Evaluating a Sugar-Sweetened Beverage Tax in Canada: A Cost-Benefit Analysis

By

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An essay submitted to the Department of Economics

in partial fulfillment of the requirements for the degree

of Master of Arts

Queen's University

Kingston, Ontario, Canada

September 2021

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Acknowledgements

I would like to express my gratitude and appreciation for Dr. Allen Head for his supervision and support throughout the development of this essay. I would also like to thank Limestone Analytics for the opportunity to work on empirical projects that have substantially strengthened my knowledge and enjoyment in economics.

I lastly would like to thank my colleagues for the great memories during my master's degree, especially Zachary Robb, André Labossière, Trevor Knetchel, Joel Jackson, Léo Leroux, and Deaglan Jakob.

All errors and omissions are solely my responsibility.

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Abstract

Non-communicable diseases (NCDs) place substantial health and economic burdens on Canadians and the public health system. While not all NCDs can be prevented by improving nutritional health, sugar-sweetened beverages (SSBs) have been linked to higher risks of type 2 diabetes and obesity-related cancers and chronic diseases. The early indicators among nearly 50 local and national SSB taxes around the world have influenced Canadian provinces such as British Columbia and Newfoundland and Labrador to implement their own province-wide SSB tax. With the growing interest in a federal tax, the purpose of this paper is to model the benefits against the costs of implementing a 20% SSB tax in Canada via cost-benefit analysis (CBA). Sensitivity analysis and 1,000 Monte Carlo simulations are conducted to handle uncertainties in the model. Stakeholder analysis is then utilized to understand how the benefits and costs affect different members of society. Health improvements are presented as disability-adjusted life years (DALYs), which are then converted into dollar values using the value of a statistical life year (VSLY). The result of the CBA estimates a net present value (NPV) of $25.7 billion, while the cost-effectiveness fails to meet the World Health Organization's recommended threshold. Taking a less conservative approach increases the NPV four-fold and makes the SSB tax very cost-effective. While the model predicts a net benefit to society, concerns still remain around potential job losses in the retail industry and the regressive nature of a flat tax rate.

1. Introduction

Non-communicable diseases (NCDs) have been on the rise in Canada and have become the leading cause of death in the country.[1] While NCDs are not entirely preventable by improving nutritional health, the prevalence of diet-related NCDs such as obesity-related chronic illnesses and type 2 diabetes have emerged as a growing problem among the country's population. In 2018, 26.8% of adult Canadians were estimated to have a body-mass index (BMI) classified as obesity, equivalent to over 8 million Canadians.[2] In 2019, 7.6% of Canadians aged 20 and older were estimated to have diabetes, equivalent to over 2.3 million Canadians.[3] From these cases of diabetes, only 10% are genetically inherited type 1 diabetes. While there are no reliable and publicly available updated estimates on the prevalence of obesity and diabetes for 2021, the 2020 Global Nutrition Report on Canada states that Canada has shown little or worsening progress on reducing diet-related NCDs.[4] Given the prevalence of these chronic diseases and their upward trajectory, there is an opportunity for national programs to influence better health outcomes for Canadians.

When focusing on the effect that diet-related NCDs have on the economy, obesity and diabetes produce significant burdens on Canada's economy. Twells et al. (2014) estimated that the annual direct cost of healthcare for obesity-related cancers and chronic diseases in 2017 to be between \$4.6 and \$7.1 billion (CAD), projecting to rise to \$8.8 billion in 2021.[5] The Public Health Agency of Canada estimated in 2010 (the most recent reliable estimate) that the cost of direct healthcare due to diabetes was just over \$6.1 billion.[6] The funds spent on healthcare costs

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[1] (PHAC and WHO 2019)
[2] (Statistics Canada 2017)
[3] (International Diabetes Federation 2019)
[4] (Global Nutrition Report 2020)
[5] (Twells et al. 2014)
[6] (EBIC Tool 2010)

due to these chronic diseases are funds that could flow into other sectors of the economy. Thus, the economic burden of diet-related NCDs gives the government of Canada an incentive to influence behaviours that reduce their prevalence.

Though the causes of obesity and diabetes are complex, the overconsumption of sugar-sweetened beverages (SSBs) has contributed to the rise of sugar in diets. An estimated $9 billion (CAD) was spent on flavoured soft drinks in Canada in 2020 alone.[7] The World Health Organization (WHO) recommends that individuals should limit their free sugar intake to 10% or less per day.[8] A single 355mL can of soda contains up to 80% of this limit, and many Canadians surpass this limit from consuming SSBs alone.[9]

The proposed solution to reduce the prevalence of obesity and type 2 diabetes in Canada is to introduce a nationwide 20% *ad valorem* excise tax on all SSBs effective January 1, 2021. The rate of 20% is based on the WHO's recommendation.[10] SSBs are defined as any drinks that include added sugars or sweeteners such as soft drinks, fruit drinks, juices, sports drinks, energy drinks, sweetened milk, teas, and waters.[11]

There have been multiple studies on the impact of SSB taxes in various countries and therefore the purpose of this paper is not to assess whether a properly designed SSB tax can have a positive impact on health outcomes for Canadians. However, even in countries that have successfully reduced consumption of sugary drinks through SSB taxes, there are not many models that advocate for the monetary benefits to the economy. There is also a major concern on both economic and political fronts about the regressive nature of the taxation, as low-income

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[7] (Statistics Canada 2021)
[8] (Davies and Lindmeier 2015)
[9] (Pound and Critch 2020)
[10] (Waqanivalu et al. 2015)
[11] (CDC 2021)

households consume more SSBs due to a combination of a lack of nutritional awareness and low relative prices for energy intake. While this concern is commonly addressed in other contexts, there is a knowledge gap on how Canada can use its existing tax infrastructure to solve this issue. Addressing this knowledge gap can help articulate the economic benefits to the public as well as to policymakers involved with the implementation of the tax.

This paper contributes to the literature by evaluating the cost-effectiveness of a 20% SSB tax in Canada over the next 20 years, along with an additional focus on the various effects across different socioeconomic demographics. The analysis results in a significant net benefit to society, yet concerns around redistributing benefits and mitigating losses among stakeholders remain.

2. Literature Review

2.1 SSB Taxes in Other Contexts

The first section of this literature review looks at the experiences that other countries have had after implementing an SSB tax. It covers their year of implementation, the specific details of the tax, research designs to study the effectiveness of their respective tax, the result of these studies, and then a discussion on these findings. By looking at other countries, there should be a better understanding of what to expect based on the proposed 20% *ad valorem* tax in Canada. The two main countries studied are Chile and France for their wildly varying results, with an additional list of all known SSB taxes implemented in the world.

2.1.1 Chile

Chile implemented a tax on SSBs in 2014 called the Impuesto Adicional a las Bebidas Analcohólicas (IABA), translated to "the Additional Tax on Non-Alcoholic Beverages"[12] as part

[12] Translated via Google Translate

of a large tax reform to reduce obesity and diabetes among the population.[13] The IABA increased taxes on soft drinks above 6.25 grams of added sugar per 100 mL[14] and decreased taxes on drinks below this threshold. Drinks above and below the threshold were taxed at 18% and 10%, respectively (both originally at 13%). This design was to reduce the intake of sugar through SSBs while encouraging the consumption of healthier drink options.

To measure the impact of the IABA, Nakamura et al. (2018) used household-level food purchasing panel data collected by Kantar WorldPanel from 2011 to 2015. The data contained insights on 2,836 households' detailed transaction records on drinks based on household income, size of households, and BMI of household members. A second dataset was collected by the authors to get information on the sugar content for products that accounted for the top 90% of all soft drink sales. They combined these datasets to construct a monthly, household-level panel dataset to analyze the impact of the IABA policy on the volume of soft drinks purchased.

The methodology utilized a quasi-experimental approach to evaluate the impact of the SSB tax via time-series variation before and after the tax implementation in October 2014. Fixed-effects were used under the assumption that after controlling for unobserved characteristics, general time trends, and seasonality, all changes to outcome variables were due to the IABA. The outcome variables estimated were: Differential changes by tax category and share of soft drink purchases, the volume of sugar from soft drink items, and shopping patterns. While there were four outcome variables, they can be broken down into two groups: changes in the price of soft drinks and changes in the purchased quantities of soft drinks. They also included models that replaced the policy implementation date with the policy announcement date as the

[13] (Nakamura et al. 2018)
[14] Ibid.

treatment variable, under the assumption that the economy reacted due to the announcement of the IABA. Additional controls included quarterly regional unemployment and temperature.

When modelling the effect that the IABA had on prices, average soft drink prices increased by 1.6%, high-tax drinks increased in price by 1.9%, and low-tax drinks decreased by 1.7%. When modelling the effect on purchased quantities, the results indicated a decrease in the total volume of soft drinks purchased of roughly 6% and a substantial decrease in the monthly purchased volume of high-tax soft drinks by 21.6%. This corresponded to a reduction of 766mL per person per month for an average household. In addition, the IABA was estimated to reduce the amount of sugar purchased via soft drinks by 15.1%. When looking at the effect on the volume of low-taxed and untaxed soft drinks purchased, neither was affected by the IABA.

Lastly, Nakamura et al. (2018) looked at SES indicators and found that most of the reduction in high-tax drinks was driven by middle and high-SES groups and high pre-IABA purchasers. Low-SES groups were found to have a non-statistically significant reduction in the purchasing of high-tax drinks. Low-SES groups were also predicted to decrease their purchasing of low-tax drinks, however, that too was statistically insignificant. The concern is that while Nakamura et al.'s (2018) analysis predicted a strong decrease in the overall purchasing of SSBs, low-income households are maintaining their level of consumption despite higher effective prices. There have not been studies on the prevalence of obesity among various SES groups since the implementation of the IABA to analyze the distribution of health outcomes by household income.

2.1.2 French Soda Tax

France introduced a “soda tax” in January 2012 to discourage the consumption of drinks containing sugar and/or sweetener.[15] The tax was set to 0.0716 Euros per litre and is paid by manufacturers, processors, and importers.[16]

Capacci et al. (2019) estimated the price and consumption effects of the French soda tax using a difference-in-differences (DiD) approach with Italian household data as a natural control group. The combined dataset of French and Italian home-scan data contains 2,928 French households and 400 Italian households observed between 2011 and 2012. SES was accounted for through information on age, size of household, and income levels.

