The influence of sugar taxes and front-of-package nutrition labels on consumer purchasing behaviours: a randomized experimental marketplace

by

Rachel Breanne Acton

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EXAMINING COMMITTEE MEMBERSHIP

The following served on the Examining Committee for this thesis. The decision of the Examining Committee is by majority vote.

External Examiner	DR. PATTI-JEAN (PJ) NAYLOR Professor School of Exercise Science, Physical & Health Education University of Victoria
Supervisor	DR. DAVID HAMMOND Professor School of Public Health & Health Systems University of Waterloo
Internal Member	DR. SHARON I. KIRKPATRICK Associate Professor School of Public Health & Health Systems University of Waterloo
Internal Member	DR. CHRISTINA A. ROBERTO Assistant Professor Medical Ethics & Health Policy Perelman School of Medicine University of Pennsylvania
Internal-external Member	DR. LEIA MINAKER Assistant Professor School of Planning University of Waterloo

AUTHOR'S DECLARATION

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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STATEMENT OF CONTRIBUTIONS

This thesis consists in part of four manuscripts that have been published or submitted for publication. Exceptions to sole authorship:

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As lead author of these four chapters, I was responsible for conceptualizing the study design, planning and executing data collection, conducting the analyses, and drafting and submitting manuscripts. My co-authors provided guidance during each step of the research and provided feedback on draft manuscripts. Dr. David Hammond provided significant direction and editorial assistance throughout.

Under Dr. David Hammond's supervision, I also prepared the remaining chapters in this thesis, which were not written for publication.

ABSTRACT

Background: Poor dietary intake remains one of the leading causes of non-communicable disease in Canada and globally. In response, sugar taxes and front-of-package (FOP) nutrition labelling systems are increasingly being implemented around the world with the intention of improving dietary intake and reducing the associated health and economic impacts of diet-related non-communicable disease. However, there is relatively little experimental data on how these strategies influence consumer behaviour and how different policy measures—such as taxes and FOP labels—may interact. In addition, policymakers who implement these measures must decide what type of tax structure or FOP format to use; however, the relative impact of different tax structures or FOP labels on food and beverage purchases remains unclear.

Objectives: This dissertation examined the following research questions: (1) do different FOP labels and sugar taxes influence consumer purchases of sugars, sodium, saturated fats, or energy?; (2) do different sociodemographic or individual characteristics moderate the effects of FOP labels and sugar taxes on participants' purchasing of sugars, sodium, saturated fats, or energy?; (3) how do consumers' purchases of specific product categories vary across different FOP labelling systems?; and (4) how do consumers' purchases of specific product categories vary across different sugar taxation formats?

Methods: An experimental marketplace study was conducted from March 12 – May 20, 2018. A final sample of 3,584 Canadians 13 years and older participated in the 5 (FOP label condition) × 8 (tax condition) between-within group experiment. Participants received $5 and were presented with images of 20 beverages and 20 snack foods available for purchase. Participants were randomized to one of five FOP label conditions (no label; 'high in' nutrient symbol; multiple traffic light (MTL); health star rating (HSR); nutrition grade) and completed eight within-subject purchasing tasks with different taxation conditions (*beverages*: no tax, 20% tax on sugar-sweetened beverages (SSBs), 20% tax on sugary drinks, tiered tax on SSBs, tiered tax on sugary drinks; *snack foods*: no tax, 20% tax on high-sugar foods, tiered tax on high-sugar foods). Upon conclusion, one of eight selections was randomly chosen for purchase, and participants received the product and any change from the $5. In Paper 1, analyses compared the sugars, sodium, saturated fats and calorie content of participants' purchases across tax and labelling conditions. Paper 2 investigated the main and moderating effects of individual-level characteristics on

participants' purchases of sugars, sodium, saturated fats and calories. Paper 3 evaluated participants' purchases of five specific product categories that received conflicting ratings across FOP label conditions. Paper 4 assessed the impact of the tax conditions on participants' purchases of two relevant product categories (moderately sugary beverages and 100% fruit juice).

