3.3	(-1.3, 7.9)	1.26	(-0.09, 2.61)	0.912	(-0.023, 1.847)	0.07	(-0.07, 0.20)
Energy, kcal	0.8	(-0.3, 1.8)	0.29	(-0.02, 0.61)	0.210	(-0.005, 0.425)	0.02	(-0.02, 0.05)
Coffee sugar-sweetened at the table								
Volume, ml	0.10	(-0.11, 0.31)	1.79	(-0.05, 3.62)	0.4	(-0.2, 1.0)	0.1	(-0.1, 0.4)
Energy, kcal	0.03	(-0.04, 0.10)	0.82	(-0.05, 1.70)	0.1	(-0.1, 0.3)	0.1	(-0.1, 0.2)
Hot chocolate prepared from scratch								
Volume, ml	-	-	0.08	(-0.05, 0.20)	0.09	(-0.05, 0.23)	0.2	(-0.1, 0.5)
Energy, kcal	-	-	0.06	(-0.04, 0.17)	0.06	(-0.04, 0.17)	0.1	(-0.1, 0.3)
Tea sugar-sweetened at the table								
Volume, ml	-	-	-	-	-	-	-	-
Energy, kcal	-	-	-	-	-	-	-	-

Note: Negative values in 95% confidence intervals are a result of the bootstrap resampling method and not an indication of 'negative' consumption.
95% CI, 95% confidence intervals

Appendix E, Table 5. Pairwise comparisons of socio-economic variables for per capita average daily 100% juice consumption

	100% JUICE					
	Volume, ml			**Energy**, kcal		
	Estimate	95% CI	P value	Estimate	95% CI	P value
Sex	$F_{(1,20176)}$=28.11 (P<0.001)			$F_{(1,20176)}$=24.12 (P<0.001)		
Female vs male	-23.1	(-31.7, -14.6)	<.0001	-9.9	(-13.9, -5.9)	<.0001
Age (years)	$F_{(7,20176)}$=30.57 (P<0.001)			$F_{(7,20176)}$=34.38 (P<0.001)		
4-8 vs 1-3	39.2	(19.8, 58.6)	<.0001	19.5	(10.4, 28.5)	<.0001
9-13 vs 1-3	24.3	(7.3, 41.3)	0.0052	11.9	(4.0, 19.8)	0.0033
14-18 vs 1-3	19.3	(1.6, 36.9)	0.0323	9.0	(0.8, 17.2)	0.0325
19-30 vs 1-3	-3.8	(-28.1, 20.4)	0.7570	-2.5	(-13.9, 9.0)	0.6715
31-50 vs 1-3	-34.6	(-49.4, -19.8)	<.0001	-17.0	(-23.9, -10.2)	<.0001
51-70 vs 1-3	-45.5	(-59.9, -31.1)	<.0001	-22.4	(-29.0, -15.8)	<.0001
71+ vs 1-3	-22.4	(-38.1, -6.6)	0.0054	-11.6	(-18.8, -4.4)	0.0016
9-13 vs 4-8	-14.9	(-34.4, 4.7)	0.1354	-7.6	(-16.9, 1.7)	0.1102
14-18 vs 4-8	-19.9	(-39.5, -0.3)	0.0461	-10.5	(-19.9, -1.1)	0.0291
19-30 vs 4-8	-43.0	(-68.9, -17.1)	0.0012	-21.9	(-34.1, -9.8)	0.0004
31-50 vs 4-8	-73.9	(-91.2, -56.5)	<.0001	-36.5	(-44.6, -28.4)	<.0001
51-70 vs 4-8	-84.8	(-100.8, -68.7)	<.0001	-41.9	(-49.5, -34.3)	<.0001
71+ vs 4-8	-61.6	(-79, -44.2)	<.0001	-31.1	(-39.4, -22.8)	<.0001
14-18 vs 9-13	-5.0	(-22.3, 12.2)	0.5658	-2.9	(-11.0, 5.2)	0.4834
19-30 vs 9-13	-28.1	(-51.2, -5.1)	0.0169	-14.4	(-25.1, -3.6)	0.0090
31-50 vs 9-13	-59.0	(-73.7, -44.2)	<.0001	-28.9	(-35.8, -22.1)	<.0001
51-70 vs 9-13	-69.9	(-83.7, -56.0)	<.0001	-34.3	(-40.8, -27.8)	<.0001
71+ vs 9-13	-46.7	(-62.8, -30.7)	<.0001	-23.5	(-31.0, -16.0)	<.0001
19-30 vs 14-18	-23.1	(-47.8, 1.5)	0.0659	-11.5	(-23, 0.1)	0.0524
31-50 vs 14-18	-53.9	(-69.8, -38.1)	<.0001	-26.0	(-33.5, -18.6)	<.0001
51-70 vs 14-18	-64.8	(-79.5, -50.1)	<.0001	-31.4	(-38.2, -24.6)	<.0001
71+ vs 14-18	-41.7	(-58.4, -25.0)	<.0001	-20.6	(-28.4, -12.9)	<.0001
31-50 vs 19-30	-30.8	(-52.6, -9.0)	0.0056	-14.6	(-24.8, -4.4)	0.0052
51-70 vs 19-30	-41.7	(-63.3, -20.1)	0.0002	-20.0	(-30.0, -9.9)	0.0001
71+ vs 19-30	-18.6	(-41.9, 4.8)	0.1185	-9.2	(-20.1, 1.8)	0.1000
51-70 vs 31-50	-10.9	(-20.7, -1.1)	0.0298	-5.4	(-9.9, -0.9)	0.0187
71+ vs 31-50	12.2	(-0.8, 25.2)	0.0651	5.4	(-0.5, 11.4)	0.0749

	100% JUICE					
	Volume, ml			**Energy**, kcal		
	Estimate	95% CI	P value	Estimate	95% CI	P value
71+ vs 51-70	**23.1**	**(12.0, 34.3)**	**<.0001**	**10.8**	**(5.7, 15.9)**	**<.0001**
Ethnicity	$F_{(5,20176)}$=3.36 (P=0.0054)			$F_{(5,20176)}$=2.92 (P=0.0132)		
Chinese only vs White only	**-22.9**	**(-38.2, -7.6)**	**0.0034**	**-9.4**	**(-16.5, -2.2)**	**0.0102**
South Asian only vs White only	-10.2	(-25.8, 5.4)	0.2010	-2.8	(-10.3, 4.6)	0.4563
Black only vs White only	23.3	(-2.5, 49.2)	0.0771	**12.7**	**(0.1, 25.3)**	**0.0474**
Indigenous inclusive vs White only	5.1	(-21.8, 32)	0.7105	3.6	(-9.5, 16.6)	0.5912
Mixed/other/not stated/missing vs White only	5.3	(-8.3, 19)	0.4431	3.3	(-2.9, 9.6)	0.2934
South Asian only vs Chinese only	12.7	(-9, 34.5)	0.2491	6.5	(-3.8, 16.8)	0.2131
Black only vs Chinese only	**46.3**	**(17, 75.5)**	**0.0020**	**22.1**	**(7.9, 36.3)**	**0.0023**
Indigenous inclusive vs Chinese only	28.0	(-1.9, 57.9)	0.0659	12.9	(-1.4, 27.3)	0.0763
Mixed/other/not stated/missing vs Chinese only	**28.3**	**(8.4, 48.1)**	**0.0053**	**12.7**	**(3.6, 21.9)**	**0.0065**
Black only vs South Asian only	**33.5**	**(5.2, 61.8)**	**0.0203**	**15.5**	**(1.8, 29.3)**	**0.0270**
Indigenous inclusive vs South Asian only	15.3	(-15.2, 45.8)	0.3255	6.4	(-8.4, 21.2)	0.3946
Mixed/other/not stated/missing vs South Asian only	15.5	(-2.5, 33.6)	0.0915	6.2	(-2.4, 14.8)	0.1572
Indigenous inclusive vs Black only	-18.2	(-55.7, 19.2)	0.3397	-9.1	(-27.3, 9.0)	0.3237
Mixed/other/not stated/missing vs Black only	-18.0	(-46.5, 10.6)	0.2168	-9.4	(-23.1, 4.4)	0.1805
Mixed/other/not stated/missing vs Indigenous inclusive	0.2	(-29.3, 29.8)	0.9870	-0.2	(-14.3, 13.9)	0.9761
Province	$F_{(9,20176)}$=8.13 (P<0.001)			$F_{(9,20176)}$=7.51 (P<0.001)		
Prince Edward Island vs Newfoundland and Labrador	7.2	(-16.8, 31.1)	0.5568	2.9	(-8.3, 14.2)	0.6066
Nova Scotia vs Newfoundland and Labrador	-5.3	(-22.7, 12.2)	0.5532	-3.2	(-11.4, 5.0)	0.4400
New Brunswick vs Newfoundland and Labrador	-1.6	(-18.9, 15.7)	0.8536	-1.6	(-9.7, 6.5)	0.6976
Quebec vs Newfoundland and Labrador	**48.4**	**(29.5, 67.3)**	**<.0001**	**20.4**	**(11.3, 29.4)**	**<.0001**
Ontario vs Newfoundland and Labrador	-4.4	(-18.8, 10.0)	0.5499	-2.8	(-9.7, 4.2)	0.4345
Manitoba vs Newfoundland and Labrador	-7.0	(-25.3, 11.3)	0.4539	-3.9	(-12.3, 4.5)	0.3634
Saskatchewan vs Newfoundland and Labrador	-7.0	(-25.0, 11.0)	0.4477	-3.5	(-12.1, 5.2)	0.4309
Alberta vs Newfoundland and Labrador	-13.6	(-29.6, 2.4)	0.0961	-7.5	(-14.989, 0.004)	0.0501
British Columbia vs Newfoundland and Labrador	-12.2	(-28.5, 4.1)	0.1430	-7.0	(-14.8, 0.8)	0.0787
Nova Scotia vs Prince Edward Island	-12.4	(-35.3, 10.4)	0.2860	-6.2	(-16.8, 4.5)	0.2557
New Brunswick vs Prince Edward Island	-8.8	(-31.8, 14.2)	0.4532	-4.5	(-15.2, 6.1)	0.4022
Quebec vs Prince Edward Island	**41.2**	**(17.5, 64.9)**	**0.0007**	**17.4**	**(6.5, 28.4)**	**0.0019**
Ontario vs Prince Edward Island	-11.6	(-32.5, 9.4)	0.2793	-5.7	(-15.5, 4.1)	0.2523