The DiD model estimated the impact of the soda tax on beverage prices and purchases using a panel regression with fixed cross-sectional effects and differential time trends. The outcome variables they regressed on are national consumer price indices (CPIs), regional average prices, household average purchases, and purchases by heavy soda consumers. Similar to the Chilean IABA, the results can be broken down into two groups: the impact on prices and the impact on purchased quantities.

When running their DiD regressions, the effect on prices after one year of treatment (soda tax), the CPI for soft drinks increased by 5.6% at the national level, with no significant effect on fruit juice prices. When expanding their analysis to include 5 years before and after the tax implementation (via common trends assumption), the CPI returns a larger increase of 8.2% on soft drinks and 4.2% on fruit juices. These findings coincide with Berardi et al. (2016), who have estimated a full tax pass-through for sodas and an almost full tax pass-through for fruit juices[17]. While the model estimated increases in the price of soft drinks, it found no significant changes in

[15] (Berardi et al. 2016)
[16] (Capacci 2019)
[17] (Berardi 2016)

the purchased quantities of soft drinks in any model. Thus, despite evidence that the tax passes through to the price of soft drinks, there was no evidence that it affected the purchasing behaviour of French households. While this would imply that the French soda tax has failed to affect the health outcomes of households, the goal of the soda tax may have been to generate tax revenue. This revenue can be spent on other expenditures that can improve the health, financial, and/or other outcomes of households. Additionally, a possible limitation to this study is that the use of Italian households as a natural control group. France and Italy have different obesity rates, marketing policies, and attitudes towards foods, among many other confounding factors that prevent causal inference of an SSB tax on obesity rates.

2.1.3 Learning Outcomes from Other Contexts

The Chilean IABA and the French soda tax are both similar fiscal policy measures, yet their effects on purchasing behaviour were found to differ substantially. The Chilean IABA decreased the purchasing of high-tax drinks substantially, leading to an overall decrease in the purchasing of soft drinks in Chile. It also produced a significant decrease in the purchasing of non-taxed drinks and an insignificant change in low-tax drinks, which may be evidence that the IABA has made households poorer overall. Using this information, the IABA teaches an important lesson that low and high-income households are affected differently, and therefore there should be additional measures to redistribute wealth among the economy. Additionally, there may be a need for additional interventions to target low-income households to reduce their consumption of high-tax drinks. The French soda tax on the other hand has not led to evidence of a reduction in the consumption of unhealthy sugary drinks despite an increase in their effective prices. While Chile and France differ in income levels, it is reasonable to believe that a strong portion of their contrasting results is due to the difference in policy design.

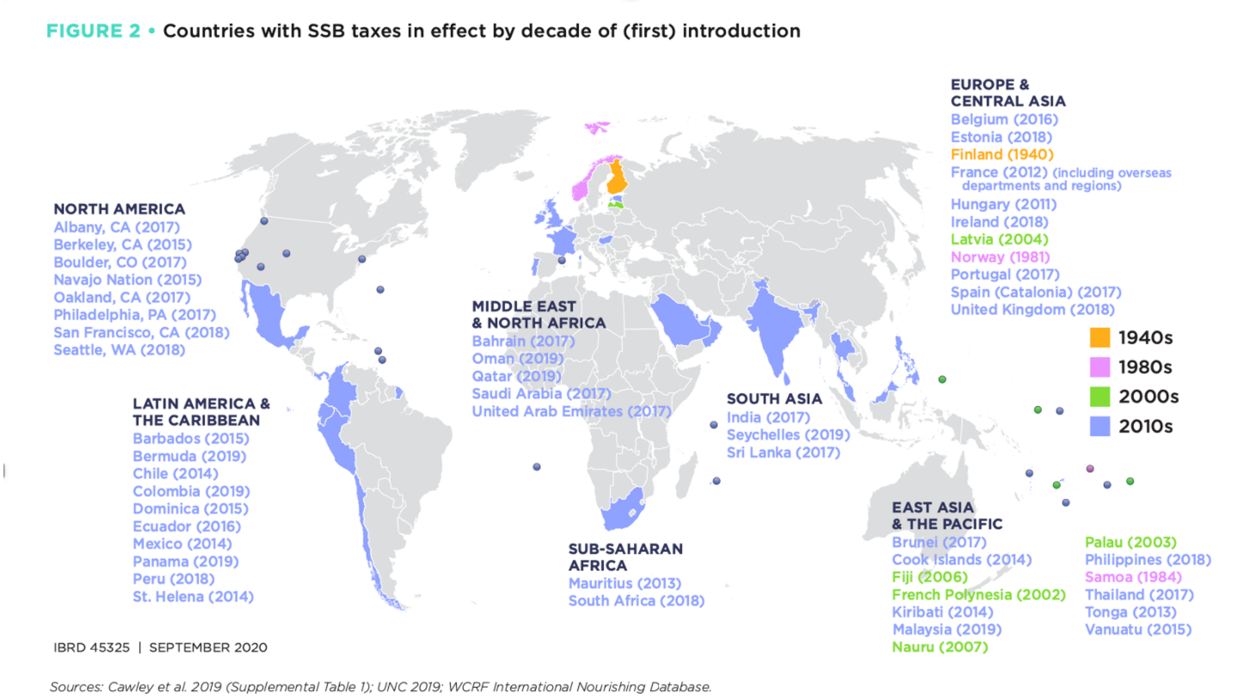
Given the findings between the two taxes, a concern for an SSB tax is whether they are effective or not, which may be up to the design of the policy. The Chilean IABA taxes a higher amount than the French soda tax while also incentivizing the purchasing of healthier alternatives. However, it is impossible to declare policy design as the definitive difference between the two results. The Chilean IABA was implemented as a portion of large tax reform to eradicate the consumption of unhealthy foods whereas the French soda tax was implemented as a standalone solution. Additionally, attitudes may be different, as Chile's obesity rate of 34.4%[18] (2016) is significantly higher than France's rate of 17% (2018)[19], perhaps indicating that French households were already keen to avoid the overconsumption of SSBs. Another concern would be if consumers are substituting their sugar intake through different sources of unhealthy foods or increasing their consumption of relatively healthy foods in excessive amounts. Lastly, there are again concerns about being a regressive tax, as there appears to be a dominant income effect on purchasing behaviour. Using these findings, this study uses sensitivity analysis on consumers' purchasing behaviour (price elasticity of demand) to consider the possibility that a 20% SSB tax in Canada reflects closer to the Chilean or French experience. Modelling these different possibilities on the economic effect of an SSB tax gives Canadian policymakers a better understanding of the risk associated with the tax. There is also a qualitative discussion on how Canada can redistribute the tax revenue to low SES households.

2.1.4 SSB Taxes Across the Globe

While sections **2.1.1-2.2.3** describe the experiences of SSB taxes in Chile and France, dozens of variations of SSB taxes exist across the globe in many countries and contexts. The graphic

[18] (OECD 2019)
[19] (OECD and Union 2020)

below contains a list of locations that have implemented an SSB tax.



List of Countries with SSB Taxes; sourced from the World Health Organization (WHO)[20]

The incentives for areas/countries of North America and Latin America and the Caribbean are clear, as SSB consumption per capita are among the highest in these regions[21]. In other regions where SSB consumption (and the risk of obesity through SSB consumption) are low, the incentives of an SSB tax may be to generate tax revenue or to proactively prevent a rise in obesity rates.

2.2 Existing Canadian Literature

The next vital part of this literature review is to look at the existing relevant literature on SSB taxes in a Canadian context. Included are sections on the current interest in Canada and its

[20] (Hattersley et al. 2020)
[21] Ibid.

provinces/territories to implement an SSB tax, and a recent study that models their health and economic impacts.

2.2.1 Status of SSB Taxes in Canada

There is already a great deal of interest and action of SSB taxes in Canada at the provincial level. British Colombia (BC) announced that effective April 1, 2021, soda beverages were no longer qualified for the exemption of food products for human consumption[22]. A 7% PST now applies to all retail sales of soda beverages, which are any carbonated or effervescent drinks that contain added sugar or any sweeteners. The government of Newfoundland and Labrador (NL) has recently followed suit by announcing an SSB tax that charges 20 cents per liter on any drinks with added sugar or sweetener, effective April 1, 2022[23]. In addition to the SSB tax, the government of NL also announced a “Physical Activity Tax Credit” (PATC) as a refundable tax credit up to $2,000 per family to increase sport and recreational activities access for children. The combination of the SSB tax and PATC serve to influence healthier choices for Canadians, generate revenue for the city of St. John’s, and ease the future burden on NL’s healthcare system.

The implementation of a PST exemption removal in BC and the announcement of an SSB tax in NL shows that there is growing interest in Canada to incentivize against the consumption of SSBs. As provincial interest continues to grow, it is a matter of time before policymakers for Canada’s federal government have a serious discussion on the taxation of SSBs.

2.2.2 Previous Impact Study in Canada

[22] (Government of BC 2021)
[23] (Government of NL 2021)

Jones's Ph.D. thesis (2018) models the health and economic impacts of a 20% tax in Canada[24]. While her study includes the disability-adjusted life years (DALYs) averted and the direct healthcare savings due to the tax policy, this analysis has identified opportunities to build upon her analysis. The DALYs averted can be assigned dollar values using the value of a statistical life (VSL) and the value of a statistical life year (VSLY). More importantly, her study focuses only on the benefits of an SSB tax in Canada whereas this paper models the costs and compares them with the benefits. Including these additional analyses provides a better understanding of the economic impacts as well as improvements to the advocacy of an SSB tax in Canada.

3. Data

3.1 Drink Purchases and Prices

Archived in 2001, Statistics Canada used to collect both household food expenditure and the price they were paying via their *Food Expenditure Survey* (FOODEX)[25]. Since then, there has not been a sufficient set of data that captures household purchasing behaviour in response to price changes. Statistics Canada has collected food purchasing data in the years 2004 and 2015 in the Canadian Community Health Survey (CCHS)[26], but this does not contain information on the price of SSBs. While the price of food and drink items does not change much over time, the long gap between the two years of data collection is vulnerable to confounding factors and therefore price elasticities cannot be reliably estimated. A more descriptive explanation of the price elasticities used in this analysis is presented in section **4.1.2**.