Results:

Paper 1 – Overall, there were significant differences in the nutrient levels of participants' purchases across several of the experimental conditions. Compared to those who saw no FOP label, participants who viewed the 'high in' symbol purchased less sugar (− 2.5 g), saturated fat (− 0.09 g), and calories (− 12.6 kcal) in the beverage purchasing tasks, and less sodium (− 13.5 mg) and calories (− 8.9 kcal) in the food tasks. All taxes resulted in substantial reductions in mean sugars (− 1.4 to − 4.7 g) and calories (− 5.3 to − 19.8 kcal) purchased, and in some cases, reductions in sodium (− 2.5 to − 6.6 mg) and saturated fat (− 0.03 to − 0.08 g). Taxes that included 100% fruit juice ('sugary drink' taxes) produced greater reductions in sugars and calories than those that did not.

Paper 2 – There were few moderating effects of individual-level characteristics on the nutrient content of participants' purchases. Participants who were younger, male, and more frequent consumers of sugary drinks tended to purchase products containing more sugars, sodium, saturated fats and calories. Sex and age moderated the relationship between tax condition and sugars or calories purchased: female participants were more responsive to a tax that included fruit juice compared to males, and younger participants were more responsive to all sugar tax conditions compared to older participants. Reported thirst and education level also moderated the relationship between tax condition and calories purchased.

Paper 3 – Participants' purchases of products that received conflicting ratings varied across some FOP label conditions. Participants who saw the HSR were more likely to purchase 100% fruit juice (compared to MTL) and cheese snacks (compared to no label and 'high in'). The 'high in' label led to fewer purchases of chocolate milk compared to no label. Diet beverage purchases were higher in all FOP conditions relative to no label.

Paper 4 – Participants' responses to the different tax structures were as hypothesized. The odds of purchasing a moderately sugary beverage were higher under tiered versus non-tiered taxes, while purchases of high sugary beverages differed very little under tiered versus non-tiered. The odds of purchasing 100% fruit juice were lower when these products were included in a tax versus when they were not.

Conclusions: This study expands the evidence indicating that sugar taxation and FOP labelling strategies can promote healthy food and beverage choices. All sugar taxes were effective at reducing the sugars and energy content of participants' beverage and snack food purchases; however, some formats, including those that taxed 100% fruit juice, were more effective than others. The results suggest that two key tax formats are likely to function as hypothesized: taxes that include 100% fruit juice products may lead to fewer purchases of fruit juice, and taxes that incorporate multiple tiers may encourage purchases of moderately sugary products to a greater extent than non-tiered formats. The FOP nutrition labels demonstrated smaller—but nevertheless meaningful—effect sizes relative to the taxes, and results were more variable across formats, with the 'high in' FOP labels exhibiting the greatest impact. Results also suggest that, despite some similarities, existing FOP systems differ in the extent to which they promote or dissuade common food categories. 'High in' and MTL systems may more effectively discourage purchases of products contributing negative nutrients than HSR or nutrition grade systems. Few individual-level characteristics moderated the effects of sugar taxes or FOP labels on nutrients purchased in this study, suggesting that these policies may produce similar effects across key sociodemographic groups. Overall, the results of this experimental study are consistent with evidence from other studies in suggesting that both taxes and FOP nutrition labels have the potential to generate meaningful reductions in the intake of sugars and other nutrients of public health concern. The magnitude of effects observed in this study suggest that sugar taxes and 'high in' labels could significantly reduce non-communicable disease at a population level, but would generate even greater improvements when implemented alongside other strategies to improve the food environment.

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LIST OF ABBREVIATIONS

%DV	percent daily value
AI	adequate intake
AOR	adjusted odds ratio
BMI	body mass index
CAD$	Canadian dollars
CCHS	Canadian Community Health Survey
CDC	Centers for Disease Control and Prevention
CEGEP	*collège d'enseignement général et professionnel* (general and vocational college)
CI	confidence interval
FDR	false discovery rate
FOP	front-of-package
GDA	Guideline Daily Amount
GLMM	generalized linear mixed model
HSR	health star rating
LDL	low-density lipoprotein
LMM	linear mixed model
MF	milk fat
MTL	multiple traffic light
NCD	non-communicable disease
NFt	nutrition facts table
NVS	Newest Vital Sign
ORE	Office of Research Ethics
pp	percentage point
SD	sugary drink
SES	socioeconomic status
SSB	sugar-sweetened beverage