	100% JUICE					
	Volume, ml			**Energy**, kcal		
	Estimate	95% CI	P value	Estimate	95% CI	P value
Manitoba vs Prince Edward Island	-14.1	(-36.7, 8.4)	0.2179	-6.8	(-17.2, 3.6)	0.1965
Saskatchewan vs Prince Edward Island	-14.1	(-36.8, 8.5)	0.2208	-6.4	(-17.0, 4.2)	0.2337
Alberta vs Prince Edward Island	-20.8	(-42.8, 1.3)	0.0645	**-10.4**	**(-20.7, -0.2)**	**0.0452**
British Columbia vs Prince Edward Island	-19.4	(-39.8, 1.1)	0.0639	**-9.9**	**(-19.5, -0.4)**	**0.0419**
New Brunswick vs Nova Scotia	3.6	(-12.8, 20.1)	0.6649	1.6	(-5.9, 9.2)	0.6726
Quebec vs Nova Scotia	**53.6**	**(37.0, 70.2)**	**<.0001**	**23.6**	**(15.8, 31.4)**	**<.0001**
Ontario vs Nova Scotia	0.9	(-12.1, 13.8)	0.8958	0.5	(-5.6, 6.5)	0.8828
Manitoba vs Nova Scotia	-1.7	(-19.1, 15.7)	0.8460	-0.7	(-8.5, 7.1)	0.8656
Saskatchewan vs Nova Scotia	-1.7	(-17.9, 14.5)	0.8364	-0.3	(-7.9, 7.4)	0.9479
Alberta vs Nova Scotia	-8.3	(-22.0, 5.3)	0.2295	-4.3	(-10.4, 1.9)	0.1740
British Columbia vs Nova Scotia	-6.9	(-22.0, 8.1)	0.3648	-3.8	(-10.8, 3.2)	0.2901
Quebec vs New Brunswick	**50.0**	**(31.1, 68.9)**	**<.0001**	**22.0**	**(13.2, 30.8)**	**<.0001**
Ontario vs New Brunswick	-2.8	(-15.9, 10.4)	0.6793	-1.2	(-7.2, 4.9)	0.7033
Manitoba vs New Brunswick	-5.4	(-22.9, 12.2)	0.5491	-2.3	(-10.1, 5.5)	0.5653
Saskatchewan vs New Brunswick	-5.3	(-22.2, 11.5)	0.5337	-1.9	(-9.7, 6.0)	0.6397
Alberta vs New Brunswick	-12.0	(-26.7, 2.8)	0.1115	-5.9	(-12.5, 0.7)	0.0807
British Columbia vs New Brunswick	-10.6	(-25.1, 4.0)	0.1536	-5.4	(-12.1, 1.3)	0.1146
Ontario vs Quebec	**-52.8**	**(-68.0, -37.5)**	**<.0001**	**-23.1**	**(-30.3, -16.0)**	**<.0001**
Manitoba vs Quebec	**-55.3**	**(-73.2, -37.5)**	**<.0001**	**-24.3**	**(-32.4, -16.1)**	**<.0001**
Saskatchewan vs Quebec	**-55.3**	**(-73.1, -37.6)**	**<.0001**	**-23.9**	**(-32.2, -15.5)**	**<.0001**
Alberta vs Quebec	**-62.0**	**(-78.0, -45.9)**	**<.0001**	**-27.9**	**(-35.4, -20.4)**	**<.0001**
British Columbia vs Quebec	**-60.6**	**(-76.9, -44.2)**	**<.0001**	**-27.4**	**(-35.0, -19.7)**	**<.0001**
Manitoba vs Ontario	-2.6	(-16.1, 10.9)	0.7071	-1.1	(-7.1, 4.9)	0.7129
Saskatchewan vs Ontario	-2.6	(-16.2, 11.1)	0.7112	-0.7	(-7.2, 5.8)	0.8308
Alberta vs Ontario	-9.2	(-20.8, 2.4)	0.1191	-4.7	(-10.0, 0.6)	0.0807
British Columbia vs Ontario	-7.8	(-18.7, 3.1)	0.1616	-4.2	(-9.4, 0.9)	0.1087
Saskatchewan vs Manitoba	0.01	(-16.9, 17.0)	0.9988	0.4	(-7.4, 8.2)	0.9157
Alberta vs Manitoba	-6.6	(-21.8, 8.6)	0.3935	-3.6	(-10.3, 3.1)	0.2934
British Columbia vs Manitoba	-5.2	(-20.7, 10.3)	0.5080	-3.1	(-10.0, 3.8)	0.3800
Alberta vs Saskatchewan	-6.6	(-21.9, 8.7)	0.3951	-4.0	(-11.1, 3.1)	0.2674
British Columbia vs Saskatchewan	-5.2	(-20.6, 10.2)	0.5051	-3.5	(-10.8, 3.8)	0.3433

	100% JUICE					
	Volume, ml			**Energy**, kcal		
	Estimate	95% CI	P value	Estimate	95% CI	P value
British Columbia vs Alberta	1.4	(-11.9, 14.7)	0.8361	0.5	(-5.6, 6.6)	0.8715
BMI category	$F_{(3,20176)}$=10.51 (P<0.001)			$F_{(3,20176)}$=10.64 (P<0.001)		
Overweight vs Underweight/normal	**-25.3**	**(-37.1, -13.6)**	**<.0001**	**-11.0**	**(-16.7, -5.4)**	**0.0001**
Obese vs Underweight/normal	**-31.3**	**(-43.7, -19.0)**	**<.0001**	**-14.8**	**(-20.3, -9.3)**	**<.0001**
DK/Refusal/NS vs Underweight/normal	**-24.2**	**(-35.2, -13.2)**	**<.0001**	**-10.6**	**(-15.7, -5.6)**	**<.0001**
Obese vs Overweight	-6.0	(-18.4, 6.4)	0.3426	-3.8	(-9.5, 2.0)	0.2012
DK/Refusal/NS vs Overweight	1.1	(-10.2, 12.4)	0.8482	0.4	(-5.0, 5.8)	0.8892
DK/Refusal/NS vs Obese	7.1	(-4.6, 18.8)	0.2339	4.1	(-1.2, 9.5)	0.1275

Separate ANOVA analyses with F-Wald test of 100% juice volume and energy by each socio-economic variable (sex, age, ethnicity, province, and BMI category), followed by Student t-test for pairwise comparisons. The estimate represents the difference two variable categories. For example, compared to male Canadians, a female Canadian consumes an average of 23.1 ml less 100% juice per day. 100% juice volume and energy did not differ by income quintile; accordingly, no contrasts are reported.
Values in bold font represent findings significant at P<0.01 level.
95% CI, 95% confidence intervals; BMI, body-mass index; DK, don't know; NS, not stated

Appendix E, Table 6. Pairwise comparisons of socio-economic variables for per capita average daily total SSB consumption

	TOTAL SSBs					
	Volume, ml			**Energy**, kcal		
	Estimate	95% CI	P value	Estimate	95% CI	P value
Sex	$F_{(1,20176)}$=74.45 (P<0.001)			$F_{(1,20176)}$=65.94 (P<0.001)		
Female vs male	-86.6	(-106.3, -66.9)	<.0001	-42.3	(-52.6, -32.1)	<.0001
Age (years)	$F_{(7,20176)}$=58.53 (P<0.001)			$F_{(7,20176)}$=57.70 (P<0.001)		
4-8 vs 1-3	78.1	(55.3, 101.0)	<.0001	43.3	(29.9, 56.7)	<.0001
9-13 vs 1-3	166.2	(141.9, 190.5)	<.0001	80.1	(67.0, 93.2)	<.0001
14-18 vs 1-3	274.1	(235.4, 312.8)	<.0001	128.5	(108.0, 149.1)	<.0001
19-30 vs 1-3	246.4	(194.1, 298.7)	<.0001	118.8	(90.9, 146.7)	<.0001
31-50 vs 1-3	133.7	(110.1, 157.3)	<.0001	54.2	(40.6, 67.9)	<.0001
51-70 vs 1-3	67.4	(47.4, 87.4)	<.0001	20.7	(9.9, 31.6)	0.0002
71+ vs 1-3	32.4	(13.2, 51.7)	0.001	3.1	(-6.7, 12.8)	0.5342
9-13 vs 4-8	88.1	(61.0, 115.2)	<.0001	36.8	(22.0, 51.6)	<.0001
14-18 vs 4-8	196.0	(158.5, 233.5)	<.0001	85.2	(64.5, 105.9)	<.0001
19-30 vs 4-8	168.3	(115.0, 221.5)	<.0001	75.5	(46.8, 104.1)	<.0001
31-50 vs 4-8	55.6	(30.7, 80.5)	<.0001	10.9	(-4.3, 26.1)	0.1591
51-70 vs 4-8	-10.7	(-34.0, 12.6)	0.3667	-22.6	(-35.8, -9.4)	0.0008
71+ vs 4-8	-45.7	(-66.6, -24.7)	<.0001	-40.2	(-52.0, -28.5)	<.0001
14-18 vs 9-13	107.9	(68.4, 147.4)	<.0001	48.5	(27.3, 69.6)	<.0001
19-30 vs 9-13	80.2	(27.2, 133.2)	0.0031	38.7	(10.3, 67.1)	0.0077
31-50 vs 9-13	-32.5	(-59.0, -5.9)	0.0167	-25.8	(-40.5, -11.2)	0.0006
51-70 vs 9-13	-98.8	(-123.5, -74.1)	<.0001	-59.3	(-72.0, -46.7)	<.0001
71+ vs 9-13	-133.7	(-157.5, -109.9)	<.0001	-77.0	(-88.8, -65.2)	<.0001
19-30 vs 14-18	-27.7	(-90.4, 35.0)	0.3856	-9.8	(-43.6, 24.1)	0.5712
31-50 vs 14-18	-140.4	(-177.5, -103.3)	<.0001	-74.3	(-94.1, -54.5)	<.0001
51-70 vs 14-18	-206.7	(-244.2, -169.2)	<.0001	-107.8	(-127.7, -87.9)	<.0001
71+ vs 14-18	-241.6	(-278.1, -205.2)	<.0001	-125.5	(-144.7, -106.3)	<.0001
31-50 vs 19-30	-112.7	(-166.3, -59.0)	<.0001	-64.5	(-94.6, -34.5)	<.0001
51-70 vs 19-30	-179.0	(-229.8, -128.2)	<.0001	-98.0	(-125.8, -70.3)	<.0001
71+ vs 19-30	-213.9	(-265.0, -162.9)	<.0001	-115.7	(-142.9, -88.5)	<.0001
51-70 vs 31-50	-66.3	(-90.0, -42.7)	<.0001	-33.5	(-46.2, -20.8)	<.0001
71+ vs 31-50	-101.3	(-124.4, -78.1)	<.0001	-51.2	(-63.5, -38.8)	<.0001

	TOTAL SSBs					
	Volume, ml			**Energy**, kcal		
	Estimate	95% CI	P value	Estimate	95% CI	P value
71+ vs 51-70	**-35.0**	**(-54.9, -15.1)**	**0.0006**	**-17.7**	**(-27.1, -8.2)**	**0.0003**
Ethnicity	$F_{(5,20176)}$=10.57 (P<0.001)			$F_{(5,20176)}$=13.15 (P<0.001)		
Chinese only vs White only	**-87.5**	**(-116.3, -58.7)**	**<.0001**	**-44.5**	**(-57.6, -31.4)**	**<.0001**
South Asian only vs White only	-6.5	(-48.9, 35.9)	0.7640	5.8	(-20.6, 32.3)	0.6665
Black only vs White only	17.8	(-23.3, 58.9)	0.3951	9.3	(-13.2, 31.8)	0.4175
Indigenous inclusive vs White only	**99.6**	**(37.4, 161.7)**	**0.0018**	**43.9**	**(14.7, 73.2)**	**0.0033**
Mixed/other/not stated/missing vs White only	2.9	(-29.1, 35.0)	0.8571	8.8	(-17.6, 35.2)	0.5122
South Asian only vs Chinese only	**81.0**	**(33.0, 129.0)**	**0.0010**	**50.3**	**(23.4, 77.3)**	**0.0003**
Black only vs Chinese only	**105.3**	**(57.6, 152.9)**	**<.0001**	**53.8**	**(29.9, 77.8)**	**<.0001**
Indigenous inclusive vs Chinese only	**187.1**	**(120.9, 253.2)**	**<.0001**	**88.5**	**(57.6, 119.4)**	**<.0001**
Mixed/other/not stated/missing vs Chinese only	**90.4**	**(50.6, 130.2)**	**<.0001**	**53.3**	**(25.4, 81.3)**	**0.0002**
Black only vs South Asian only	24.3	(-30.9, 79.4)	0.3877	3.5	(-29.0, 36.0)	0.8324
Indigenous inclusive vs South Asian only	**106.0**	**(30.8, 181.3)**	**0.0058**	38.1	(-0.7, 77.0)	0.0543
Mixed/other/not stated/missing vs South Asian only	9.4	(-35.1, 54.0)	0.6779	3.0	(-29.9, 35.9)	0.8572
Indigenous inclusive vs Black only	**81.8**	**(5.8, 157.7)**	**0.0349**	34.6	(-2.2, 71.4)	0.0650
Mixed/other/not stated/missing vs Black only	-14.9	(-65.9, 36.2)	0.5677	-0.5	(-33.3, 32.3)	0.9767
Mixed/other/not stated/missing vs Indigenous inclusive	**-96.6**	**(-165.4, -27.9)**	**0.0060**	-35.1	(-74.5, 4.3)	0.0807
Province	$F_{(9,20176)}$=8.00 (P<0.001)			$F_{(9,20176)}$=6.33 (P<0.001)		
Prince Edward Island vs Newfoundland and Labrador	-25.8	(-73.7, 22.1)	0.2910	-6.1	(-29.1, 16.8)	0.6001
Nova Scotia vs Newfoundland and Labrador	-25.3	(-73.4, 22.8)	0.3015	-10.8	(-33.8, 12.2)	0.3584
New Brunswick vs Newfoundland and Labrador	0.8	(-53.2, 54.7)	0.9780	4.8	(-21.9, 31.4)	0.7264
Quebec vs Newfoundland and Labrador	-40.6	(-85.0, 3.7)	0.0725	-19.7	(-41.3, 1.9)	0.0732
Ontario vs Newfoundland and Labrador	-25.0	(-71.4, 21.4)	0.2910	-7.4	(-31.1, 16.3)	0.5419
Manitoba vs Newfoundland and Labrador	16.0	(-31.6, 63.6)	0.5089	2.7	(-20.0, 25.4)	0.8148
Saskatchewan vs Newfoundland and Labrador	-28.8	(-78.5, 20.9)	0.2554	-14.1	(-36.8, 8.5)	0.2201
Alberta vs Newfoundland and Labrador	13.1	(-32.2, 58.3)	0.5705	12.8	(-11.9, 37.4)	0.3094
British Columbia vs Newfoundland and Labrador	**-85.4**	**(-126.8, -44.1)**	**<.0001**	**-38.0**	**(-58.4, -17.7)**	**0.0003**
Nova Scotia vs Prince Edward Island	0.5	(-38.2, 39.1)	0.9812	-4.6	(-23.3, 14.0)	0.6245
New Brunswick vs Prince Edward Island	26.5	(-15.6, 68.7)	0.2171	10.9	(-10.9, 32.7)	0.3277
Quebec vs Prince Edward Island	-14.9	(-47.6, 17.9)	0.3731	-13.6	(-30.2, 3.0)	0.1087
Ontario vs Prince Edward Island	0.8	(-31.4, 33.1)	0.9604	-1.2	(-18.4, 15.9)	0.8877