[24] (Jones 2018)
[25] (Statistics Canada 2003)
[26] (Statistics Canada 2021)

3.2 Diet-Related Noncommunicable Diseases

The prevalence of obesity is collected from Statistics Canada's Canadian Community Health Survey (CCHS) in 2015[27]. Given that the surveys are self-reported, heights tend to be overestimated while weight tends to be underestimated. This data is adjusted for this fact to prevent the underrepresentation of obesity in Canada. Diabetes is collected from the International Diabetes Federation's Diabetes Atlas, which is listed in the World Bank's publicly available database[28].

3.3 Relative Risk of Disease

The analysis calculates the reduction in obesity-related cancers and chronic diseases through their relative risk (RR) due to high BMI classified as obesity. The Global Burden of Disease 2019 (GBD 2019) contains a list of the relative risk of disease for over 30 diseases given that an individual has a high BMI classified as obese[29]. The RR of diabetes due to SSB consumption comes from a meta-analysis from Malik et al. (2010)[30]. The meta-analysis provides various RRs given different levels of daily SSB consumption.

3.4 Disability Weights

Disability weights were first established by the World Health Organization (WHO) during the development of the Global Burden of Disease. Disability weights represent the magnitude of health loss associated with specific health conditions or disabilities, where 0

[27] (Statistics Canada 2017)
[28] (International Diabetes Federation 2019)
[29] (Global Burden of Disease Collaborative Network 2020)
[30] (Malik et al. 2010)

equates to perfect health and 1 equates to death.[31] The Global Burden of Disease assigns disability weights to a comprehensive list of diseases with various levels of severity. While studies exist in some countries (e.g. Dutch Burden of Disease)[32] to recommend disability weights within their context, the GBD's disability weights were designed to be used in a global context. This implies that the burden of disease for individuals is equal across countries. Nonetheless, this analysis uses the GBD's most recently released list of age-controlled disability weights in 2019 due to the lack of Canadian-specific equivalents.

3.5 Population Age

The methodology to calculating the economic value of DALYs averted due to an SSB tax revolve around an age discounted VSLY to capture a more conservative value. This requires the Canadian population as well as disaggregating the population into separate age groups. The data comes from table 17-10-0005-01 from Statistics Canada, which uses information from the 2016 census to estimate the total population sorted by age from 2016 to 2020[33]. The results of the 2021 census have not been calculated at the time of this paper and therefore will use the estimated 2020 values to represent the population and its age characteristics at the start of 2021.

3.7 Healthcare Costs

All data on healthcare costs are estimated by the Public Health Agency of Canada using their publicly provided Economic Burden of Illness in Canada (EBIC), 2010[34]. The EBIC estimates the total expenditure on healthcare in both public and private sectors of health. While

[31] (Global Burden of Disease Collaborative Network 2020)
[32] (Melse et al. 2000)
[33] (Statistics Canada 2020)
[34] (PHAC 2017)

the 2021 EBIC may have increased due to a potential rise in total disease cases, improvements to technologies and healthcare productivity may put downward pressure on the EBIC. This is reflected in how the 2008 EBIC of $192.8 billion (2010 CAD)[35] decreased to $183.1 billion in 2010[36]. Dollar values are converted to 2021 CAD levels using CPI as all values in this analysis are standardized to 2021 CAD.

4. Methodology

The methodology in this section describes how the benefits and costs of a 20% *ad valorem* tax are calculated over 20 years in Canada beginning in 2021 and a discount rate of 3%. A sugar-sweetened beverage (SSB) is used synonymously with a sugary drink, which means that fruit juices are included in the tax as well. Data mining, quantitative analyses, and calculations are conducted in Microsoft Excel while graphs and are produced in Google Sheets.

4.1 Estimating Benefit 1 – Improved Health Outcomes

4.1.1 Building a Counterfactual

A counterfactual is created over the next 20 years using population growth forecasts from Statistics Canada (2021)[37] to estimate the effect of the tax. To capture the benefits against this counterfactual, prevalence in obesity and diabetes are multiplied with the forecasted population growth to estimate new cases of diet-related NCDs over the next 20 years. The prevalence of both obesity and diabetes are held constant because they may increase or decrease within that period. The benefits are underestimated if the prevalence of obesity increases in the next 20 years.

[35] (PHAC 2014)
[36] (PHAC 2017)
[37] (Statistics Canada 2019)

4.1.2 Price Elasticity

Price elasticity of demand represents the households' consumption response when given a change to the price of a good. In the case of an SSB tax, the tax raises the effective price of SSBs and therefore price elasticities can estimate how households will alter their consumption behaviour.

Price elasticity is usually calculated using methodology developed by Deaton (1990)[38] , which requires balanced panel data on SSB expenditure in response to price shifts over several years. However, the only reliable and publicly available dataset on food expenditure in Canada comes from Statistic Canada's CCHS 2015 and 2014 study. The gap between 2015 and 2004 makes the calculation of elasticities vulnerable to confounding factors that have affected SSB consumption and are unobserved in the data. These can be other policies at national or local levels, a shift in social norms, and/or reformulation of drinks. Two meta-analyses by Powell et al. (2012) and Bourke and Veerman (2018) report a self-price elasticity for SSBs of -1.21 (-3.87, 0.71)[39] and -1.20 (-1.34, -1.06), respectively.[40] The tighter 95% confidence interval from Bourke and Veerman is used for this analysis. Escobar et al. (2013) conduct a meta-analysis on the cross-price elasticities of SSB with milk, fresh juice, and diet sodas[41]. However, this paper equates an SSB with a sugary drink, making milk's cross-price elasticity the only energy-dense alternative drink. Water, coffee, and tea were considered but the lack of energy intake from these sources disqualified them from being included.

4.1.3 Consumption and Energy Intake

[38] (Deaton, 1990)
[39] (Powell 2012)
[40] (Bourke and Veerman 2018)
[41] (Escobar 2013)

$$\Delta Consumption_{SSB} = Consumption_{SSB}(e_{SSBSSB} * \Delta P_{SSB}) \quad (1)$$

$$\Delta Consumption_{Milk} = Consumption_{Milk}(e_{SSBMilk} * \Delta P_{SSB}) \quad (2)$$

- e_{ij} is the elasticity of j given a price change in i
- P is the price of good i

The price elasticities are multiplied with the change in the effective price due to a 20% SSB tax to estimate the change in consumption of SSBs and milk, modelled in equations (1) and (2). An assumption made in this step is that consumers are fully aware of the price increase in sugary drinks due to the introduction of the tax. However, given that prices presented in grocery stores are pre-tax, consumers may overestimate the final price of SSBs and reduce their consumption compared to if they were fully aware. Sensitivity analysis considers various tax rates, which would capture through inclusion the cases where consumers are not fully aware of the magnitude of the tax.

The effect on energy intake is calculated from the reduced consumption of SSBs using a rate of 176kJ per 100 grams[42]. The purpose of converting consumption into energy intake is to estimate weight changes using methodology from Hall et al. (2011)[43] and Swinburn et al. (2009).[44]

4.1.4 Reduced Cases of Diabetes and Obesity-related Diseases

$$\Delta Cases_{Diabetes} = (1 - RR_{Tax}) * Prevalence_{diabetes} \quad (3)$$

The relative risk (RR) of diabetes before and after the tax are used to calculate the reduced RR (RRR) due to the SSB tax. The RRR is then used in equation (3) to estimate the total

[42] (USDA 2019)
[43] (Hall et al. 2011)
[44] (Swinburn et al. 2009)

cases of diabetes reduced due to the tax. This process is repeated over the next 20 years to capture the reduction in new cases of diabetes.

$$\Delta Weight_{Tax} = \Delta Energy_{SSB} * (0.94\text{kg}/100) \quad (4)$$

This process differs for obesity. Energy intake reduction from the tax is used to calculate the weight change for the average adult. Weight change is particularly helpful because a percentage change in kilograms is equivalent to a percentage change in BMI, assuming height remains stable. Measuring the percentage change in the average adult requires an adjustment, as Canadians' weights are not uniformly distributed among the population. Without data on the distribution of obesity at the threshold (BMI ≥ 30), a correction is required to capture the reduction in obesity. Since there is a higher proportion of Canadians that are mildly obese than severely, a multiplier of 2 to the average weight change to capture the reduction in the prevalence of obesity.

The GBD (2019) contains a list of RRs for 33 cancers and diseases due to individuals having a high BMI classified as obese. The RRs of these diseases are used to calculate the proportion of these all cases that correlate with obesity. This process is done before and after the tax to estimate the reduction in all diseases and repeated over the next 20 years.

$$DALYs_{Diabetes} = (1 - RR_{Tax}) * Prevalence_{Diabetes} * DW_{Diabetes} * LE_{Diabetes} \quad (5)$$

$$DALYs_{Disease} = \Sigma_{n=1}^{33}[(Disease_{preTax} - Disease_{postTax}) * DW_{disease} * LE_{Obesity}] \quad (6)$$

The total reduced cases of cancers and diseases are multiplied with their respective disability weights from the Global Burden of Disease[45] and the average length of effect[46][47] to capture the DALYs averted by the project. All disability weights[48] reported are for the mildest cases of disease to coincide with the conservative approach of this paper's estimation of benefits.

The DALYs averted are then converted into dollar values by assigning the value of a statistical life year (VSLY) to each DALY. This conversion is covered in section **4.2**.

4.2 Quantifying Health Outcomes

4.2.1 Purpose

The quantification of health outcomes is an important step for companies and government organizations to better understand the financial impact of a project or policy. Since investments and operations are quantified in dollar values, it is important to standardize benefits with costs to make an equal comparison. Although there is no standard approach, researchers and economists in health, environment development, and other industries often use the value of a statistical life (VSL).

VSL does not directly measure how much a life is worth, rather it estimates an individual's willingness to pay (WTP) to reduce their risk of mortality, otherwise known as the marginal cost of safety. The advantage of using VSLs is that researchers can use individuals' actions to determine their WTP. If one person's WTP is $500 (USD) to reduce their risk of mortality by 1/10,000, then it would take 10,000 identical individuals to reduce one death, making the VSL

[45] (Global Burden of Disease Collaborative Network 2020)
[46] (Norris et al. 2020)
[47] (Hayashino et al. 2017)
[48] See appendix (table 7-8)

$5,000,000. To get the VSL over a total project, this figure is then multiplied with the total number of beneficiaries reached.