STL	single/simple traffic light
UK	United Kingdom
UL	upper intake level
US	United States
VAT	value-added tax
WCRF	World Cancer Research Fund
WHO	World Health Organization

Chapter 1: Introduction

1.1 Dietary patterns and health

Unhealthy dietary patterns are one of the leading risk factors for non-communicable diseases (NCDs) globally.[1,2] The Global Burden of Disease Study estimates that in 2016, almost one in five deaths were attributable to dietary risk factors, due to their contribution to disease outcomes such as diabetes, heart disease, stroke, obesity, and some cancers.[3] In Canada, it has been estimated that poor dietary intake is responsible for direct and indirect health costs of up to CAD$13.8 billion annually.[4]

In response to these growing concerns, the Government of Canada has introduced a Healthy Eating Strategy, which aims to improve the food environment to make it easier for Canadians to make the healthier choice.[5] Although dietary patterns influence health through a complex combination of energy intake, nutrient intake, and other factors, the Healthy Eating Strategy identifies three key nutrients of public health concern due to their salience in the food supply and their contribution to NCDs.[5] These three nutrients include sugars, sodium and saturated fats, discussed further below. Sugary drinks, which have emerged as a specific food category of major public health concern, will also be discussed.

1.1.1 Sugars

Sugars include those incorporated within the structure of intact fruits and vegetables; sugars from milk (lactose and galactose); all monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook or consumer; and sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates.[6] In the context of health concerns, the terms *added sugars* and *free sugars* are used to define the source of sugars in the food supply. Typically, the term *added sugars* incorporates sugars added to foods and beverages during processing or preparation, but does not include sugars naturally present in fruit juice or milk products.[7] In contrast, the World Health Organization (WHO) has proposed the term *free sugars*, which includes all sugars under the umbrella of *added sugars*, plus those naturally occurring in fruit juices and fruit juice concentrates.[6]

The strongest evidence to date suggests that excess dietary sugar intake is associated with two direct health risks. First, excess sugar intake has been associated with an increased risk of dental caries.[8–10] Dental caries represent a highly prevalent and costly NCD in both industrialized and lower income countries, and extensive evidence suggests that free sugars are the primary factor in their development.[8–10] Second, free sugars lead to increased body weight through their contribution to the overall energy density of dietary patterns:[11–13] excess consumption of free sugars may replace and therefore reduce the intake of more nutrient-dense foods in an individual's daily intake. Through this association with increased body weight, excess free sugars may also be linked to weight-related health risks including heart disease[14], stroke[15], diabetes[16], high blood cholesterol[17], and several cancers[2].

The WHO recommends that individuals reduce their intake of free sugars to less than 10% of total energy intake, or less than 5% for further health benefits.[6] Other organizations propose similar recommendations: the Heart and Stroke Foundation of Canada recommends free sugars to make up no more than 10% of total calories per day, and ideally less than 5%;[14] and the Canadian Diabetes Association recommends Canadians to limit their intake of free sugars to less than 10% of total daily caloric intake.[16]

Data from the Canadian Community Health Survey (CCHS) indicates that in 2015, average daily total sugars consumption was 101 g (24 teaspoons) for ages 1 to 8, 115 g (27 teaspoons) for ages 9 to 18, and 85 g (20 teaspoons) for adults.[18] Fruit was the top source of total sugars for all age groups; however, when combined, sugary beverages as a whole (regular soft drinks, sweetened milk, juice, fruit drinks, energy drinks, sweetened tea and coffee) represent the top source across all ages.[18] The format of the data makes it difficult to distinguish the amount of added or free sugars consumed compared to those naturally present in milk and whole fruits and vegetables; however, Brisbois and colleagues estimated that added sugars accounted for an average of 11 to 13% of Canadians' total energy intake in 2004.[19] Unfortunately, these analysis were subject to substantial limitations of the data source, and several industry affiliations among the authors call for caution when interpreting the results. These analyses did not account for 100% fruit juice; therefore, it is likely that free sugars account for much more than 13% of Canadians' daily caloric intake. Regardless, it is clear that a large proportion of Canadians consume free sugars in excess of the recommended 5 to 10% of daily energy intake.