	TOTAL SSBs					
	Volume, ml			**Energy**, kcal		
	Estimate	95% CI	P value	Estimate	95% CI	P value
Manitoba vs Prince Edward Island	**41.8**	**(0.6, 83.0)**	**0.0470**	8.8	(-11.1, 28.8)	0.3846
Saskatchewan vs Prince Edward Island	-3.0	(-45.0, 39.0)	0.8869	-8.0	(-27.6, 11.5)	0.4206
Alberta vs Prince Edward Island	**38.8**	**(0.4, 77.3)**	**0.0475**	18.9	(-2.4, 40.2)	0.0818
British Columbia vs Prince Edward Island	**-59.7**	**(-90.0, -29.3)**	**0.0001**	**-31.9**	**(-47.1, -16.7)**	**<.0001**
New Brunswick vs Nova Scotia	26.1	(-19.8, 71.9)	0.2645	15.5	(-7.3, 38.3)	0.1818
Quebec vs Nova Scotia	-15.3	(-51.8, 21.1)	0.4093	-8.9	(-26.5, 8.6)	0.3173
Ontario vs Nova Scotia	0.4	(-35.5, 36.2)	0.9846	3.4	(-14.7, 21.5)	0.7124
Manitoba vs Nova Scotia	41.3	(-0.1, 82.8)	0.0506	13.5	(-6.3, 33.2)	0.1806
Saskatchewan vs Nova Scotia	-3.5	(-49.8, 42.8)	0.8818	-3.4	(-24.0, 17.3)	0.7480
Alberta vs Nova Scotia	38.4	(-1.5, 78.3)	0.0592	**23.5**	**(1.9, 45.2)**	**0.0334**
British Columbia vs Nova Scotia	**-60.1**	**(-94.0, -26.3)**	**0.0005**	**-27.3**	**(-43.5, -11.0)**	**0.0011**
Quebec vs New Brunswick	**-41.4**	**(-81.9, -0.9)**	**0.0451**	**-24.5**	**(-45.3, -3.6)**	**0.0214**
Ontario vs New Brunswick	-25.7	(-63.9, 12.5)	0.1862	-12.1	(-32.2, 8.0)	0.2366
Manitoba vs New Brunswick	15.3	(-31.2, 61.7)	0.5191	-2.0	(-25.4, 21.3)	0.8633
Saskatchewan vs New Brunswick	-29.6	(-76.0, 16.9)	0.2116	-18.9	(-41.6, 3.8)	0.1019
Alberta vs New Brunswick	12.3	(-32.0, 56.6)	0.5854	8.0	(-17.3, 33.4)	0.5343
British Columbia vs New Brunswick	**-86.2**	**(-123.8, -48.6)**	**<.0001**	**-42.8**	**(-62.2, -23.4)**	**<.0001**
Ontario vs Quebec	15.7	(-12.9, 44.3)	0.2822	12.3	(-2.9, 27.6)	0.1124
Manitoba vs Quebec	**56.6**	**(17.9, 95.4)**	**0.0042**	**22.4**	**(3.9, 40.9)**	**0.0175**
Saskatchewan vs Quebec	11.8	(-26.5, 50.1)	0.5451	5.6	(-12.1, 23.2)	0.5381
Alberta vs Quebec	**53.7**	**(20.0, 87.4)**	**0.0019**	**32.5**	**(13.0, 51.9)**	**0.0011**
British Columbia vs Quebec	**-44.8**	**(-71.3, -18.4)**	**0.0009**	**-18.3**	**(-31.5, -5.1)**	**0.0066**
Manitoba vs Ontario	**41.0**	**(4.0, 78)**	**0.0301**	10.1	(-9.0, 29.1)	0.3001
Saskatchewan vs Ontario	-3.9	(-40.8, 33.0)	0.8374	-6.8	(-25.1, 11.5)	0.4670
Alberta vs Ontario	**38.0**	**(5.3, 70.7)**	**0.0227**	20.1	(-0.4, 40.7)	0.0548
British Columbia vs Ontario	**-60.5**	**(-86.4, -34.5)**	**<.0001**	**-30.7**	**(-45, -16.3)**	**<.0001**
Saskatchewan vs Manitoba	-44.8	(-90.8, 1.1)	0.0558	-16.9	(-37.9, 4.2)	0.1166
Alberta vs Manitoba	-2.9	(-44.5, 38.6)	0.8890	10.1	(-12.1, 32.3)	0.3736
British Columbia vs Manitoba	**-101.5**	**(-136.4, -66.5)**	**<.0001**	**-40.7**	**(-57.8, -23.7)**	**<.0001**
Alberta vs Saskatchewan	41.9	(-0.3, 84.1)	0.0515	**26.9**	**(4.6, 49.2)**	**0.0181**
British Columbia vs Saskatchewan	**-56.6**	**(-92.8, -20.4)**	**0.0022**	**-23.9**	**(-40.1, -7.6)**	**0.0040**

	TOTAL SSBs					
	Volume, ml			**Energy**, kcal		
	Estimate	95% CI	P value	Estimate	95% CI	P value
British Columbia vs Alberta	**-98.5**	**(-129.8, -67.3)**	**<.0001**	**-50.8**	**(-69.9, -31.7)**	**<.0001**
BMI category				$F_{(3,20176)}$=3.10 (P=0.0265)		
Overweight vs Underweight/normal				**-19.3**	**(-31.8, -6.9)**	**0.0025**
Obese vs Underweight/normal				-11.1	(-26.8, 4.6)	0.1665
DK/Refusal/NS vs Underweight/normal				-13.4	(-29.4, 2.7)	0.1025
Obese vs Overweight				8.3	(-7.3, 23.8)	0.2961
DK/Refusal/NS vs Overweight				6.0	(-7.8, 19.7)	0.3933
DK/Refusal/NS vs Obese				-2.3	(-20.5, 15.9)	**0.0025**

Separate ANOVA analyses with F-Wald test of total SSBs volume and energy by each socio-economic variable (sex, age, ethnicity, province, and BMI category), followed by Student t-test for pairwise comparisons. The estimate represents the difference two variable categories. For example, compared to male Canadians, a female Canadian consumes an average of 86.6 ml less SSBs per day. SSB volume and energy did not differ by income quintile and SSB volume did not differ by BMI category; accordingly, no contrasts are reported.
Values in bold font represent findings significant at P<0.01 level.
95% CI, 95% confidence intervals; BMI, body-mass index; DK, don’t know; NS, not stated; SSB, sugar-sweetened beverage

SSB AND SUGARY DRINK TAXES

ENERGY INTAKE

Appendix E, Table 7. Average change in per capita daily energy intake due to 20% SSBs tax, males

Age group	**SSBs** Mean change (per person, per day; kcal)	(95% UI)	**100% juice** Mean change (per person, per day; kcal)	(95% UI)	**Plain milk** Mean change (per person, per day; kcal)	(95% UI)	**Diet beverages** Mean change (per person, per day; kcal)	(95% UI)	**Total change** Mean change (per person, per day; kcal)	(95% UI)
20-24	-34.8	(-39.9, -30.1)	1.7	(1.1, 2.4)	1.1	(0.4, 1.8)	0.0	(-0.1, 0.0)	-32.0	(-37.3, -27.1)
25-29	-34.8	(-39.9, -29.9)	1.7	(1.1, 2.4)	1.1	(0.4, 1.8)	0.0	(-0.1, 0.0)	-32.0	(-37.1, -27.0)
30-34	-30.8	(-35.2, -26.5)	1.4	(0.9, 1.9)	0.8	(0.3, 1.3)	-0.1	(-0.2, -0.1)	-28.7	(-33.3, -24.3)
35-39	-30.7	(-34.9, -26.6)	1.4	(0.9, 1.9)	0.8	(0.3, 1.3)	-0.1	(-0.2, -0.1)	-28.7	(-32.8, -24.4)
40-44	-19.3	(-22.1, -16.5)	1.1	(0.7, 1.6)	0.7	(0.3, 1.2)	-0.1	(-0.2, -0.1)	-17.5	(-20.4, -14.7)
45-49	-19.3	(-22.2, -16.6)	1.1	(0.7, 1.6)	0.7	(0.3, 1.2)	-0.1	(-0.2, -0.1)	-17.5	(-20.5, -14.7)
50-54	-15.2	(-17.3, -13.0)	1.1	(0.7, 1.4)	0.8	(0.3, 1.2)	-0.1	(-0.3, -0.1)	-13.5	(-15.7, -11.2)
55-59	-15.2	(-17.5, -12.9)	1.1	(0.7, 1.4)	0.8	(0.3, 1.2)	-0.1	(-0.2, -0.1)	-13.4	(-16.0, -11.0)
60-64	-13.9	(-16.3, -11.8)	1.1	(0.7, 1.5)	0.8	(0.3, 1.4)	-0.1	(-0.1, -0.1)	-12.1	(-14.6, -9.7)
65-69	-14.0	(-16.3, -11.8)	1.1	(0.7, 1.5)	0.8	(0.3, 1.3)	-0.1	(-0.1, -0.1)	-12.1	(-14.6, -9.8)
70-74	-8.4	(-9.9, -6.9)	1.1	(0.7, 1.5)	1.1	(0.4, 1.8)	-0.1	(-0.3, -0.1)	-6.3	(-8.1, -4.5)
75-79	-8.4	(-9.8, -7.0)	1.1	(0.7, 1.6)	1.1	(0.4, 1.8)	-0.1	(-0.3, -0.1)	-6.3	(-8.0, -4.7)
80+	-11.7	(-13.8, -9.6)	1.6	(1.0, 2.2)	1.1	(0.4, 1.8)	0.0	(-0.1, 0.0)	-9.0	(-11.4, -6.7)
All ages	**-21.3**	**(-23.6, -19)**	**1.3**	**(0.8, 1.7)**	**0.9**	**(0.3, 1.4)**	**-0.1**	**(-0.2, -0.1)**	**-19.3**	**(-21.8, -16.8)**

95% UI, 95% uncertainty intervals; SSB, sugar-sweetened beverage

Appendix E, Table 8. Average change in per capita daily energy intake due to 20% SSBs tax, females