Reliable revealed preferences are the gold standard for calculating VSLs. In the context of VSLs, revealed preferences use individuals' actions to determine the value that consumers hold on their safety. There are many techniques to reveal these preferences. However, revealed preferences come with limitations. Data may not always be available or reliable enough to measure revealed preferences. Revealed preferences also deal with omitted variable bias: the difference in pricing may be due to other factors and thus confounds correlation with causation. In such cases, it may be necessary or more appropriate to survey beneficiaries to estimate their WTP. Rather than direct questions on how much individuals value their lives, surveys can question individuals on how much they are willing to risk their safety for additional rewards.

While many peer-reviewed studies calculate VSLs, the VSL chosen for this analysis is from Meng and Smith (1999)[49] (cited from Viscusi and Aldy, 2003)[50] because it uses revealed preferences of WTP through wage-risk studies in a Canadian context. They report a VSL of $5,200,000 ($5,100,000 - $5,300,000) per Canadian life (2000 USD).

4.2.2 Converting DALYs using VSL

The methodology of estimating health benefits in section **4.1** provides estimates in DALYs, which are the sum of years of life lost to death or disability (YLL or YLD). DALYs are non-monetary and therefore the communication of health impacts can be improved by assigning dollar values to DALYs averted. This can be done by converting VSL to the value of statistical life years (VSLYs), as the purpose of using the VSLY is to assign economic values to DALYs

[49] (Meng and Smith 1999)
[50] (Viscusi and Aldy 2003)

averted due to an intervention (Robinson et al., 2016).[51] A DALY averted is equivalent to one death year reduced, and thus its value is equivalent to the VSLY (Narain and Sall, 2016).[52]

VSL is an annuity of VSLY and remaining life expectancy, which can be represented in the equations below:

$$PV = \frac{P\left[1-(1+r)^{-N}\right]}{r} \qquad (7)$$

$$P = \frac{rPV}{1-(1+r)^{-N}} \qquad (8)$$

$$VSLY = \frac{rVSL}{1-(1+r)^{-L}} \qquad (9)$$

- Where PV = Present Value = VSL
- P = Payment = VSLY
- r = Discount Rate
- N = Years of Annuity = Remaining Life Expectancy = L

The standard accounting equation for an annuity is shown in equation (7) and is rearranged in equation (8) to isolate payments. When substituting economic values for the annuity, equation (9) represents the formula for converting VSLs to VSLYs. Additionally, equation (8) can be used to convert VSLYs back to VSLs.

Additional adjustments can be made to make conversions more accurate to the context of the program. Methods include constant VSLYs, declining VSLYs, and "inverted-U" VSLYs.

Constant VSLY implies that individuals do not change their risk tolerance over time and is a standard for calculating the value of DALYs (Robinson et al., 2017).[53] The advantage of this method is its simplicity and general acceptability. However, if interventions target specific age

[51] (Robinson, Sullivan, and Shogren 2021)
[52] (Sall and Narain 2018)
[53] (Robinson et al. 2017)

groups, then constant VSLYs are likely to overestimate/underestimate benefits and bias results. Inaccurate estimates can lead to unfavourable outcomes and reduce the credibility of the analysis.

The European Commission in 2001 recommended the use of VSLs that decline with age and the US Environment Protection Agency (EPA) conducted an analysis that utilized declining VSLYs (Aldy and Viscusi, 2008).[54] Declining VSLYs assume that as people age, they are less willing to pay to reduce their risk of mortality. A common method is a "senior discount," which puts less weight on individuals 65 and older.

Shephard and Zeckhauser (1984)[55] first introduced the idea in their "Robinson-Crusoe" analysis, where they found that individuals initially have low-risk tolerances that peak as they age to 40 years old, and then decline after reaching the peak (Aldy and Viscusi, 2007).[56] Many studies have since supported that idea with slight modifications. Aldy and Viscusi (2004)[57] found the peak to be around 29 years old, Smith et al. (2004)[58] found that risk tolerances increase for workers aged 61-65, and Kniesner et al. (2006)[59] found that the decline after the peak is much smaller than in other studies. Despite the different valuations of VSLYs, they all conclude that VSLs follow some variation of an "inverted-U " shape.

$$VSLY_{Inverted-U} = \left(PR_{U18} * D_{U18} * \frac{rVSL}{1-(1+r)^{-L}}\right) + \left(PR_{18-64} * D_{18-64} * \frac{rVSL}{1-(1+r)^{-L}}\right) + \left(PR_{O64} * D_{O64} * \frac{rVSL}{1-(1+r)^{-L}}\right) \quad (10)$$

[54] (Aldy and Viscusi 2007)
[55] (Shepard and Zeckhauser 1984)
[56] (Aldy and Viscusi 2007)
[57] (Aldy and Viscusi 2004)
[58] (Aldy and Viscusi 2004)
[59] (Kniesner, Viscusi, and Ziliak 2006)

$$VSLY_{Inverted-U} = \frac{rVSL}{1-(1+r)^{-L}}[(PR_{U18} * D_{U18}) + (PR_{18-64} * D_{18-64}) + (PR_{O18} * D_{O18})] \quad (11)$$

- $PR\ is\ the\ proportion\ of\ Canadians\ in\ age\ group\ i$
- $D\ is\ the\ discount\ factor\ of\ age\ group\ i$
- $U18 - Under\ 18\ Years\ old;$
- $18 - 64 - Ages\ 18\ to\ 64$
- $O64 - Over\ 64$

This analysis uses the inverted-U VSLY methodology in equations (10) and (11) as it is a more conservative approach to estimate benefits.

4.3 Benefit – Reduced Healthcare Costs

$$2021:\ \Sigma_{k=1}^{34}(Savings_t = \Delta Cases_t * C) \quad (12)$$

$$2022+:\ Savings_t = \Sigma_{k=1}^{34}(\Delta Cases_t * C + \Sigma_{n=1}^{19} Savings_{t-n}) \quad (13)$$

- $C\ the\ average\ cost\ of\ each\ disease$
- $t = time\ (year)$
- $n = year\ before\ time\ t$
- $k = disease\ (34\ total)$

The benefit of reduced healthcare costs is calculated by multiplying the total healthcare costs due to obesity and type 2 diabetes with the number of each respective case reduced due to the implementation of a Canadian SSB tax. Whereas the benefits of health impacts (Benefit 1) only consider the reduction of new cases of disease after the first year (due to the inclusion of length of effect in DALY calculation), healthcare savings need to include both new cases and previously existed cases. This is due to the counterfactual: if the tax were to be stopped any time before the end of the program, the healthcare savings would return to pre-tax levels over time. An assumption is made that all disease cases would return to pre-tax levels immediately as it would be difficult to estimate the distribution of diseases that relapse over time.

4.4 Implementation Cost

The increase in price due to a 20% *ad valorem* tax is considered a transfer within the economy rather than a cost and therefore is not modelled in this analysis as a cost. Given that the tax applies to drinks with any added sugar or sweetener, the options for brands to reformulate their drinks to avoid the tax are limited. Thus, the only implementation cost of the program is the total legal and administrative cost of the tax policy.

The implementation costs are the annual costs of tax compliance and administration. The proposed tax is an excise tax and therefore compliance costs are only relevant to firms and the government (federal). The costs for the federal government have been estimated by Plamondon and Zussman (1998)[60] from the Canadian Tax Foundation, while the costs for firms have been estimated by Vaillancourt et al. (2008)[61]. The total cost of compliance and administration for the federal government of Canada and firms were estimated to be $15-$30 million (1998 CAD) and $740,000 (2011 CAD), respectively. This analysis uses $740,000/year for firms by Vallaincourt et al. (2013), however, Plamondon and Zussman's (1998) estimate includes the infrastructure that has already been built by the government of Canada. When looking at the literature on the cost of compliance in other countries, the WHO reports an annual $0.20-0.67 (International dollars) per head of household for various countries[62]. The Australian Department of Health

[60] (Plamondon and Zussman 1998)
[61] (Vaillancourt, Clemens, and Palacios 2008)
[62] (Anderson, Chisholm, and Fuhr 2009)

reported an annual AU$12.69 for tax compliance and administration for the period of 2020-2030[63]. Combining these pieces of literature led to the use of an annual $0.50 (2021 CAD) per head of household for the total cost of compliance and administration for the government of Canada, equivalent to roughly $7-9 million a year. Total households are forecasted using the ratio of households to total Canadians. Total implementation costs are modeled in equations (12) and (13).

$$Costs_t^T = CA_t^G + CA_t^F \qquad (12)$$

$$Costs_t^T = 0.5(HH_t) + 740{,}000 \qquad (13)$$

- $time\ t$
- G = Government
- F = Firms
- T = Government + Firms
- HH = Households

4.5 Lost Sales

Estimating the cost of reduced sales over the next 20 years involves a counterfactual; how much SSB consumption would occur in the absence of the tax? This is difficult to measure reliably due to the time discrepancy between the two years of data collection (2015 and 2004). While there has been a decrease in the consumption of SSBs between the two periods, assuming the trend continues may not capture interventions that have maximized their effect on reducing consumption. Projections conducted by private firms were considered but ultimately were not included due to the lack of transparency in methodology and data. Although a counterfactual

[63] (Lal et al. 2017)

estimation on the consumption of SSBs in the absence of the tax would be ideal, this analysis assumes SSB consumption rates remain constant. The lost sales by the introduction of the tax are a recurrent annual cost.

To calculate the cost, average monthly retail sales of SSBs are gathered from Statistics Canada's Retail Commodity Survey (2018)[64] and aggregated over 12 months to get the annual sales of SSBs. Aggregating the total 2020 sales was an alternative option but the lack of consistent trends every year meant that using past data may not be ideal. Total sales are multiplied with the percentage reduction in SSB consumption (assuming consumption = purchases) to capture the lost sales due to the tax. Sensitivity analysis considers various levels of total sales.