Sugary drinks

Beverages high in sugars have recently emerged as a distinct point of public health concern, over and above sugars in general.[20,21] Similar to sugars themselves, high-sugar beverages are discussed and defined in several ways. The term *sugar-sweetened beverage* (SSB) has largely dominated early and present discussions of high-sugar beverages and the interventions targeting them. The definition of an SSB varies slightly across organizations and jurisdictions, but generally includes carbonated soft drinks, fruit drinks, sports drinks, energy drinks, flavoured waters, sweetened teas and coffees, and often sugar-sweetened milk (e.g., chocolate milk).[22] The definition of SSBs can be thought of as beverages containing *added sugars* (i.e., it does not consider sugars from fruit juices when defining high-sugar beverages). Alternatively, a more novel term—*sugary drinks*—has been proposed to reflect the fact that fruit juices and fruit juice concentrates should be considered on the same level as other forms of sugars.[23] This definition of *sugary drinks* reflects WHO's characterisation of *free sugars*, and encompasses all products that are covered under the definition of SSBs, as well as 100% fruit juice.[23]

Existing evidence suggests that excess consumption of sugary drinks is a distinct and separate risk factor for NCDs, apart from sugar intake in general. A well-established link exists between sugary drink consumption and weight gain[11,24–27], which is explained through multiple mechanisms: sugary drinks are energy-dense and contain little to no additional nutritional value, and higher consumption is associated with nutritionally poorer dietary intake overall.[24,28] Additionally, beverages generate a lower feeling of satiety compared to foods, therefore individuals who consume sugary drinks are less likely to compensate by reducing their caloric intake later.[24] Through its association with weight gain, sugary drink consumption increases the risk of obesity-mediated diseases such as type 2 diabetes, metabolic syndrome, cardiovascular disease, cancer, kidney disease, and musculoskeletal disorders.[17,28–35] Excess consumption has also been identified as having a direct impact on the risk of type 2 diabetes[36,37], cardiovascular disease[38], and dental caries[9]. It has been estimated that the consumption of SSBs leads to 184,000 deaths worldwide every year, and will account for over 38,000 deaths in Canada between 2016 and 2041.[23,39]

Data from the 2015 CCHS–Nutrition provide insights into Canadians' sugary drink intake. In 2015, 53% of children aged 1 to 18 years and 41% of adults 19 years and older reported consuming any type of SSB in the previous 24-hour period.[40] Similarly, 39% of children and 23% of adults reported consuming 100% fruit juice in the previous day. Overall, the average Canadian consumed a mean volume of 204 ml (99 kcal) of total SSBs and 74 ml (34 kcal) of 100% juice per day.[40] Daily consumption of 100% juice was much higher among children (118 ml) than adults (63 ml), and daily SSB consumption was higher in males (247 ml) than in females (160 ml).[40]

1.1.2 Sodium

Sodium is an essential nutrient for maintenance of fluid balance and normal cell function.[41] Day-to-day losses of sodium are minimal, and even under conditions of extreme heat or physical activity, losses through sweat can usually be replaced through regular food consumption without dietary alterations or specially formulated products.[42] Sodium, however, is highly prevalent in the food supply. It is found naturally in some foods, such as milk and meat products, and is a major component of common table salt, but the primary contributor of dietary sodium in developed countries is processed foods.[43–45]

Major international and national regulatory health bodies recognize excess sodium intake as a risk factor for NCDs.[41,46] Consumption of sodium at excess levels is associated with increased blood pressure, which in turn is considered a major risk factor for cardiovascular disease. Maintaining healthy levels of sodium intake has been shown to reduce the risk of high blood pressure, heart disease, and stroke.[41,47] Health Canada recommends adults limit their sodium consumption to less than a tolerable upper intake level (UL) of 2300 mg per day to avoid negative health consequences.[48] Although the US and Canada's Dietary Reference Intakes recommend adults aim for an adequate intake (AI) of 1500 mg of sodium per day,[48] existing evidence suggests that the minimum daily intake necessary for proper bodily function may be as little as 200-500 mg.[41]