Age group	**SSBs** Mean change (per person, per day; kcal)	(95% UI)	**100% juice** Mean change (per person, per day; kcal)	(95% UI)	**Plain milk** Mean change (per person, per day; kcal)	(95% UI)	**Diet beverages** Mean change (per person, per day; kcal)	(95% UI)	**Total change** Mean change (per person, per day; kcal)	(95% UI)
20-24	-22.4	(-25.8, -19.2)	1.1	(0.7, 1.5)	0.7	(0.3, 1.2)	0.0	(-0.1, 0.0)	-20.6	(-23.9, -17.2)
25-29	-22.3	(-25.7, -19.1)	1.1	(0.7, 1.5)	0.7	(0.3, 1.2)	0.0	(-0.1, 0.0)	-20.5	(-24.0, -17.2)
30-34	-15.1	(-17.4, -12.8)	1.2	(0.7, 1.6)	0.7	(0.3, 1.1)	0.0	(-0.1, 0.0)	-13.3	(-15.6, -10.9)
35-39	-15.1	(-17.6, -12.8)	1.2	(0.8, 1.6)	0.7	(0.3, 1.1)	0.0	(-0.1, 0.0)	-13.3	(-15.9, -10.9)
40-44	-12.5	(-14.4, -10.7)	0.7	(0.4, 1.0)	0.8	(0.3, 1.2)	-0.1	(-0.3, -0.1)	-11.2	(-13.1, -9.3)
45-49	-12.5	(-14.4, -10.8)	0.7	(0.4, 1.0)	0.8	(0.3, 1.2)	-0.1	(-0.2, -0.1)	-11.2	(-13.2, -9.3)
50-54	-12.0	(-13.8, -10.2)	0.8	(0.5, 1.1)	0.6	(0.2, 1.0)	-0.1	(-0.1, -0.1)	-10.8	(-12.6, -8.8)
55-59	-12.1	(-13.9, -10.3)	0.8	(0.5, 1.1)	0.6	(0.2, 1.0)	-0.1	(-0.1, -0.1)	-10.8	(-12.7, -9.0)
60-64	-9.8	(-11.5, -8.3)	0.8	(0.5, 1.1)	0.8	(0.3, 1.2)	-0.1	(-0.2, -0.1)	-8.4	(-10.2, -6.8)
65-69	-9.8	(-11.6, -8.3)	0.8	(0.5, 1.1)	0.8	(0.3, 1.2)	-0.1	(-0.2, -0.1)	-8.4	(-10.2, -6.7)
70-74	-8.3	(-9.9, -6.9)	1.1	(0.7, 1.5)	0.8	(0.3, 1.2)	-0.1	(-0.2, -0.1)	-6.6	(-8.2, -5.0)
75-79	-8.4	(-9.8, -6.9)	1.1	(0.7, 1.5)	0.8	(0.3, 1.2)	-0.1	(-0.2, -0.1)	-6.6	(-8.3, -5.0)
80+	-8.3	(-9.4, -7.1)	1.5	(1.0, 2.0)	0.8	(0.3, 1.3)	0.0	(0.0, 0.0)	-5.9	(-7.3, -4.6)
All ages	**-13.5**	**(-15.0, -12.0)**	**1.0**	**(0.6, 1.3)**	**0.7**	**(0.3, 1.1)**	**-0.1**	**(-0.1, -0.1)**	**-11.9**	**(-13.5, -10.3)**

95% UI, 95% uncertainty intervals; SSB, sugar-sweetened beverage

Appendix E, Table 9. Average change in per capita daily energy intake due to 20% sugary drinks tax, males

Age group	**Sugary drinks** Mean change (per person, per day; kcal)	(95% UI)	**Plain milk** Mean change (per person, per day; kcal)	(95% UI)	**Diet beverages** Mean change (per person, per day; kcal)	(95% UI)	**Total change** Mean change (per person, per day; kcal)	(95% UI)
20-24	-43.1	(-48.4, -37.4)	1.1	(0.4, 1.9)	0.0	(-0.1, 0.0)	-42.0	(-47.2, -36.3)
25-29	-43.1	(-49.0, -37.5)	1.1	(0.4, 1.9)	0.0	(-0.1, 0.0)	-42.0	(-47.9, -36.4)
30-34	-37.3	(-42.3, -32.5)	0.8	(0.3, 1.3)	-0.1	(-0.2, -0.1)	-36.6	(-41.6, -31.8)
35-39	-37.4	(-42.0, -32.6)	0.8	(0.3, 1.3)	-0.1	(-0.2, -0.1)	-36.7	(-41.4, -31.9)
40-44	-24.9	(-28.2, -21.5)	0.7	(0.3, 1.2)	-0.1	(-0.2, -0.1)	-24.2	(-27.6, -20.8)
45-49	-24.8	(-28.2, -21.6)	0.7	(0.3, 1.2)	-0.1	(-0.2, -0.1)	-24.2	(-27.6, -20.9)
50-54	-20.3	(-23.2, -17.7)	0.8	(0.3, 1.3)	-0.1	(-0.2, -0.1)	-19.7	(-22.6, -17.0)
55-59	-20.3	(-23.1, -17.6)	0.8	(0.3, 1.2)	-0.1	(-0.2, -0.1)	-19.7	(-22.5, -17.0)
60-64	-19.2	(-21.8, -16.5)	0.8	(0.3, 1.4)	-0.1	(-0.1, -0.1)	-18.4	(-21.2, -15.7)
65-69	-19.2	(-22.0, -16.7)	0.8	(0.3, 1.4)	-0.1	(-0.1, -0.1)	-18.5	(-21.2, -15.8)
70-74	-13.9	(-16.0, -11.9)	1.1	(0.4, 1.8)	-0.1	(-0.3, -0.1)	-12.9	(-15.2, -10.9)
75-79	-13.9	(-16.0, -11.8)	1.1	(0.4, 1.8)	-0.1	(-0.2, -0.1)	-12.9	(-15.1, -10.7)
80+	-19.3	(-22.4, -16.2)	1.1	(0.4, 1.8)	0.0	(-0.1, 0.0)	-18.2	(-21.4, -15.0)
All ages	**-27.6**	**(-30.4, -24.6)**	**0.9**	**(0.3, 1.4)**	**-0.1**	**(-0.2, -0.1)**	**-26.8**	**(-29.7, -23.8)**

95% UI, 95% uncertainty intervals

Appendix E, Table 10. Average change in per capita daily energy intake due to 20% sugary drinks tax, females

Age group	**Sugary drinks** Mean change (per person, per day; kcal)	(95% UI)	**Plain milk** Mean change (per person, per day; kcal)	(95% UI)	**Diet beverages** Mean change (per person, per day; kcal)	(95% UI)	**Total change** Mean change (per person, per day; kcal)	(95% UI)
20-24	-27.7	(-31.5, -24.1)	0.7	(0.3, 1.2)	0.0	(-0.1, 0.0)	-27.0	(-30.8, -23.4)
25-29	-27.7	(-31.6, -23.9)	0.7	(0.3, 1.2)	0.0	(-0.1, 0.0)	-27.0	(-30.9, -23.2)
30-34	-20.8	(-23.5, -18.0)	0.7	(0.3, 1.1)	0.0	(-0.1, 0.0)	-20.1	(-23.0, -17.4)
35-39	-20.8	(-23.6, -18.1)	0.7	(0.3, 1.1)	0.0	(-0.1, 0.0)	-20.1	(-23.0, -17.4)
40-44	-15.9	(-18.2, -13.8)	0.8	(0.3, 1.3)	-0.1	(-0.2, -0.1)	-15.3	(-17.7, -13.1)
45-49	-15.9	(-18.3, -13.8)	0.8	(0.3, 1.2)	-0.1	(-0.2, -0.1)	-15.3	(-17.7, -13.1)
50-54	-15.8	(-18.0, -13.6)	0.6	(0.2, 1.0)	-0.1	(-0.1, -0.1)	-15.2	(-17.6, -13.0)
55-59	-15.8	(-18.2, -13.5)	0.6	(0.2, 1.0)	-0.1	(-0.1, -0.1)	-15.3	(-17.7, -13.0)
60-64	-13.5	(-15.8, -11.5)	0.8	(0.3, 1.2)	-0.1	(-0.2, -0.1)	-12.8	(-15.1, -10.7)
65-69	-13.5	(-15.6, -11.5)	0.8	(0.3, 1.3)	-0.1	(-0.2, -0.1)	-12.9	(-15.1, -10.8)
70-74	-13.7	(-15.9, -11.8)	0.8	(0.3, 1.3)	-0.1	(-0.2, -0.1)	-13.1	(-15.2, -11.0)
75-79	-13.7	(-15.8, -11.7)	0.8	(0.3, 1.3)	-0.1	(-0.2, -0.1)	-13.1	(-15.1, -11.0)
80+	-15.7	(-17.6, -13.9)	0.8	(0.3, 1.3)	0.0	(0.0, 0.0)	-14.9	(-16.9, -13.0)
All ages	**-18.2**	**(-20.0, -16.2)**	**0.7**	**(0.3, 1.2)**	**-0.1**	**(-0.1, -0.1)**	**-17.5**	**(-19.5, -15.5)**

95% UI, 95% uncertainty intervals

Appendix E, Table 11. Average change in body mass index due to 20% beverage taxes

	SSBs Mean change (kg/m^2)				Sugary drinks Mean change (kg/m^2)			
	Males		Females		Males		Females	
Age group		(95% UI)		(95% UI)		(95% UI)		(95% UI)
20-24	-0.45	(-0.53, -0.38)	-0.34	(-0.40, -0.28)	-0.59	(-0.68, -0.51)	-0.45	(-0.52, -0.38)
25-29	-0.45	(-0.53, -0.38)	-0.34	(-0.40, -0.28)	-0.60	(-0.69, -0.51)	-0.45	(-0.52, -0.38)
30-34	-0.41	(-0.48, -0.34)	-0.22	(-0.26, -0.18)	-0.52	(-0.60, -0.44)	-0.33	(-0.39, -0.28)
35-39	-0.41	(-0.47, -0.34)	-0.22	(-0.27, -0.18)	-0.52	(-0.60, -0.45)	-0.33	(-0.39, -0.28)
40-44	-0.25	(-0.30, -0.21)	-0.19	(-0.23, -0.16)	-0.35	(-0.40, -0.29)	-0.26	(-0.30, -0.22)
45-49	-0.25	(-0.30, -0.21)	-0.19	(-0.23, -0.16)	-0.34	(-0.40, -0.30)	-0.26	(-0.31, -0.22)
50-54	-0.19	(-0.23, -0.16)	-0.18	(-0.22, -0.15)	-0.28	(-0.33, -0.24)	-0.26	(-0.30, -0.22)
55-59	-0.19	(-0.23, -0.16)	-0.18	(-0.22, -0.15)	-0.28	(-0.32, -0.24)	-0.26	(-0.31, -0.22)
60-64	-0.18	(-0.22, -0.14)	-0.15	(-0.18, -0.12)	-0.27	(-0.32, -0.23)	-0.23	(-0.27, -0.19)
65-69	-0.18	(-0.22, -0.14)	-0.15	(-0.18, -0.12)	-0.27	(-0.32, -0.23)	-0.23	(-0.27, -0.19)
70-74	-0.09	(-0.12, -0.07)	-0.12	(-0.15, -0.09)	-0.19	(-0.23, -0.16)	-0.23	(-0.27, -0.19)
75-79	-0.09	(-0.12, -0.07)	-0.12	(-0.15, -0.09)	-0.19	(-0.23, -0.16)	-0.23	(-0.27, -0.19)
80+	-0.13	(-0.17, -0.10)	-0.11	(-0.13, -0.08)	-0.27	(-0.32, -0.22)	-0.26	(-0.30, -0.23)
All ages	**-0.28**	**(-0.32, -0.24)**	**-0.20**	**(-0.23, -0.17)**	**-0.38**	**(-0.43, -0.33)**	**-0.30**	**(-0.34, -0.26)**

SSBs, sugar-sweetened beverages; BMI, body-mass index; 95% UI, 95% uncertainty intervals

Appendix E, Table 12. Prevented cases of overweight and obesity due to 20% beverage taxes, 2016-2041

	SSBs		Sugary drinks	
	Mean	(95% UI)	Mean	(95% UI)
Overweight				
Males	22,211	(17,838, 27,287)	31,131	(25,023, 37,753)
Females	29,123	(24,559, 34,040)	43,997	(37,834, 50,345)
Total	51,334	(42,820, 60,558)	75,129	(63,781, 87,212)
Obesity				
Males	250,777	(216,504, 287,887)	348,704	(305,040, 392,891)
Females	147,891	(126,171, 170,699)	219,103	(190,685, 247,305)
Total	398,668	(343,264, 457,695)	567,807	(496,088, 641,127)

SSBs, sugar-sweetened beverages; 95% UI, 95% uncertainty intervals

DISEASES

TYPE 2 DIABETES

Appendix E, Table 13. Prevented incident cases of type 2 diabetes due to 20% beverage taxes, 2016-2041

	SSBs		Sugary drinks	
	Mean	(95% UI)	Mean	(95% UI)
Type 2 diabetes mellitus				
Males	84,096	(62,961, 109,156)	117,707	(89,378, 149,942)
Females	59,979	(44,137, 76,573)	86,071	(65,176, 109,197)
Total	144,074	(111,012, 180,560)	203,778	(161,815, 251,368)

SSBs, sugar-sweetened beverages; 95% UI, 95% uncertainty intervals

Appendix E, Table 14. Prevented prevalent cases of type 2 diabetes due to 20% beverage taxes, 2041

	SSBs		Sugary drinks	
	Mean	(95% UI)	Mean	(95% UI)
Type 2 diabetes mellitus				
Males	70,687	(53,025, 91,672)	97,989	(74,329, 124,575)
Females	52,085	(38,345, 66,396)	74,095	(56,197, 93,937)
Total	122,772	(94,685, 153,721)	172,084	(136,593, 212,432)

SSBs, sugar-sweetened beverages; 95% UI, 95% uncertainty intervals

CANCERS

Appendix E, Table 15. Prevented incident cases of cancer due to 20% beverage taxes, 2016-2041