A limitation in this methodology is that lost sales in the retail industry may lead to job losses and supply chain shortages across different industries. It is also true that this may not occur, as companies may potentially reformulate their drinks or produce different products to offset losses. Additionally, a portion of the lost sales revenue could be defined as a transfer among the economy, as households can use their money saved from reduced SSB purchases for other commodity items. However, this CBA models 100% of lost sales as a cost due to the lack of methods to estimate the reallocation costs of firms and the change in purchasing behaviour.

4.6 Tax Revenue

Tax revenue generated from an SSB tax is calculated by multiplying SSB sales with the 20% tax. However, tax revenue is a transfer in the economy rather than an economic cost and therefore is not used to compute decision criteria for this CBA/cost-effectiveness study.

[64] (Statistics Canada 2021)

4.7 Input Tables

Tables (1) – (5) contain every input for each cost and benefit in this paper while tables (6) – (8) contain the RR and disability weight of each disease. The disability weights chosen for this analysis reflect the mildest forms of symptoms; using moderate or severe forms of each disease can easily overestimate the DALYs averted.

4.8 Sensitivity Analysis and Monte Carlo Simulations

Risk analysis is conducted by performing 1,000 Monte Carlo simulations. Monte Carlo simulations generate a distribution of outputs based on a distribution of inputs. The inputs used in the Monte Carlo are price elasticity of demand, length of obesity, weight loss per 100kJ reduced, and government compliance and administration costs per head of household. A normal distribution around the 95% confidence interval is assumed for each input. The simulations produced the worst and best-case scenarios, the frequency of outputs based on Z-scores, and the frequency of decision criteria being positive or negative.

Whereas risk analysis relies on an assumption of the distribution of data, sensitivity analysis is unconstrained to any distributions. There are additional learning opportunities when isolating the effect of one input and holding the rest constant. Sensitivity analysis is applied to the inputs with the most volatile to capture a better understanding of the variability of an SSB tax in Canada. Understanding what inputs are more sensitive allows researchers and policymakers to prioritize areas of research that are more volatile than others. A full list of inputs considered in this sensitivity and risk analysis is provided in table (9).

Impacts	Discount Rate	Tax Rate	Price Elasticity	Remaining Life Years	Length of Obesity-Related Disease	Weight Loss per 100kJ	Govt Compliance and Admin
B1 Improved Health	✓	✓	✓	✓	✓	✓	
B2 Healthcare Savings	✓	✓	✓		✓	✓	
C1 Implementation Costs	✓						✓
C2 Lost Sales Revenue	✓	✓	✓				
Range for sensitivity analysis	1 - 5%	5 - 30%	-1.34 - -1.06	15 - 45	5.9 - 14.7	0.88 - 0.998	0.34 - 0.67
Distribution for Monte Carlo analysis	N/A	N/A	Type: normal Mean: -1.20 S.D.: 0.07	N/A	Type: normal Mean: 9.7 S.D.: 2.244	Type: normal Mean: 0.94 S.D.: 0.030	Type: normal Mean: 0.5 S.D.: 0.084

Table 9: Inputs used in sensitivity analysis and their effects on stakeholders

4.9 Stakeholder Analysis

The last section of this CBA looks at the distribution of benefits, costs, and tax revenue transfers in the economy. The purpose of this analysis is to get a better understanding of how different stakeholders get impacted by an SSB tax.

Impacts	Households	Private Industry	Government
B1 Improved Health	✓		
B2 Healthcare Savings	✓	✓	✓
C1 Implementation Costs		✓	✓
C2 Lost Sales Revenue		✓	
T1 Tax Revenue	✓-		✓+

Table 10: Distribution of Benefits, Costs, and Transfers

5. Results

5.1 Net Present Value

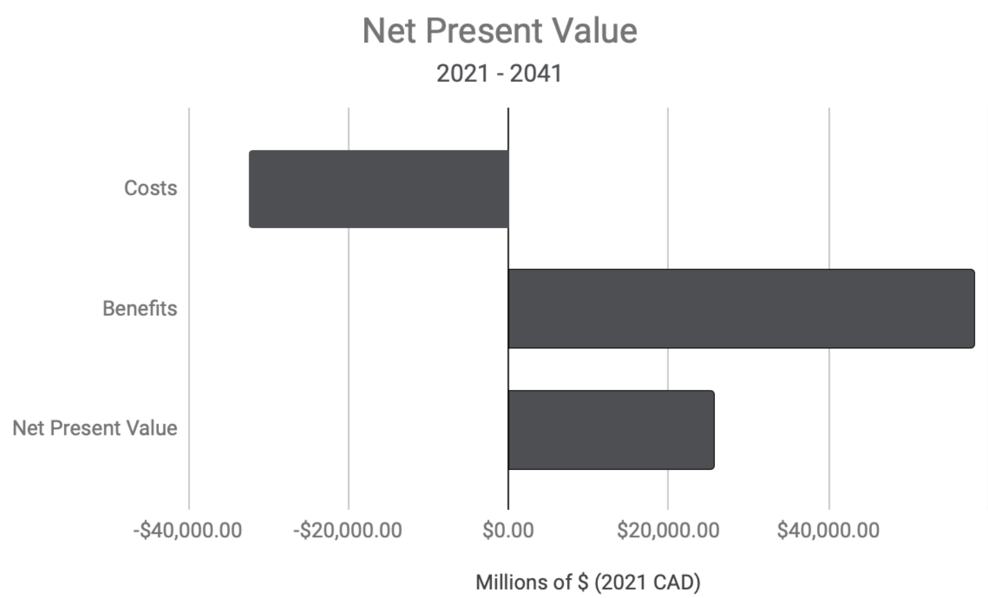


Chart 1: Net Present Value, Costs, and Benefits

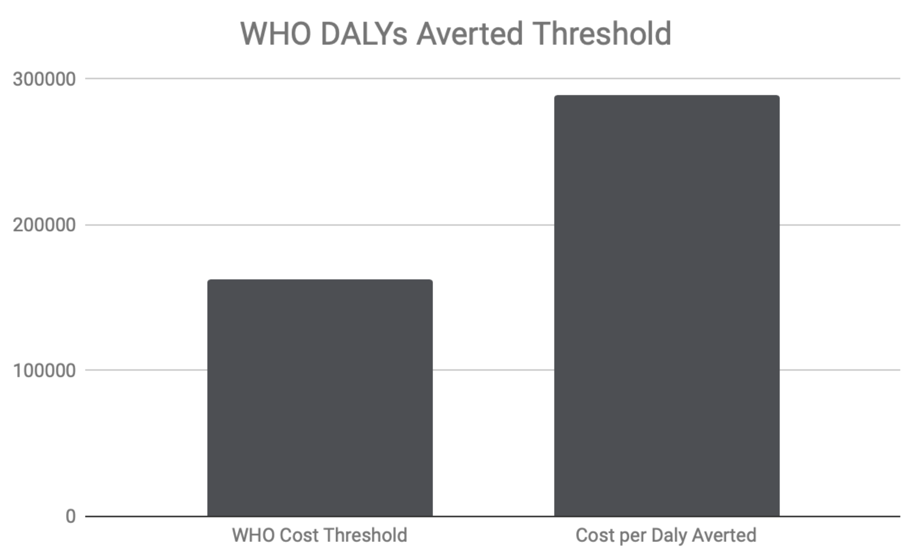


Chart 2: $/DALY Averted vs. WHO Threshold

Criteria	Net Present Value	Benefit Cost Ratio	Cost per DALY Averted	DALYs Averted/GDP per Capita

Final Case	25.7 billion	1.79	288,614	4.77

Table 11: Outcomes of Tax

The final estimation of the 20% *ad valorem* tax on SSBs predicts a Net Present Value (NPV) of $25.7 billion (2021 CAD) and a cost per DALY averted of $288,614. Note that these are conflicting findings: a positive NPV is a sign of a good project, whereas the WHO recommends a threshold of costs/DALY averted of less than 3 times GDP. The tax is a cost-inefficient intervention before assigning dollar values to human lives. The project's benefits easily outweighed its costs once dollar values were assigned. Additionally, the DALYs averted were calculated assuming the mildest symptoms of diseases; DALYs averted can increase by 500% by changing the parameter on disability weights.

5.2 Benefits, Costs, and Transfers

The present value of total benefits, costs, and transfers are estimated to be $58.2, $23.5, and $20.5 billion, respectively.

Estimates	Present Value in 2021 Canadian Dollars
Benefits	$58.2 billion
Costs	$32.5 billion
Transfers	$20.5 billion