	SSBs		Sugary drinks	
	Mean	(95% UI)	Mean	(95% UI)
Breast cancer				
Males				
Females	4,414	(1,504, 8,123)	7,537	(2,583, 13,700)
Total	4,414	(1,504, 8,123)	7,537	(2,583, 13,700)
Colon and rectum cancer				
Males	1,629	(1,266, 2,055)	2,805	(2,183, 3,448)
Females	338	(153, 543)	639	(303, 999)
Total	1,967	(1,530, 2,473)	3,444	(2,712, 4,202)
Esophageal cancer				
Males	483	(121, 906)	835	(133, 1,640)
Females	123	(11, 273)	234	(14, 503)
Total	607	(211, 1,060)	1,069	(341, 1,906)
Gallbladder and biliary track cancer				
Males	102	(18, 200)	176	(29, 337)
Females	231	(144, 336)	446	(276, 644)
Total	333	(204, 482)	622	(389, 893)
Kidney cancer				
Males	656	(446, 903)	1,066	(739, 1,433)
Females	448	(327, 577)	785	(600, 1,007)
Total	1,104	(830, 1,416)	1,851	(1,461, 2,294)
Leukemia				
Males	201	(112, 298)	341	(188, 512)
Females	176	(71, 301)	337	(132, 560)
Total	377	(230, 542)	678	(430, 961)
Liver cancer				
Males	474	(181, 815)	783	(269, 1,345)
Females	111	(14, 226)	208	(32, 411)
Total	586	(266, 937)	990	(440, 1,570)
Ovarian cancer				
Males				
Females	60	(-13, 139)	102	(-24, 235)
Total	60	(-13, 139)	102	(-24, 235)
Pancreatic cancer				
Males	123	(-23, 299)	221	(-42, 511)
Females	132	(44, 228)	253	(87, 446)
Total	256	(92, 457)	474	(157, 817)
Thyroid cancer				
Males	270	(83, 472)	397	(125, 685)
Females	397	(266, 540)	603	(405, 811)
Total	667	(434, 935)	1,000	(652, 1,379)
Uterine cancer				
Males				
Females	2,430	(1,988, 2,924)	4,042	(3,356, 4,743)
Total	2,430	(1,988, 2,924)	4,042	(3,356, 4,743)

SSBs, sugar-sweetened beverages; 95% UI, 95% uncertainty intervals

Appendix E, Table 16. Prevented cancer deaths due to 20% beverage taxes, 2016-2041

	SSBs		Sugary drinks	
	Mean	(95% UI)	Mean	(95% UI)
Breast cancer				
Males				
Females	574	(180, 1,072)	946	(296, 1,739)
Total	574	(180, 1,072)	946	(296, 1,739)
Colon and rectum cancer				
Males	526	(410, 665)	875	(676, 1,079)
Females	88	(32, 149)	159	(60, 265)
Total	615	(477, 775)	1,034	(805, 1,274)
Esophageal cancer				
Males	416	(104, 778)	713	(112, 1,400)
Females	80	(-13, 203)	169	(-11, 388)
Total	496	(157, 881)	882	(261, 1,586)
Gallbladder and biliary track cancer				
Males	21	(3, 42)	34	(4, 67)
Females	48	(30, 70)	86	(53, 124)
Total	70	(43, 101)	120	(74, 174)
Kidney cancer				
Males	145	(98, 201)	230	(159, 311)
Females	81	(58, 106)	143	(108, 185)
Total	226	(168, 295)	373	(290, 467)
Leukemia				
Males	55	(28, 84)	92	(44, 145)
Females	62	(22, 109)	117	(42, 198)
Total	117	(66, 174)	209	(121, 305)
Liver cancer				
Males	235	(88, 405)	382	(127, 658)
Females	63	(7, 129)	115	(16, 229)
Total	299	(135, 476)	497	(221, 786)
Ovarian cancer				
Males				
Females	19	(-10, 52)	32	(-20, 87)
Total	19	(-10, 52)	32	(-20, 87)
Pancreatic cancer				
Males	86	(-21, 213)	152	(-38, 361)
Females	102	(31, 179)	197	(63, 352)
Total	188	(64, 336)	349	(111, 605)
Thyroid cancer				
Males	8	(2, 15)	12	(3, 21)
Females	2	(1, 2)	3	(1, 4)
Total	10	(4, 16)	14	(5, 24)
Uterine cancer				
Males				
Females	279	(229, 335)	448	(373, 526)
Total	279	(229, 335)	448	(373, 526)

SSBs, sugar-sweetened beverages; 95% UI, 95% uncertainty intervals

Appendix E, Table 17. Prevented incident cases of cardiovascular disease due to 20% beverage taxes, 2016-2041

	SSBs		Sugary drinks	
	Mean	(95% UI)	Mean	(95% UI)
Ischemic heart disease				
Males	23,304	(16,708, 30,552)	35,599	(26,337, 46,371)
Females	13,908	(9,780, 18,549)	22,698	(16,045, 29,941)
Total	37,212	(28,565, 47,137)	58,297	(45,942, 71,959)
Ischemic stroke				
Males	1,703	(1,141, 2,350)	2,675	(1,793, 3,683)
Females	1,199	(758, 1,707)	2,015	(1,223, 2,936)
Total	2,902	(2,151, 3,767)	4,690	(3,426, 6,094)
Hemorrhagic stroke				
Males	1,120	(688, 1,615)	1,678	(1,013, 2,486)
Females	923	(538, 1,418)	1,466	(787, 2,301)
Total	2,043	(1,413, 2,774)	3,145	(2,103, 4,316)

SSBs, sugar-sweetened beverages; 95% UI, 95% uncertainty intervals

Appendix E, Table 18. Prevented prevalent cases of cardiovascular disease due to 20% beverage taxes, 2041

	SSBs		Sugary drinks	
	Mean	(95% UI)	Mean	(95% UI)
Ischemic heart disease				
Males	15,890	(11,415, 20,978)	23,588	(17,493, 30,815)
Females	9,881	(7,006, 13,134)	15,433	(10,991, 20,409)
Total	25,772	(19,807, 32,588)	39,021	(30,656, 48,240)
Ischemic stroke				
Males	893	(621, 1,206)	1,330	(944, 1,766)
Females	662	(454, 899)	1,024	(699, 1,396)
Total	1,555	(1,196, 1,977)	2,354	(1,804, 2,961)
Hemorrhagic stroke				
Males	397	(248, 566)	574	(356, 833)
Females	362	(219, 536)	544	(316, 814)
Total	759	(533, 1,014)	1,118	(772, 1,494)
Hypertensive heart disease				
Males	483	(174, 887)	756	(248, 1,394)
Females	522	(152, 1,037)	976	(256, 1,924)
Total	1,005	(483, 1,675)	1,732	(823, 2,902)

SSBs, sugar-sweetened beverages; 95% UI, 95% uncertainty intervals

Appendix E, Table 19. Prevented cardiovascular disease deaths due to 20% beverage taxes, 2016-2041

	SSBs		Sugary drinks	
	Mean	(95% UI)	Mean	(95% UI)
Ischemic heart disease				
Males	3,156	(2,226, 4,176)	4,876	(3,543, 6,445)
Females	1,309	(881, 1,789)	2,291	(1,536, 3,119)
Total	4,466	(3,364, 5,745)	7,166	(5,518, 9,016)
Ischemic stroke				
Males	503	(312, 724)	831	(501, 1,200)
Females	352	(187, 543)	651	(315, 1,028)
Total	855	(595, 1,157)	1,482	(994, 2,022)
Hemorrhagic stroke				
Males	624	(384, 898)	939	(569, 1,385)
Females	499	(289, 769)	807	(427, 1,274)
Total	1,123	(780, 1,525)	1,746	(1,166, 2,396)

SSBs, sugar-sweetened beverages; 95% UI, 95% uncertainty intervals

CHRONIC KIDNEY DISEASE

Appendix E, Table 20. Prevented prevalent cases of chronic kidney disease due to 20% beverage taxes, 2041

	SSBs		Sugary drinks	
	Mean	(95% UI)	Mean	(95% UI)
Chronic kidney disease due to diabetes mellitus				
Males	6,974	(960, 14,980)	11,132	(1,847, 23,998)
Females	10,825	(1,920, 23,132)	16,612	(2,606, 35,129)
Total	17,800	(5,988, 32,495)	27,744	(9,931, 49,861)
Chronic kidney disease due to hypertension				
Males	3,811	(682, 7,942)	5,903	(1,073, 12,412)
Females	5,773	(930, 12,259)	8,786	(1,168, 19,549)
Total	9,583	(3,553, 17,273)	14,689	(5,221, 26,504)
Chronic kidney disease due to glomerulonephritis				
Males	6,326	(1,117, 13,681)	9,693	(1,881, 20,366)
Females	9,846	(1,167, 20,610)	14,967	(2,242, 31,561)
Total	16,172	(5,739, 29,115)	24,659	(9,009, 43,789)
Chronic kidney disease due to other causes				
Males	5,414	(944, 11,080)	8,446	(1,320, 17,360)
Females	8,309	(1,072, 17,614)	12,576	(1,600, 27,526)
Total	13,723	(4,994, 24,976)	21,022	(7,127, 37,916)

SSBs, sugar-sweetened beverages; 95% UI, 95% uncertainty intervals

Appendix E, Table 21. Prevented chronic kidney disease deaths due to 20% beverage taxes, 2016-2041

	SSBs		Sugary drinks	
	Mean	(95% UI)	Mean	(95% UI)
Chronic kidney disease due to diabetes mellitus				
Males	32	(-274, 450)	283	(-237, 1,022)
Females	188	(31, 400)	310	(41, 663)
Total	219	(-151, 679)	593	(-28, 1,404)
Chronic kidney disease due to hypertension				
Males	215	(32, 463)	368	(47, 804)
Females	155	(17, 345)	275	(16, 659)
Total	370	(128, 681)	643	(202, 1,168)
Chronic kidney disease due to glomerulonephritis				
Males	64	(10, 138)	106	(17, 224)
Females	48	(5, 102)	82	(10, 178)
Total	112	(40, 204)	188	(68, 333)
Chronic kidney disease due to other causes				
Males	5	(0, 12)	9	(0, 21)
Females	5	(0, 12)	9	(0, 24)
Total	11	(3, 20)	19	(4, 36)

SSBs, sugar-sweetened beverages; 95% UI, 95% uncertainty intervals

OSTEOARTHRITIS

Appendix E, Table 22. Prevented prevalent cases of osteoarthritis due to 20% beverage taxes, 2041

	SSBs		Sugary drinks	
	Mean	(95% UI)	Mean	(95% UI)
Osteoarthritis of the hip				
Males	832	(331, 1,367)	1,164	(468, 1,912)
Females	807	(358, 1,336)	1,165	(479, 1,893)
Total	1,639	(950, 2,413)	2,330	(1,305, 3,361)
Osteoarthritis of the knee				
Males	6,417	(3,340, 9,899)	9,058	(4,610, 13,939)
Females	7,329	(3,529, 11,683)	10,763	(4,993, 17,318)
Total	13,746	(8,738, 19,721)	19,821	(12,183, 27,943)

SSBs, sugar-sweetened beverages; 95% UI, 95% uncertainty intervals

LOW BACK PAIN

Appendix E, Table 23. Prevented prevalent cases of low back pain due to 20% beverage taxes, 2041

	SSBs		Sugary drinks	
	Mean	(95% UI)	Mean	(95% UI)
Low back pain				
Males	1,123	(589, 1,690)	1,429	(697, 2,235)
Females	1,002	(540, 1,540)	1,304	(613, 2,005)
Total	2,125	(1,391, 2,956)	2,733	(1,702, 3,808)

SSBs, sugar-sweetened beverages; 95% UI, 95% uncertainty intervals

Appendix E, Table 24. Disease rates for business as usual scenario and 20% beverage tax intervention scenario, and % change in disease rate, 2016-2041

	SSBs			Sugary drinks		
	Business as usual scenario Cases per 100,000	Intervention scenario Cases per 100,000	% change in disease rate	Business as usual scenario Cases per 100,000	Intervention scenario Cases per 100,000	% change in disease rate
Type 2 diabetes mellitus						
INCIDENCE						
2016	371.72	349.72	-5.9%	371.72	341.02	-8.3%
2021	412.99	390.00	-5.6%	412.96	380.56	-7.8%
2026	453.85	429.42	-5.4%	453.76	419.21	-7.6%
2031	490.51	465.93	-5.0%	490.34	455.33	-7.1%
2036	526.97	503.10	-4.5%	526.70	492.30	-6.5%
2041	561.39	538.13	-4.1%	561.04	527.12	-6.0%
PREVALENCE						
2016	8,035.07	8,024.09	-0.1%	8,034.70	8,019.37	-0.2%
2021	9,268.48	9,166.29	-1.1%	9,265.03	9,122.37	-1.5%
2026	10,863.15	10,638.37	-2.1%	10,856.98	10,542.77	-2.9%
2031	12,515.91	12,157.56	-2.9%	12,506.20	12,005.04	-4.0%
2036	14,285.41	13,787.68	-3.5%	14,271.68	13,575.01	-4.9%
2041	16,219.47	15,578.76	-4.0%	16,201.18	15,303.13	-5.5%
Breast cancer						
INCIDENCE						
2016	147.21	146.16	-0.7%	147.21	145.52	-1.1%
2021	169.43	168.21	-0.7%	169.40	167.38	-1.2%
2026	196.37	194.99	-0.7%	196.34	193.98	-1.2%
2031	222.70	221.14	-0.7%	222.75	220.04	-1.2%
2036	247.92	246.18	-0.7%	248.26	245.17	-1.2%
2041	271.13	269.17	-0.7%	271.97	268.44	-1.3%
MORTALITY						
2016	31.08	31.08	0.0%	31.08	31.07	0.0%
2021	37.35	37.28	-0.2%	37.34	37.22	-0.3%
2026	46.08	45.93	-0.3%	46.06	45.81	-0.5%
2031	53.95	53.72	-0.4%	53.91	53.53	-0.7%
2036	61.98	61.66	-0.5%	61.96	61.44	-0.8%
2041	70.63	70.22	-0.6%	70.66	69.99	-0.9%
Colon & rectum cancer						
INCIDENCE						
2016	72.73	72.50	-0.3%	72.73	72.34	-0.5%
2021	89.14	88.87	-0.3%	89.09	88.62	-0.5%
2026	108.18	107.86	-0.3%	108.23	107.67	-0.5%
2031	124.98	124.63	-0.3%	125.49	124.86	-0.5%
2036	138.96	138.58	-0.3%	140.74	140.05	-0.5%
2041	148.75	148.37	-0.3%	152.86	152.13	-0.5%
MORTALITY						
2016	26.86	26.86	0.0%	26.86	26.85	0.0%

	SSBs			Sugary drinks		
	Business as usual scenario Cases per 100,000	Intervention scenario Cases per 100,000	% change in disease rate	Business as usual scenario Cases per 100,000	Intervention scenario Cases per 100,000	% change in disease rate
2021	34.51	34.46	-0.1%	34.46	34.38	-0.2%
2026	44.63	44.54	-0.2%	44.61	44.46	-0.4%
2031	53.13	53.00	-0.2%	53.20	52.97	-0.4%
2036	61.16	61.00	-0.3%	61.46	61.19	-0.4%
2041	68.09	67.91	-0.3%	68.98	68.68	-0.4%
Esophageal cancer						
INCIDENCE						
2016	6.66	6.59	-1.0%	6.66	6.55	-1.6%
2021	8.25	8.17	-0.9%	8.25	8.12	-1.6%
2026	10.23	10.13	-0.9%	10.24	10.07	-1.6%
2031	12.19	12.08	-0.9%	12.22	12.03	-1.6%
2036	14.29	14.16	-0.9%	14.37	14.14	-1.6%
2041	16.49	16.35	-0.9%	16.65	16.39	-1.6%
MORTALITY						
2016	6.02	6.00	-0.2%	6.02	6.00	-0.3%
2021	7.42	7.36	-0.8%	7.42	7.31	-1.4%
2026	9.31	9.22	-0.9%	9.31	9.17	-1.5%
2031	11.12	11.03	-0.8%	11.15	10.99	-1.5%
2036	12.99	12.88	-0.9%	13.06	12.85	-1.6%
2041	15.06	14.92	-0.9%	15.18	14.94	-1.6%
Gallbladder & biliary track cancer						
INCIDENCE						
2016	5.53	5.50	-0.6%	5.53	5.48	-1.0%
2021	7.13	7.09	-0.6%	7.13	7.06	-1.0%
2026	9.23	9.18	-0.6%	9.24	9.14	-1.0%
2031	11.21	11.15	-0.5%	11.25	11.13	-1.0%
2036	13.19	13.12	-0.5%	13.30	13.17	-1.0%
2041	15.24	15.16	-0.5%	15.49	15.33	-1.0%
MORTALITY						
2016	1.43	1.43	0.0%	1.43	1.43	-0.1%
2021	1.85	1.85	-0.3%	1.85	1.84	-0.4%
2026	2.44	2.43	-0.4%	2.44	2.43	-0.7%
2031	2.97	2.95	-0.5%	2.97	2.95	-0.9%
2036	3.52	3.50	-0.5%	3.53	3.50	-0.9%
2041	4.11	4.09	-0.5%	4.15	4.11	-1.0%
Kidney cancer						
INCIDENCE						
2016	18.63	18.50	-0.7%	18.63	18.41	-1.2%
2021	21.83	21.67	-0.7%	21.82	21.57	-1.2%
2026	25.61	25.44	-0.7%	25.61	25.31	-1.1%
2031	29.30	29.10	-0.7%	29.33	28.99	-1.1%
2036	32.81	32.60	-0.6%	32.92	32.55	-1.1%
2041	35.99	35.76	-0.6%	36.26	35.85	-1.1%
MORTALITY						

	SSBs			Sugary drinks		
	Business as usual scenario Cases per 100,000	Intervention scenario Cases per 100,000	% change in disease rate	Business as usual scenario Cases per 100,000	Intervention scenario Cases per 100,000	% change in disease rate
2016	5.24	5.24	0.0%	5.24	5.24	0.0%
2021	6.61	6.59	-0.2%	6.60	6.58	-0.3%
2026	8.39	8.36	-0.4%	8.39	8.34	-0.6%
2031	10.05	10.00	-0.5%	10.05	9.97	-0.8%
2036	11.77	11.71	-0.5%	11.79	11.69	-0.9%
2041	13.60	13.52	-0.6%	13.65	13.52	-1.0%
Leukemia						
INCIDENCE						
2016	17.5	17.5	-0.3%	17.49	17.42	-0.4%
2021	21.2	21.2	-0.3%	21.23	21.14	-0.4%
2026	25.7	25.6	-0.2%	25.68	25.56	-0.4%
2031	29.3	29.2	-0.2%	29.49	29.37	-0.4%
2036	32.0	31.9	-0.2%	32.65	32.52	-0.4%
2041	33.4	33.3	-0.2%	34.92	34.78	-0.4%
MORTALITY						
2016	7.6	7.6	0.0%	7.63	7.63	0.0%
2021	9.8	9.8	-0.1%	9.75	9.73	-0.2%
2026	12.4	12.4	-0.1%	12.39	12.36	-0.3%
2031	14.6	14.5	-0.2%	14.64	14.60	-0.3%
2036	16.5	16.4	-0.2%	16.69	16.64	-0.3%
2041	17.7	17.7	-0.2%	18.27	18.21	-0.3%
Liver cancer						
INCIDENCE						
2016	9.85	9.78	-0.7%	9.85	9.74	-1.1%
2021	11.83	11.75	-0.7%	11.82	11.69	-1.1%
2026	14.25	14.15	-0.7%	14.25	14.09	-1.1%
2031	16.51	16.41	-0.6%	16.54	16.36	-1.1%
2036	18.77	18.66	-0.6%	18.85	18.65	-1.1%
2041	21.00	20.88	-0.6%	21.19	20.96	-1.1%
MORTALITY						
2016	6.09	6.09	0.0%	6.09	6.08	-0.1%
2021	7.47	7.45	-0.3%	7.47	7.43	-0.5%
2026	9.29	9.24	-0.5%	9.29	9.21	-0.8%
2031	11.03	10.96	-0.6%	11.03	10.93	-0.9%
2036	12.81	12.74	-0.6%	12.84	12.71	-1.0%
2041	14.66	14.57	-0.6%	14.73	14.58	-1.0%
Ovarian cancer						
INCIDENCE						
2016	18.56	18.54	-0.1%	18.56	18.53	-0.2%
2021	20.95	20.93	-0.1%	20.94	20.91	-0.2%
2026	23.10	23.08	-0.1%	23.10	23.06	-0.2%
2031	24.07	24.05	-0.1%	24.18	24.14	-0.1%
2036	23.51	23.49	-0.1%	23.99	23.96	-0.1%
2041	20.92	20.91	-0.1%	22.22	22.19	-0.1%

	SSBs			Sugary drinks		
	Business as usual scenario Cases per 100,000	Intervention scenario Cases per 100,000	% change in disease rate	Business as usual scenario Cases per 100,000	Intervention scenario Cases per 100,000	% change in disease rate
MORTALITY						
2016	10.06	10.06	0.0%	10.06	10.06	0.0%
2021	11.90	11.90	0.0%	11.90	11.89	0.0%
2026	13.68	13.68	0.0%	13.65	13.64	-0.1%
2031	14.56	14.55	-0.1%	14.49	14.48	-0.1%
2036	14.35	14.34	-0.1%	14.32	14.30	-0.1%
2041	12.59	12.59	-0.1%	12.74	12.73	-0.1%
Pancreatic cancer						
INCIDENCE						
2016	16.04	16.01	-0.2%	16.04	15.99	-0.3%
2021	19.60	19.56	-0.2%	19.59	19.52	-0.3%
2026	23.38	23.33	-0.2%	23.43	23.35	-0.3%
2031	26.36	26.32	-0.2%	26.66	26.57	-0.3%
2036	28.31	28.27	-0.2%	29.21	29.12	-0.3%
2041	28.63	28.58	-0.2%	30.63	30.54	-0.3%
MORTALITY						
2016	13.18	13.18	0.0%	13.18	13.18	0.0%
2021	16.42	16.40	-0.1%	16.41	16.36	-0.2%
2026	20.16	20.13	-0.2%	20.20	20.14	-0.3%
2031	23.08	23.04	-0.2%	23.30	23.23	-0.3%
2036	25.08	25.04	-0.2%	25.75	25.67	-0.3%
2041	25.52	25.48	-0.2%	27.18	27.10	-0.3%
Thyroid cancer						
INCIDENCE						
2016	21.46	21.36	-0.5%	21.46	21.31	-0.7%
2021	22.80	22.69	-0.5%	22.78	22.62	-0.7%
2026	23.99	23.87	-0.5%	23.95	23.77	-0.7%
2031	24.52	24.41	-0.5%	24.46	24.28	-0.7%
2036	24.25	24.14	-0.5%	24.19	24.02	-0.7%
2041	23.41	23.31	-0.5%	23.40	23.24	-0.7%
MORTALITY						
2016	0.54	0.54	0.0%	0.54	0.54	0.0%
2021	0.67	0.67	-0.1%	0.67	0.67	-0.1%
2026	0.83	0.83	-0.1%	0.83	0.83	-0.2%
2031	0.97	0.97	-0.2%	0.97	0.96	-0.3%
2036	1.11	1.10	-0.3%	1.10	1.09	-0.4%
2041	1.24	1.24	-0.3%	1.23	1.22	-0.4%
Uterine cancer						
INCIDENCE						
2016	37.77	37.19	-1.5%	37.77	36.86	-2.4%
2021	44.16	43.50	-1.5%	44.16	43.09	-2.4%
2026	51.63	50.89	-1.4%	51.63	50.39	-2.4%
2031	59.11	58.27	-1.4%	59.12	57.69	-2.4%
2036	66.73	65.79	-1.4%	66.78	65.16	-2.4%