Table 12: Total Benefits, Costs, and Transfers

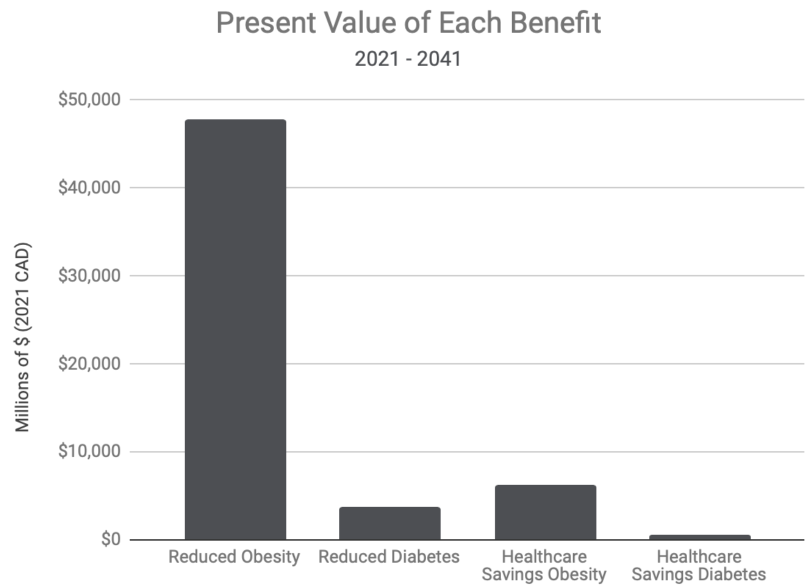


Chart 3: Present Value of Benefits

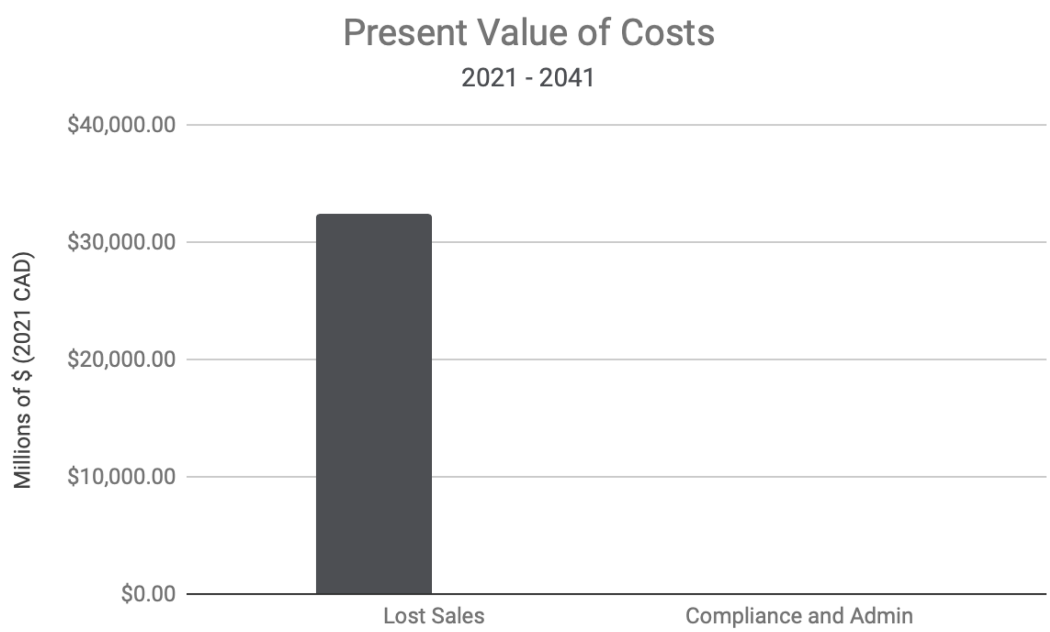


Chart 4: Present Value of Costs

When separating the benefits, reduced obesity and reduced diabetes account for $47.8 and $3.7 billion of total benefits, respectively. Healthcare savings are estimated to be $6.1 billion for the reduction of obesity-related diseases and $607 million for the reduction of diabetes. When separating the costs, the lost sales make up nearly all of the total costs at $32.4 billion.

Compliance and administration are estimated at approximately $120 million. 100% of the $20.5 billion transfers are from the generated tax revenue from SSBs. While making up a small portion of the total cost, the burden of compliance and administration of the tax is primarily put on the government.

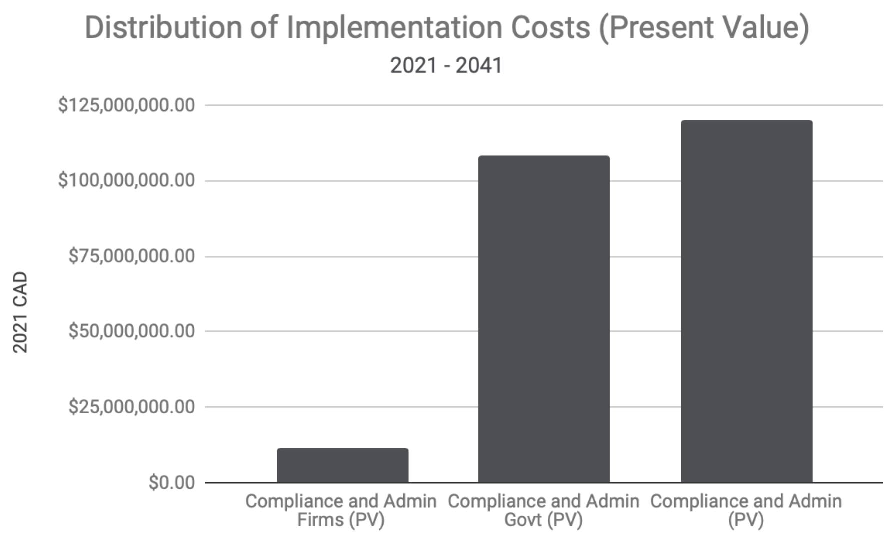


Chart 5: Distribution of Implementation Costs

5.3 Risk and Sensitivity Analysis

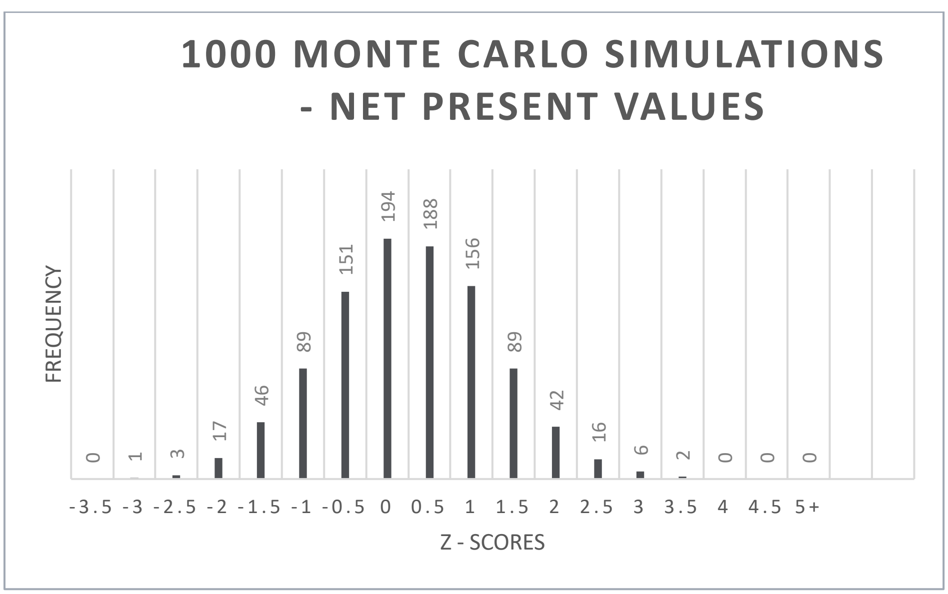


Chart 6: 1,000 Monte Carlo Simulations

Criteria	Worst Case	Best Case	# Of Times NPV Positive
NPV	- 9.7 billion	59.6 billion	986
DALYs Averted/GDP per Capita	982,300	167,004	5

Table 13: 1000 Monte Carlo Simulations

After running 1,000 simulations by constraining various inputs to a normal distribution, the NPV is positive for 986 or 98.6% of simulations. When utilizing the WHO's cost per DALY averted criteria, only 5 of 1,000 or 0.5% of simulations returned a positive outcome. The "worst-case" scenario (maximizing costs and minimizing benefits) estimated a -$9.7 billion NPV while the "best-case" scenario (minimizing costs and maximizing benefits) estimated a $59.6 net benefit. Expanding the Monte Carlo to 2,000 and 10,000 simulations returned similar results.

Input	Range	Low Range (billions)	High Range (billions)
Discount Rate	1 - 3%	$23.5	$27.1
Tax Rate	5 - 30%	$9.7	$36.5
Price Elasticity	-1.34 - -1.06	$22.3	$29.1
Life Expectancy Remaining	15-45	$15.4	$58.8
Length of Obesity- Related Disease	5.9 - 14.7	$7.0	$50.4

Weight Loss/100kJ	0.88 - 0.998	$22.3	$29.0
Govt Costs	0.34 - 0.67	$25.7	$25.7
Non-alcoholic Drink Sales per Month (Retail)	650 – 950 (million)	$15.9	$29.3

Table 14: Sensitivity Analysis

After running sensitivity analysis, none of the inputs alone cause a negative NPV. The length of obesity-related disease is the most sensitive input, causing NPV to range from just under $7 billion to $50.4 billion. The second most sensitive input is the expected life years remaining, as it greatly affects the VSLY used in the calculation of health benefits. Changing the parameter for government cost of compliance and administration proved to be the least impactful input.

5.4 Stakeholder Analysis

Estimates	Households (billions)	Firms (billions)	Government (billions)
Net Benefit	$52.5	- $31.4	$4.6
Transfers	- $20.5	-	+ $20.5