	SSBs			Sugary drinks		
	Business as usual scenario Cases per 100,000	Intervention scenario Cases per 100,000	% change in disease rate	Business as usual scenario Cases per 100,000	Intervention scenario Cases per 100,000	% change in disease rate
2041	74.81	73.77	-1.4%	74.93	73.11	-2.4%
MORTALITY						
2016	6.08	6.08	-0.1%	6.08	6.07	-0.1%
2021	7.51	7.48	-0.4%	7.51	7.46	-0.7%
2026	9.46	9.39	-0.8%	9.46	9.34	-1.2%
2031	11.31	11.20	-1.0%	11.30	11.12	-1.6%
2036	13.30	13.14	-1.2%	13.29	13.04	-1.9%
2041	15.51	15.31	-1.3%	15.50	15.18	-2.1%
Ischemic heart disease						
INCIDENCE						
2016	474.79	469.09	-1.2%	474.79	466.17	-1.8%
2021	551.41	545.56	-1.1%	551.28	542.25	-1.6%
2026	644.52	638.33	-1.0%	644.25	634.57	-1.5%
2031	732.41	726.26	-0.8%	732.20	722.38	-1.3%
2036	811.52	805.57	-0.7%	812.30	802.55	-1.2%
2041	880.40	874.59	-0.7%	883.77	874.03	-1.1%
PREVALENCE						
2016	6,636.63	6,633.79	0.0%	6,636.16	6,631.88	-0.1%
2021	7,984.26	7,958.29	-0.3%	7,976.42	7,937.26	-0.5%
2026	9,643.44	9,588.52	-0.6%	9,631.60	9,548.67	-0.9%
2031	11,287.03	11,203.40	-0.7%	11,269.45	11,143.22	-1.1%
2036	12,996.74	12,886.48	-0.8%	12,973.80	12,807.17	-1.3%
2041	14,735.49	14,600.99	-0.9%	14,709.07	14,505.43	-1.4%
MORTALITY						
2016	75.37	75.35	0.0%	75.37	75.33	0.0%
2021	106.98	106.74	-0.2%	106.85	106.48	-0.3%
2026	158.98	158.43	-0.3%	158.83	157.95	-0.6%
2031	200.05	199.14	-0.5%	199.93	198.47	-0.7%
2036	245.14	243.83	-0.5%	245.18	243.07	-0.9%
2041	297.91	296.18	-0.6%	298.40	295.61	-0.9%
Ischemic stroke						
INCIDENCE						
2016	37.77	37.40	-1.0%	37.77	37.19	-1.5%
2021	50.94	50.54	-0.8%	50.93	50.29	-1.3%
2026	69.79	69.33	-0.7%	69.76	69.02	-1.1%
2031	86.04	85.55	-0.6%	86.05	85.24	-0.9%
2036	101.86	101.35	-0.5%	102.10	101.25	-0.8%
2041	117.53	117.02	-0.4%	118.42	117.55	-0.7%
PREVALENCE						
2016	354.56	354.37	-0.1%	354.55	354.26	-0.1%
2021	427.72	426.03	-0.4%	427.39	424.80	-0.6%
2026	525.15	521.62	-0.7%	524.65	519.26	-1.0%
2031	622.83	617.55	-0.8%	622.02	614.01	-1.3%
2036	722.87	716.06	-0.9%	721.71	711.39	-1.4%

	SSBs			Sugary drinks		
	Business as usual scenario Cases per 100,000	Intervention scenario Cases per 100,000	% change in disease rate	Business as usual scenario Cases per 100,000	Intervention scenario Cases per 100,000	% change in disease rate
2041	826.05	817.94	-1.0%	824.58	812.30	-1.5%
MORTALITY						
2016	15.53	15.52	0.0%	15.53	15.52	0.0%
2021	25.11	25.07	-0.2%	25.09	25.01	-0.3%
2026	38.45	38.34	-0.3%	38.49	38.29	-0.5%
2031	50.40	50.22	-0.4%	50.51	50.20	-0.6%
2036	63.02	62.77	-0.4%	63.28	62.86	-0.7%
2041	77.01	76.70	-0.4%	77.62	77.08	-0.7%
Hemorrhagic stroke						
INCIDENCE						
2016	15.40	15.12	-1.8%	15.40	14.99	-2.7%
2021	19.78	19.49	-1.5%	19.78	19.34	-2.2%
2026	26.48	26.15	-1.3%	26.47	25.96	-1.9%
2031	32.40	32.05	-1.1%	32.39	31.85	-1.7%
2036	38.28	37.93	-0.9%	38.29	37.74	-1.4%
2041	44.49	44.14	-0.8%	44.58	44.01	-1.3%
PREVALENCE						
2016	112.15	112.02	-0.1%	112.15	111.95	-0.2%
2021	128.81	127.69	-0.9%	128.76	127.11	-1.3%
2026	153.69	151.57	-1.4%	153.61	150.48	-2.0%
2031	179.04	176.08	-1.7%	178.89	174.55	-2.4%
2036	204.53	200.96	-1.7%	204.32	199.08	-2.6%
2041	231.48	227.52	-1.7%	231.19	225.36	-2.5%
MORTALITY						
2016	10.69	10.68	-0.1%	10.69	10.68	-0.1%
2021	13.89	13.81	-0.6%	13.88	13.75	-0.9%
2026	18.75	18.58	-0.9%	18.74	18.48	-1.4%
2031	23.42	23.19	-1.0%	23.41	23.04	-1.6%
2036	28.37	28.07	-1.1%	28.35	27.89	-1.6%
2041	33.92	33.57	-1.0%	33.92	33.38	-1.6%
Hypertensive heart disease						
PREVALENCE						
2016	79.42	79.33	-0.1%	79.42	79.27	-0.2%
2021	102.15	101.28	-0.8%	102.13	100.67	-1.4%
2026	135.94	133.99	-1.4%	135.97	132.68	-2.4%
2031	170.30	167.27	-1.8%	170.46	165.33	-3.0%
2036	210.32	206.19	-2.0%	210.74	203.71	-3.3%
2041	258.24	253.00	-2.0%	259.16	250.12	-3.5%
CKD due to diabetes mellitus						
PREVALENCE						
2016	2,933.75	2,932.23	-0.1%	2,933.63	2,931.28	-0.1%
2021	3,404.49	3,398.23	-0.2%	3,405.31	3,391.28	-0.4%
2026	4,040.66	4,015.07	-0.6%	4,040.66	3,997.41	-1.1%
2031	4,692.59	4,645.36	-1.0%	4,692.58	4,616.75	-1.6%

	SSBs			Sugary drinks		
	Business as usual scenario Cases per 100,000	Intervention scenario Cases per 100,000	% change in disease rate	Business as usual scenario Cases per 100,000	Intervention scenario Cases per 100,000	% change in disease rate
2036	5,387.76	5,317.76	-1.3%	5,388.90	5,278.82	-2.0%
2041	6,143.56	6,050.67	-1.5%	6,147.43	6,002.64	-2.4%
MORTALITY						
2016	4.76	4.76	0.0%	4.76	4.76	-0.1%
2021	6.80	6.81	0.1%	6.61	6.61	-0.1%
2026	10.16	10.14	-0.2%	10.26	10.20	-0.6%
2031	13.52	13.45	-0.5%	13.59	13.44	-1.1%
2036	17.01	16.87	-0.8%	17.09	16.84	-1.5%
2041	21.49	21.25	-1.1%	21.57	21.17	-1.9%
CKD due to hypertension						
PREVALENCE						
2016	1,488.64	1,487.86	-0.1%	1,488.57	1,487.37	-0.1%
2021	1,734.58	1,727.13	-0.4%	1,733.35	1,722.03	-0.7%
2026	2,069.01	2,052.13	-0.8%	2,067.62	2,041.76	-1.3%
2031	2,412.83	2,385.49	-1.1%	2,411.33	2,369.38	-1.7%
2036	2,770.79	2,732.33	-1.4%	2,769.47	2,710.54	-2.1%
2041	3,168.57	3,118.56	-1.6%	3,167.96	3,091.30	-2.4%
MORTALITY						
2016	3.16	3.16	0.0%	3.16	3.16	0.0%
2021	5.12	5.11	-0.2%	5.12	5.10	-0.4%
2026	8.00	7.97	-0.4%	8.01	7.95	-0.8%
2031	10.67	10.60	-0.6%	10.69	10.57	-1.1%
2036	13.72	13.60	-0.9%	13.76	13.55	-1.5%
2041	17.53	17.34	-1.1%	17.59	17.27	-1.8%
CKD due to glomerulonephritis						
PREVALENCE						
2016	2,042.39	2,041.06	-0.1%	2,042.30	2,040.29	-0.1%
2021	2,460.22	2,447.67	-0.5%	2,458.57	2,439.52	-0.8%
2026	3,036.61	3,008.05	-0.9%	3,033.72	2,990.15	-1.4%
2031	3,636.29	3,589.88	-1.3%	3,631.24	3,560.39	-2.0%
2036	4,277.47	4,212.28	-1.5%	4,269.50	4,170.04	-2.3%
2041	4,982.64	4,898.24	-1.7%	4,971.06	4,842.37	-2.6%
MORTALITY						
2016	0.79	0.79	0.0%	0.79	0.79	-0.1%
2021	1.41	1.41	-0.2%	1.41	1.40	-0.4%
2026	2.27	2.26	-0.4%	2.27	2.25	-0.7%
2031	3.02	3.00	-0.7%	3.02	2.99	-1.1%
2036	3.94	3.90	-0.9%	3.94	3.88	-1.6%
2041	5.08	5.02	-1.2%	5.09	4.99	-1.9%
CKD due to other causes						
PREVALENCE						
2016	2,012.01	2,010.89	-0.1%	2,011.92	2,010.20	-0.1%
2021	2,372.62	2,362.00	-0.4%	2,370.99	2,354.81	-0.7%
2026	2,850.63	2,826.60	-0.8%	2,848.55	2,811.78	-1.3%

	SSBs			Sugary drinks		
	Business as usual scenario Cases per 100,000	Intervention scenario Cases per 100,000	% change in disease rate	Business as usual scenario Cases per 100,000	Intervention scenario Cases per 100,000	% change in disease rate
2031	3,342.48	3,303.43	-1.2%	3,339.87	3,280.03	-1.8%
2036	3,867.52	3,812.47	-1.4%	3,864.61	3,780.25	-2.2%
2041	4,440.57	4,368.96	-1.6%	4,437.76	4,328.06	-2.5%
MORTALITY						
2016	0.06	0.06	0.0%	0.06	0.06	-0.1%
2021	0.14	0.14	-0.2%	0.14	0.14	-0.2%
2026	0.38	0.38	-0.2%	0.38	0.38	-0.3%
2031	0.57	0.57	-0.3%	0.58	0.57	-0.5%
2036	0.76	0.76	-0.5%	0.77	0.76	-0.8%
2041	1.05	1.04	-0.7%	1.05	1.04	-1.3%
Osteoarthritis of the hip						
PREVALENCE						
2016	2,215.36	2,215.18	0.0%	2,214.08	2,213.81	0.0%
2021	2,532.02	2,530.34	-0.1%	2,517.33	2,514.93	-0.1%
2026	2,872.76	2,869.23	-0.1%	2,848.16	2,843.09	-0.2%
2031	3,168.94	3,163.56	-0.2%	3,130.60	3,122.90	-0.2%
2036	3,400.82	3,393.76	-0.2%	3,347.09	3,337.04	-0.3%
2041	3,584.87	3,576.32	-0.2%	3,515.75	3,503.60	-0.3%
Osteoarthritis of the knee						
PREVALENCE						
2016	4,786.45	4,785.16	0.0%	4,785.53	4,783.68	0.0%
2021	5,510.63	5,498.72	-0.2%	5,500.78	5,483.72	-0.3%
2026	6,428.26	6,402.11	-0.4%	6,411.87	6,374.19	-0.6%
2031	7,323.93	7,282.58	-0.6%	7,298.65	7,239.03	-0.8%
2036	8,177.55	8,121.05	-0.7%	8,142.22	8,060.82	-1.0%
2041	9,046.33	8,974.59	-0.8%	9,000.68	8,897.24	-1.1%
Low back pain						
PREVALENCE						
2016	14,598.79	14,598.45	0.0%	14,559.25	14,558.78	0.0%
2021	15,047.43	15,044.49	0.0%	14,716.93	14,712.88	0.0%
2026	14,440.90	14,434.96	0.0%	13,955.11	13,947.01	-0.1%
2031	13,660.21	13,651.75	-0.1%	12,996.60	12,985.25	-0.1%
2036	12,621.50	12,611.27	-0.1%	11,781.11	11,767.65	-0.1%
2041	11,270.06	11,258.97	-0.1%	10,269.89	10,255.62	-0.1%

CKD, chronic kidney disease; SSB, sugar-sweetened beverage

DEATHS

Appendix E, Table 25. Postponed deaths due to 20% beverage taxes, 2016-2041

	SSBs		Sugary drinks	
	Mean	(95% UI)	Mean	(95% UI)
Postponed deaths				
Males	5,031	(4,023, 6,155)	7,753	(6,255, 9,274)
Females	3,052	(2,391, 3,778)	4,980	(4,013, 5,993)
Total	8,083	(6,660, 9,665)	12,734	(10,648, 14,948)

95% UI, 95% uncertainty intervals; SSB, sugar-sweetened beverage

DISABILITY ADJUSTED LIFE YEARS (DALYS)

Appendix E, Table 26. Averted DALYs due to 20% beverage taxes, 2016-2041

	SSBs		Sugary drinks	
	Mean	(95% UI)	Mean	(95% UI)
Averted DALYs				
Males	179,832	(146,282, 218,304)	259,667	(215,906, 308,042)
Females	134,494	(107,837, 162,336)	201,145	(166,311, 238,087)
Total	314,326	(256,268, 376,504)	460,812	(390,171, 535,277)

95% UI, 95% uncertainty intervals; SSB, sugar-sweetened beverage

HEALTH CARE COSTS SAVINGS

Appendix E, Table 27. Health care costs savings due to 20% beverage taxes, 2016-2041

	SSBs		Sugary drinks	
	Mean	(95% UI)	Mean	(95% UI)
Health care costs				
Males	$4,563,842,903	($3,715,382,441, $5,533,414,131)	$6,461,763,342	($5,364,378,012, $7,694,280,173)
Females	$2,968,842,431	($2,381,367,179, $3,570,842,263)	$4,424,598,467	($3,639,705,109, $5,275,577,721)
Total	$7,532,685,334	($6,161,778,552, $8,982,807,845)	$10,886,361,809	($9,199,719,561, $12,700,899,203)

*2015 Canadian dollars
95% UI, 95% uncertainty intervals; SSB, sugar-sweetened beverage

TAX REVENUE

Appendix E, Table 28. Tax revenue due to 20% beverage taxes, 2016-2041

	SSBs		Sugary drinks	
	Mean	(95% UI)	Mean	(95% UI)
Tax revenue				
Annual (2016)	$1,032,395,974	($999,323,908, $1,065,318,498)	$1,419,265,323	($1,377,467,447, $1,462,623,693)
25-year total	$25,809,899,350		$35,481,633,075	

*2015 Canadian dollars
95% UI, 95% uncertainty intervals; SSB, sugar-sweetened beverage

Appendix E, Table 29. Sensitivity analyses for 20% beverage taxes, 2016-2041

	SSBs		**Sugary drinks**	
	Mean	(95% UI)	Mean	(95% UI)
1) BMI remains at 2015 levels				
Deaths	6,799	(5,436, 8,331)	11,191	(9,207, 13,386)
DALYs	285,801	(236,468, 337,499)	425,342	(358,933, 495,699)
Health care costs savings	$7,031,392,535	($5,864,960,169, $8,285,137,202)	$10,185,051,470	($8,599,872,483, $11,853,807,458)
Tax revenue (annual)	$1,032,240,896	($997,293,336, $1,064,146,090)	$1,419,712,102	($1,378,306,610, $1,462,683,530)
Tax revenue	$25,806,022,407		$35,492,802,547	
2) Effect of tax on health capped at 10 years				
Deaths	3,939	(3,258, 4,687)	5,897	(4,986, 6,916)
DALYs	194,304	(159,875, 229,179)	284,875	(241,734, 331,737)
Health care costs savings	$4,150,464,686	($3,404,263,312, $4,914,834,171)	$5,910,649,536	($4,992,882,934, $6,919,091,136)
Tax revenue (annual)	$1,032,680,196	($1,001,510,191, $1,064,695,657)	$1,419,653,166	($1,376,158,626, $1,460,950,700)
Tax revenue	$25,817,004,902		$35,491,329,159	
3) Upper boundary of own-price elasticity of demand				
Deaths	7,079	(6,095, 8,127)	11,369	(9,969, 12,884)
DALYs	276,631	(240,328, 314,092)	412,489	(363,185, 462,405)
Health care costs savings	$6,647,321,933	($5,794,625,786, $7,558,166,286)	$9,757,418,075	($8,558,832,251, $10,982,484,601)
Tax revenue (annual)	$1,059,014,844	($1,039,816,647, $1,078,654,960)	$1,456,920,570	($1,436,062,012, $1,477,769,561)
Tax revenue	$26,475,371,094		$36,423,014,254	
4a) No substitute or complement beverages				
Deaths	9,444	(7,883, 11,029)	13,315	(11,234, 15,588)
DALYs	353,597	(299,537, 410,837)	478,054	(403,551, 555,852)
Health care costs savings	$8,435,268,360	($7,099,328,294, $9,778,965,254)	$11,276,576,197	($9,573,236,247, $13,122,493,866)
Tax revenue (annual)	$1,032,360,611	($998,340,498, $1,066,428,627)	$1,419,962,679	($1,375,927,079, $1,462,218,810)
Tax revenue	$25,809,015,287		$35,499,066,977	
4b) 50% energy compensation				
Deaths	4,722	(3,980, 5,553)	6,696	(5,705, 7,867)
DALYs	199,084	(164,885, 236,919)	269,537	(220,949, 321,425)
Health care costs savings	$4,765,143,116	($3,954,108,586, $5,635,512,235)	$6,378,516,992	($5,247,438,395, $7,565,586,457)
Tax revenue (annual)	$1,031,977,061	($1,000,231,662, $1,065,370,611)	$1,419,726,694	($1,379,697,028, $1,463,446,256)
Tax revenue	$25,799,426,527		$35,493,167,349	
5a) Tax pass-on 80%				
Deaths	6,740	(5,551, 8,088)	10,574	(8,808, 12,449)
DALYs	262,215	(218,138, 310,691)	384,387	(323,764, 451,501)
Health care costs savings	$6,300,930,956	($5,226,088,860, $7,472,840,577)	$9,094,095,520	($7,620,178,046, $10,676,787,864)
Tax revenue (annual)	$1,074,906,860	($1,043,289,857, $1,104,443,868)	$1,478,558,384	($1,440,868,264, $1,517,259,008)
Tax revenue	$26,872,671,488		$36,963,959,606	
5b) Tax pass-on 120%				
Deaths	9,313	(7,713, 11,098)	14,735	(12,366, 17,323)
DALYs	362,457	(302,578, 427,536)	532,655	(449,882, 617,639)
Health care costs savings	$8,674,206,145	($7,243,651,121, $10,216,386,103)	$12,571,345,348	($10,645,864,274,
Tax revenue (annual)	$992,831,007	($957,691,520, $1,031,087,821)	$1,365,036,922	($1,319,071,677, $1,409,908,972)
Tax revenue	$24,820,775,175		$34,125,923,047	
6a) Pre-tax beverage price 25% lower				
Deaths	8,094	(6,616, 9,702)	12,784	(10,792, 15,117)
DALYs	314,302	(260,397, 371,922)	462,920	(389,587, 538,103)

	SSBs		Sugary drinks	
	Mean	(95% UI)	Mean	(95% UI)
Health care costs savings	$7,535,093,203	($6,249,838,063, $8,928,839,463)	$10,924,563,403	($9,192,151,918, $12,737,453,111)
Tax revenue (annual)	$767,758,864	($743,431,441, $792,724,842)	$1,056,149,204	($1,024,819,945, $1,086,511,890)
Tax revenue	$19,193,971,592		$26,403,730,090	
6b) Pre-tax beverage price 25% higher				
Deaths	8,058	(6,671, 9,635)	12,777	(10,719, 15,017)
DALYs	312,657	(259,885, 368,762)	462,931	(390,198, 536,228)
Health care costs savings	$7,494,282,490	($6,241,772,419, $8,834,437,682)	$10,933,462,333	($9,214,622,341, $12,727,079,512)
Tax revenue (annual)	$1,292,414,299	($1,251,561,435, $1,336,750,775)	$1,777,699,986	($1,724,538,756, $1,832,188,964)
Tax revenue	$32,310,357,476		$44,442,499,641	
7) Health gain, costs and revenue discounted by 3%				
Deaths	8,105	(6,686, 9,631)	12,801	(10,715, 15,053)
DALYs	198,784	(164,778, 234,955)	291,728	(246,932, 341,114)
Health care costs savings	$4,923,959,190	($4,104,794,646, $5,840,155,049)	$7,137,430,515	($6,028,795,389, $8,397,324,092)
Tax revenue (2016)*	$1,032,009,079	($999,430,154, $1,064,148,098)	$1,419,791,015	($1,378,472,161, $1,462,941,638)
Tax revenue*	$18,509,642,311		$25,464,721,559	

*Tax revenue calculated by discounting 2016 revenue at rate of 3% annually
95% UI, 95% uncertainty intervals; BMI, body-mass index; DALYs, disability-adjusted life years; SSB, sugar-sweetened beverage

Appendix E, Table 30. Summary of health and economic benefits from 10% beverage taxes, 2016-2041*

	SSBs		Sugary drinks	
	Mean	(95% UI)	Mean	(95% UI)
Deaths postponed	4,472	(3,642, 5,370)	7,036	(5,855, 8,283)
DALYs averted	174,021	(143,740, 208,244)	256,157	(216,287, 301,036)
Overweight & obesity cases	246,768	(210,998, 282,728)	352,156	(305,534, 399,594)
Diabetes*	80,794	(62,501, 101,228)	114,650	(90,989, 141,385)
Ischemic heart disease*	20,734	(16,004, 26,110)	32,198	(25,284, 40,110)
Cancer*				
Esophageal	332	(119, 598)	587	(198, 1,033)
Colon and rectum	1,101	(847, 1,380)	1,911	(1,504, 2,374)
Liver	321	(149, 521)	544	(257, 875)
Gallbladder & biliary track	184	(113, 266)	352	(220, 502)
Pancreas	147	(47, 251)	263	(96, 454)
Breast	2,416	(707, 4,296)	4,193	(1,382, 7,642)
Uterine	1,351	(1,097, 1,625)	2,244	(1,870, 2,667)
Ovarian	33	(-7, 76)	55	(-12, 129)
Kidney	616	(467, 780)	1,025	(779, 1,278)
Thyroid	369	(237, 517)	552	(360, 757)
Leukemia	212	(126, 302)	377	(236, 537)
Stroke*				
Ischemic	1,619	(1,183, 2,102)	2,616	(1,903, 3,384)
Hemorrhagic	1,131	(778, 1,551)	1,755	(1,194, 2,421)
Health care costs savings	$4,211,728,150	($3,479,879,454, $5,027,070,950)	$6,095,910,848	($5,139,270,905, $7,171,382,080)
Tax revenue (annual)	$572,740,974	($559,550,913, $586,158,370)	$788,032,407	($771,712,969, $803,507,838)
Tax revenue	$14,318,524,347		$19,700,810,185	

*For disease conditions, refers to incident cases prevented
Note: The negative values are due to random variability in inputs throughout the model and the limited degree of certainty in inputs.
95% UI, 95% uncertainty intervals; DALYs, disability-adjusted life years; SSB, sugar-sweetened beverage

Appendix E, Table 31. Summary of health and economic benefits from 30% beverage taxes, 2016-2041*

	SSBs		Sugary drinks	
	Mean	(95% UI)	Mean	(95% UI)
Deaths postponed	10,981	(9,135, 13,095)	17,427	(14,655, 20,433)
DALYs averted	425,939	(354,704, 504,408)	628,640	(536,134, 725,484)
Overweight & obesity	617,021	(532,370, 702,847)	892,438	(784,580, 1,008,178)
Diabetes*	194,123	(151,215, 239,852)	276,236	(221,409, 334,633)
Ischemic heart disease*	50,514	(39,568, 62,557)	79,699	(62,603, 97,598)
Cancer*				
Esophageal	818	(272, 1,447)	1,439	(506, 2,556)
Colon and rectum	2,669	(2,069, 3,322)	4,725	(3,683, 5,767)
Liver	785	(340, 1,288)	1,364	(666, 2,168)
Gallbladder & biliary track	450	(272, 649)	859	(539, 1,215)
Pancreas	348	(120, 608)	649	(220, 1,114)
Breast	5,970	(1,941, 11,020)	10,411	(3,371, 18,343)
Uterine	3,295	(2,688, 3,956)	5,531	(4,618, 6,486)
Ovarian	81	(-20, 192)	143	(-32, 316)
Kidney	1,500	(1,140, 1,886)	2,551	(1,990, 3,148)
Thyroid	905	(584, 1,247)	1,379	(905, 1,912)
Leukemia	515	(308, 730)	933	(566, 1,342)
Stroke*				
Ischemic	3,922	(2,907, 5,078)	6,442	(4,670, 8,459)
Hemorrhagic	2,767	(1,907, 3,796)	4,265	(2,905, 5,846)
Health care costs savings	$10,167,558,358	($8,477,936,043, $12,107,654,028)	$14,805,659,367	($12,599,391,949, $17,095,690,201)
Tax revenue (annual)	$1,406,498,662	($1,351,030,246, $1,466,980,397)	$1,936,563,226	($1,861,630,901, $2,013,904,504)
Tax revenue	$35,162,466,561		$48,414,080,650	

*For disease conditions, refers to incident cases prevented
Note: The negative values are due to random variability in inputs throughout the model and the limited degree of certainty in inputs.
95% UI, 95% uncertainty intervals; DALYs, disability-adjusted life years; SSB, sugar-sweetened beverage