Table 15: Effect on Stakeholders

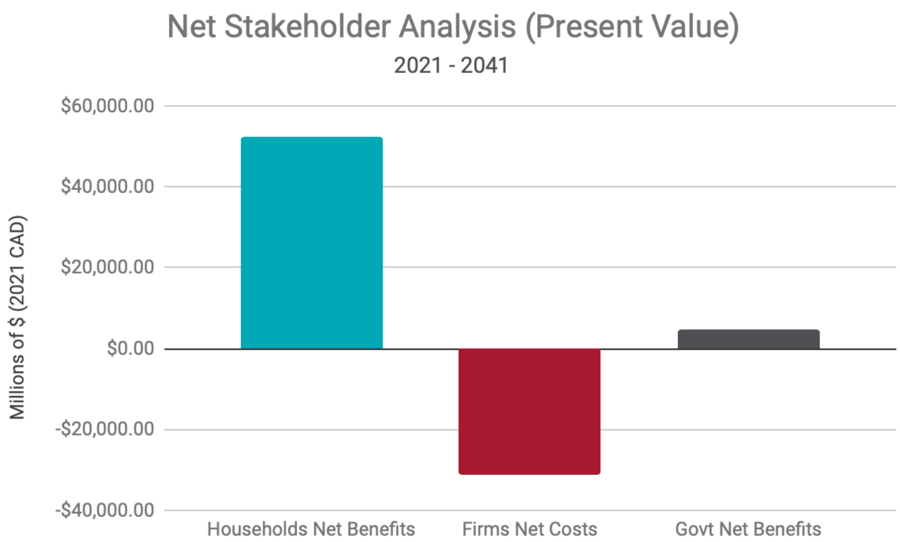


Chart 6: Net Stakeholder Analysis

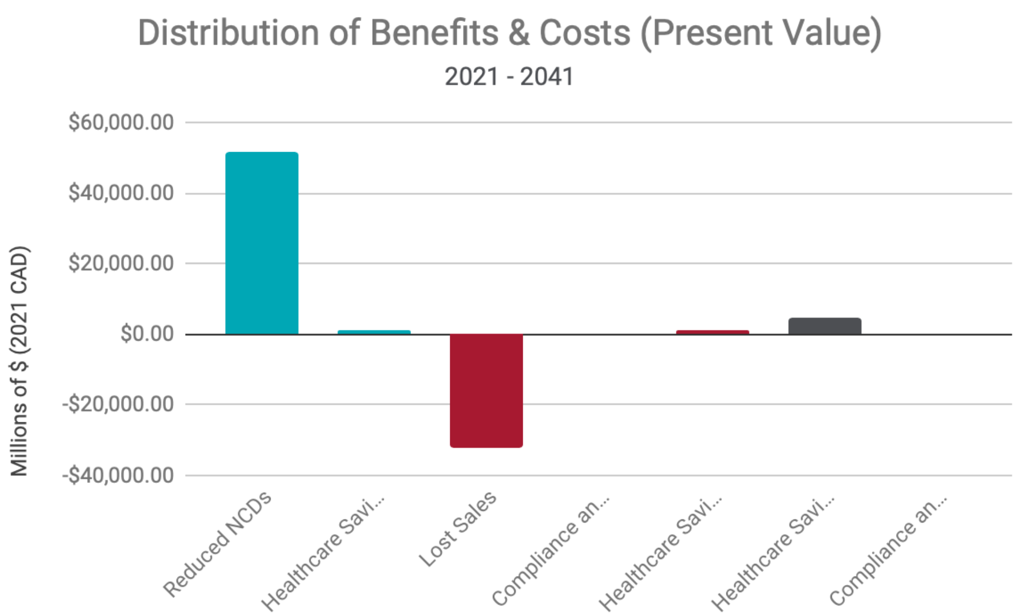


Chart 7: Distribution of Benefits & Costs

Further disaggregating the effects, the tax disproportionately benefits households ($52.5 billion) while firms bear all the net losses (-$31.4 billion). The government of Canada also benefits from the program at a total of $4.6 billion net benefits. The distribution of healthcare savings is calculated with 70% going to the government while splitting the remainder equally across households and firms. This is based on a report from the Canadian Institute for Health

Information (CIHI, 2020) that 70.4% of the share of health spending comes from public expenditure[65].

6. Discussion

6.1 Results and Limitations

The final results estimate an overwhelmingly positive NPV of over $25.7 billion (2021 CAD), indicating that an SSB tax in Canada would have an overall positive impact on the economy. However, the cost per DALY averted is 4.77 times higher than GDP per capita. When compared to the WHO's recommendation of a ratio no more than 3 times higher than GDP/capita, this means that the tax is not cost-effective. The takeaway from this is that an SSB tax is economically beneficial to society but not cost-effective when taking a conservative approach to measuring benefits. This statement does not hold when taking a less conservative approach to measuring costs and benefits. For example, raising the disability weight of ischemic heart disease to moderate and severe levels leads to $239,266 and $173,203 per DALY averted, respectively. When dividing these figures by GDP/capita to measure cost-effectiveness, they return ratios of 3.95 and 2.86, respectively. Repeating this exercise with all 33 obesity-related diseases and diabetes would continue to make an SSB tax in Canada more cost-effective and easily surpass the WHO's recommended threshold. Another limitation to using this decision criteria is that it does not consider the healthcare savings due to the reduction of diseases because they are not measured in DALYs. To further reflect the conservative approach of this paper, indirect savings due to improved healthcare have not been modeled. This includes the opportunity cost of time that can be spent either working or enjoying leisure. Including direct and

[65] (CIHI 2021)

indirect healthcare savings can easily improve the cost-effectiveness of the tax. Due to how easily this paper can manipulate parameters to meet the WHO's threshold, NPV should be used as the primary criteria to recommend an SSB tax in Canada. The NPV is calculated using heavily discounted VSLYs for youths and seniors yet is still overwhelmingly positive.

The total benefits of the SSB tax total to a present value of $58.2 billion. The majority of benefits are the improved health impacts of Canadians, contributing to $51.5 billion of the total benefits. The reduction of ischemic heart disease prevailed as the largest contributor to benefits, however, replacing the disability weight of asymptotic gout with symptomatic gout nearly doubles the total benefits to $101.6 billion. Healthcare savings contribute to $6.7 billion of the total benefits. While this is a small proportion of the total benefits, that is $6.7 billion that can flow into other sectors of the economy. A limitation to the calculation of this benefit is that it uses the EBIC from 2010; the direct healthcare cost savings have very likely changed in the last 11 years.

The total costs of the SSB tax result in a present value of $32.5 billion, with nearly all of it coming from the lost retail sales of SSBs. A limitation to the estimation of costs is that it does not consider the additional costs to society if sales were to diminish. A loss of $32.5 billion in sales revenue likely leads to job layoffs and linkages to other industries. There is no reliable method to calculating these additional losses for multiple reasons. Using data from past experiences would be a flawed methodology as they are confounded with other events that cannot be controlled for. Additionally, an argument could be made that lost retail sales are a transfer among the economy rather than a cost, as households can spend their money saved from reduced SSB consumption on other commodity items. Firms may reformulate their product to adhere to the tax or utilize their resources for other sectors in the economy. However, the costs of this reallocation and the proportion of lost retail sales that transfers to other commodity items cannot be measured. Due to these uncertainties, 100% of the loss in retail sales is listed as a cost. Treating lost sales revenue as a transfer drops the present value of total costs to $129 million.

When conducting risk analysis in the form of 1,000 Monte Carlo simulations, the small risk of a negative NPV (1.4%) assures policymakers that an SSB tax is a risk-averse intervention to improve the health outcomes of Canadians. The simulations also show that the potential net benefit from the tax can reach up to $59.6 billion. Therefore, an SSB tax in Canada is a low-risk, yet high reward policy.

Stakeholder analysis shows that households and government receive a net benefit while firms receive a net cost. Households benefit from improved health and reduced healthcare savings while Canada’s public sector benefits from healthcare savings. Although firms receive a 15% share of the total healthcare savings, this is not enough to offset the massive loss in sales revenue. Despite an SSB tax being a net benefit to society, it is difficult to advocate for a policy that produces a $31.4 billion burden on one group of stakeholders. A possible solution to deal with this non-Pareto outcome is to subsidize consumers on the purchase of healthy food and drink alternatives, which could offset some of the lost sales revenue for firms. Another solution would be to set a threshold of sugar content as a criterion to tax SSBs, similar to the Chilean IABA. However, this would not incentivize against the consumption of free sugars in the form of SSBs and households can overconsume low-tax drinks to maintain sugar consumption. The main takeaway from stakeholder analysis is that considerations should be made to accommodate firms as they reallocate resources to produce new commodity items and/or healthier food and drink items.

6.2 Socio-economic Status Groups

Another aspect to consider is how this policy affects different socio-economic status (SES) groups. This form of taxation is regressive, as a flat rate of 20% affects low SES groups disproportionately more than middle and high SES groups. Additionally, low-income countries have been found to have lower price elasticities of demand (more sensitive) than high-income countries[66], which may reflect the elasticities of different SES groups in Canada. SSBs are cheap forms of energy intake and taxing them would force low SES groups to look for alternative options for cost-efficient energy consumption. This raises two other issues, the first being that households can replace SSB consumption with other forms of cheap and unhealthy energy sources. The second issue is that an income effect may dominate a substitution effect: households consume less healthy foods because SSBs are now more expensive. While the literature review in section **2** discusses how the Chilean IABA avoids the need for redistribution by raising and lowering tax rates around a threshold of sugar content in drinks, this may not be needed in Canada. Canada already has the infrastructure in place to redistribute GST/HST from high SES households to low SES households. Utilizing the system already in place would be an efficient method to further redistribute wealth among the country. The redistribution of wealth can be combined with other projects or policies to influence consumers towards healthier foods, such as subsidies on nutrient-rich foods and/or marketing strategies to promote healthier lifestyles.

7. Conclusion

NCDs have become a large health and economic burden on Canada, and taxes on SSBs have emerged globally as a tool to combat diet-related NCDs. SSB taxes implemented in British Columbia and announced in Newfoundland and Labrador shows that there is growing interest in

[66] (Muhammad et al. 2019)

Canada to adopt a nationwide tax. The literature review identified two case studies in Chile and France that have had conflicting success due to policy design, public interest, and country context. Based on Canada's provincial interest and high prevalence rate of obesity and diabetes, a strict 20% *ad valorem* SSB tax is believed to better reflect the Chilean IABA success rather than the French soda tax's shortcomings. Data is collected by government or aid agencies where available, and meta-analyses are used to fill the gaps where public availability is limited. The benefits of improved health outcomes and healthcare savings are measured against the cost of implementation and operations and lost sales revenue. A conservative approach is taken by selecting inputs in a manner that maximizes costs and minimizes benefits. After quantifying both the benefits and costs with dollar values, a 20% SSB tax in Canada is estimated to return a large NPV of $25.7 billion. Sensitivity analysis shows that many inputs could double NPV while few could significantly lower it. Risk analysis via 1,000 Monte Carlo simulations return a positive NPV in 98.6% scenarios, indicating that an SSB tax would be a low-risk policy. Concerns still arrive when conducting stakeholder analysis, as all the costs of the tax are put onto the firms, showing that an SSB tax would not be Pareto optimal. Further costs such as job losses and linkages to other sectors of the economy are not modeled due to the unreliability of methods. Further concerns include the regressive nature of an SSB tax that disproportionately affects low SES groups, but a proposed solution would be to utilize Canada's already existing GST/HST refunds to redistribute SSB tax revenue to these groups. This analysis recommends that an SSB tax be implemented in Canada based on the results, however, there should be future discussions on how to better distribute the benefits across stakeholders in the economy.

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9. Appendix

Inputs for Benefit 1 - Improved Health Outcomes

Inputs	Parameter	95% C.I.	Source
Canadian Adults	30,263,158	-	Statistics Canada (2020)
Population Growth	(Differs by Year)	-	Statistics Canada (2020)
Obesity Prevalence (Adults)	26.80%	-	Statistics Canada (2018)
Obesity Cases	8,110,526	-	Author's Calculation
Diabetes Prevalence (Adults)	7.6%	-	International Diabetes Atlas (2019)
Type 2 Diabetes Cases	2,300,000	-	International Diabetes Atlas (2019), Statistics Canada (2017)
Price Elasticity SSB (Self)	-1.20	(-1.34, -1.06)	Bourke and Veerman (2018)
Price Elasticity SSB & Milk (Cross)	0.129	(-0.085, 0.342)	Escobar et al. (2013)
Price Elasticity SSB & Juice (Cross)	0.388	(0.009, 0.787)	Escobar et al. (2013)
Price Elasticity SSB & Diet	-0.423	(-1.219, -0.628)	Escobar et al. (2013)
Ad Valorem Tax	20%	-	WHO Recommendation

RR Diabetes	1.27	(1.11, 1.42)	Micha et al. (2017)
RR Obesity	Separate Table	-	GBD (2019)
Weight Reduced per 100 kJ	0.94	(0.88, 0.998)	USDA (2021)
Energy per 100g SSB	176kJ	-	USDA (2021)
Energy per 100g Milk	209kJ	-	USDA (2021)
Energy per 100g Juice	242kJ	-	USDA (2021)
Energy per 100g Diet	84kJ	-	USDA (2021)
Disability Weight Diabetes	0.049	(0.031, 0.072)	GBD (2019)
Disability Weight - Obesity Related	Separate Table	-	GBD (2019)
Value of a Statistical Life (2000 USD)	5,200,000 (2000 USD)	(5,100,000, 5,300,000)	Meng and Smith (2000)
Value of a Statistical Life (2021 CAD)	11,439,644 (2021 CAD)	(11,219,651, 11,659,638)	Author's Calculation
Value of a Statistical Life Year	507,735	(497,971, 517,499)	Author's Calculation
Average Weight Male	84.6	(82.8, 86.4)	Shields et al. (2011)

Average Weight Female	70.1	(68.1, 72.1)	Shields et al. (2011)
Average BMI Male	27.5	(27.1, 27.9)	Shields et al. (2011)
Average BMI Female	26.6	(25.9, 27..4)	Shields et al. (2011)

Inputs for Benefit 2 - Healthcare Cost Savings

Inputs	Parameter	95% C.I.	Source
Healthcare Cost Obesity-Related (Year 1)	Separate Table	-	EBIC (2010)
Healthcare Cost Diabetes (Year 1)	5,501,286	-	EBIC (2010)
Type 2 Diabetes Prevalence	90%	-	Multiple Sources

Inputs for Cost 1 - Implementation Costs

Inputs	Parameter	95% C.I.	Source
Households	14,072,080	-	Statistics Canada (2021)
Govt Compliance and Admin per household	0.5	(0.34, 0.67)	Anderson et al. (2009)
Firm Compliance and Admin	740,000	-	Vaillancourt (2008)

Inputs for Cost 2 - Lost Sales Revenue

Inputs	Parameter	95% C.I.	Source
Non-Alcoholic Drink Consumption Jan 2021	729,977,000	-	Statistics Canada (2021)
Estimated non-Alc-Drink Consumption 2021	8,759,724,000	-	Author's Calculation

Inputs for Transfer 1 - Tax Revenue

Inputs	Parameter	95% C.I.	Source
Non-Alcoholic Drink Consumption Jan 2021	729,977,000	-	Statistics Canada (2021)
Estimated non-Alc-Drink Consumption 2021	8,759,724,000	-	Author's Calculation
Ad Valorem Tax	20%	-	WHO Recommendation

Relative Risk of Disease for High BMI Classified as Obese (BMI >= 30)

Disease	Male	Male C.I.	Female	Female C.I.	Average
Oesophageal Cancer	1.391	(1.077,1.754)	1.351	(1.012, 1.7045)	1.371
Colon and Rectum Cancer	1.177	(1.145,1.208)	1.059	(1.031,1.083)	1.118
Liver Cancer due to Hep B	1.289	(1.109,1.491)	1.176	(1.03,1.334)	1.2325
Liver Cancer due to Hep C	1.289	(1.109, 1491)	1.176	(1.03,1.334)	1.2325
Liver Cancer due to Alcohol Use	1.289	(1.109, 1491)	1.176	(1.03,1.334)	1.2325
Gallbladder and Bilary Tract Cancer	1.155	(1.033,.281)	1.344	(1.223,1.447)	1.2495
Pancreatic Cancer	1.074	(0.999,1.153)	1.092	(1.037,1.144)	1.083
Kidney Cancer	1.24	(1.171,1.313)	1.32	(1.254,1.394)	1.28
Thyroid Cancer	1.221	(1.068,1.381)	1.136	(1.094,1.178)	1.1785
Multiple Myeloma	1.089	(1.027,1.153)	1.092	(1.034,1.157)	1.0905
Acute Lymphoid Leukemia	1.086	(1.053,1.119)	1.131	(1.061,1.208)	1.1085
Chronic Lymphoid Leukemia	1.086	(1.053,1.119)	1.131	(1.061,1.208)	1.1085

Acute Myeloid Leukemia	1.086	(1.053,1.119)	1.131	(1.061,1.208)	1.1085
Chronic Myeloid Leukemia	1.086	(1.053,1.119)	1.131	(1.061,1.208)	1.1085
Other Leukemia	1.086	(1.053,1.119)	1.131	(1.061,1.208)	1.1085
Ischemic Heart Disease	2.274	(1.259,3.683)	2.274	(1.259,3.683)	2.274
Ischemic Stroke	2.472	(1.4,3.975)	2.472	(1.4,3.975)	2.472
Intracerebral Hemorrhage	3.066	(1.751,5.334)	3.066	(1.751,5.334)	3.066
Subarachnoid hemorrhage	3.066	(1.751,5.334)	3.066	(1.751,5.334)	3.066
Hypertensive heart disease	3.122	(1.588,5.498)	3.122	(1.588,5.498)	3.122
Atrial fibrillation and flutter	1.344	(1.231,1.473)	1.346	(1.22,1.475)	1.345
Asthma	1.409	(1.29,1.545)	1.403	(1.275,1.532)	1.406
Gallbladder and biliary diseases	1.464	(1.291,1.64)	1.729	(1.571,1.893)	1.5965
Alzheimer's disease and other dementias	1.218	(1.054,1.409)	1.214	(1.047, 1.404)	1.216
Chronic kidney disease due to hypertension	1.763	(1.09,2.755)	1.763	(1.09,2.755)	1.763
Chronic kidney disease due to glomerulonephritis	1.742	(1.021,2.775)	1.742	(1.021,2.775)	1.742
Chronic kidney disease due to other and unspecified causes	1.732	(1.052,2.681)	1.732	(1.052,2.681)	1.732
Cataract	1.104	(1.052,1.157)	1.104	(1.051,1.156)	1.104
Osteoarthritis hip	1.11	(1.06,1.157)	1.112	(1.062,1.16)	1.111
Osteoarthritis knee	1.37	(1.201,1.538)	1.375	(1.188,1.559)	1.3725
Low back pain	1.1	(1.074,1.126)	1.1	(1.074,1.126)	1.1
Gout	1.628	(1.34,1.964)	1.493	(1.322,1.677)	1.5605

Disability Weights Obesity-Related Cancers

Cancer	Disability Weight (Controlled)	95 C.I.	Disability Weight (Diagnosis)	95 C.I.
Oesophageal Cancer	0.049	(0.031,0.072)	0.288	(0.193,0.399)
Colon and Rectum Cancer	0.049	(0.031,0.072)	0.288	(0.193,0.399)
Liver Cancer due to Hep B	0.049	(0.031,0.072)	0.288	(0.193,0.399)
Liver Cancer due to Hep C	0.049	(0.031,0.072)	0.288	(0.193,0.399)
Liver Cancer due to Alcohol Use	0.049	(0.031,0.072)	0.288	(0.193,0.399)
Gallbladder and Bilary Tract Cancer	0.049	(0.031,0.072)	0.288	(0.193,0.399)
Pancreatic Cancer	0.049	(0.031,0.072)	0.288	(0.193,0.399)
Kidney Cancer	0.049	(0.031,0.072)	0.288	(0.193,0.399)

Thyroid Cancer	0.049	(0.031,0.072)	0.288	(0.193,0.399)
Multiple Myeloma	0.049	(0.031,0.072)	0.288	(0.193,0.399)
Acute Lymphoid Leukemia	0.049	(0.031,0.072)	0.288	(0.193,0.399)
Chronic Lymphoid Leukemia	0.049	(0.031,0.072)	0.288	(0.193,0.399)
Acute Myeloid Leukemia	0.049	(0.031,0.072)	0.288	(0.193,0.399)
Chronic Myeloid Leukemia	0.049	(0.031,0.072)	0.288	(0.193,0.399)
Other Leukemia	0.049	(0.031,0.072)	0.288	(0.193,0.399)

Disability Weights Obesity-Related Non-cancerous Diseases

Disease	Disability Weight	95 C.I.	Note
Ischemic Heart Disease	0.041	(0.026,0.062)	Mild
Ischemic Stroke	0.019	(0.01,0.032)	Level 1
Intracerebral Hemorrhage	0.019	(0.01,0.032)	Level 1
Subarachnoid Hemorrhage	0.019	(0.01,0.032)	Level 1
Hypertensive heart disease	0.041	(0.026,0.062)	Mild
Atrial fibrillation and flutter	0	(0,0)	Asymptomatic
Asthma	0.015	(0.007,0.026)	Controlled
Gallbladder and biliary diseases	0.011	(0.005,0.021)	Mild
Alzheimer's disease and other dementias	0.069	(0.046,0.099)	Mild
Chronic kidney disease due to hypertension	0.004	(0.001,0.008)	Mild (Step 3)
Chronic kidney disease due to glomerulonephritis	0.004	(0.001,0.008)	Mild (Step 3)
Chronic kidney disease due to other and unspecified causes	0.004	(0.001,0.008)	Mild (Step 3)
Cataract	0.031	(0.019, 0.049)	Mild Vision Loss
Osteoarthritis hip	0.023	(0.013,0.037)	Mild
Osteoarthritis knee	0.023	(0.013,0.037)	Mild
Low back pain	0.02	(0.011,0.035)	Mild
Gout	0	(0,0)	Asymptomatic
Diabetes	0.049	(0.031, 0.072)	Mild