CCHS data from 2015 indicates that Canadians consumed an average of 2760 mg of sodium per day—well above Canada's recommended UL, and almost double the recommended AI value.[49] Over 70% of men and 31% to 63% of women aged 9 to 70 reported sodium intakes above the

UL.[49] The top food group contributors to sodium intake included breads and bakery products, meat and non-meat mixed dishes (such as pizza or pasta dishes), processed meats, cheeses, and soups.[49,50]

1.1.3 Saturated fat

Saturated fats are naturally found in dairy products, animal-based foods, tropical oils, lard and shortening.[51] Along with trans fats, saturated fats are one of the two forms of dietary fats whose excess consumption has been linked to negative public health concerns, and are recommended to be replaced by healthier mono- and polyunsaturated fats.[51] Existing evidence suggests that dietary patterns high in saturated fats can raise levels of low-density lipoprotein (LDL) cholesterol, leading to a greater risk for heart disease and stroke.[52]

In Canada, there is no specific recommendation for daily saturated fats intake, and international recommendations vary.[1,22,53,54] Instead, Health Canada recommends Canadians consume as little saturated fat as possible while maintaining nutritionally adequate dietary intake.[55] Similarly, the Heart and Stroke Foundation of Canada recommends an overall balanced diet that is high in vegetables and fruit, whole grains, and a variety of proteins and low in highly processed foods, which will inherently help to reduce saturated fats intake and replace them with healthier mono- and polyunsaturated fats and other essential nutrients.[52]

In 2015, Canadians consumed levels of saturated fats equal to about 10% of their daily total energy intake,[56] and nearly half of the population consumed too much saturated fat overall.[51] Analyses from Canada and the United States suggest that processed foods (e.g., pre-packaged meals), red meat, dairy products (e.g., milk, cheese, yogurt), and egg dishes are among the largest sources of dietary saturated fats.[50,57]

1.2 Policy interventions for disease reduction

With rising concern over rates of diet-related NCDs, two population-level strategies have become increasingly popular in recent years: taxes to promote healthier dietary patterns, and interpretive front-of-package (FOP) nutrition labels. Both strategies aim to help make the

healthier choice easier for all consumers at a population level. The next two sections will discuss the existing evidence available for both strategies.

1.3 Food and beverage taxes

Over the past decade, an increasing number of jurisdictions around the world have begun to implement taxes on food and beverage products with the aim of promoting healthier dietary patterns and reducing diet-related NCDs.[58,59] Although taxes have been implemented targeting a range of specific foods and nutrients, taxes on beverages—in particular, SSBs—have grown to be the most common in recent years.

Food and beverage taxes are grounded in basic economic theory.[60] Price is a well-established driver of food choice: as price increases, consumers' likelihood of buying a product decreases.[60] The concept of 'price elasticity' describes the extent to which consumption of a particular good changes in response to a change in the price of the good itself, or the price of another good.[60] If the price elasticity value of a product is greater than one, it is considered to be elastic. Existing health-oriented taxes in other areas, such as tobacco or alcohol consumption, provide examples of fiscal measures that utilize this mechanism and successfully influence behaviours to produce positive health outcomes.[59,61–63]

1.3.1 Implemented food and beverage taxes

Many jurisdictions have long taxed particular foods or product categories for the purpose of revenue generation; however, it wasn't until the last two decades that countries began to implement food and beverage taxes with the explicit intention of promoting healthier dietary intake. In September 2011, Hungary implemented a national 'public health tax', which was applied to various ready-to-eat foods high in salt, sugar or caffeine.[64] Shortly after, Denmark implemented a tax targeting foods high in saturated fats, with the specific goal of reducing consumption of the targeted products.[58] Following these two countries, a growing number of health-oriented food and beverage taxes have been implemented or are currently being planned globally.[58] Taxes on high-sugar beverages have emerged as the most prominent variation in recent years, largely due to growing evidence and awareness of their negative health effects when consumed in high quantities, as discussed previously. One of earliest and most cited

national SSB taxes comes from Mexico, where SSBs have been taxed at a rate of one peso per litre since January 2014.[65] A long list of other countries that have since established SSB taxes includes Bahrain, Barbados, Belgium, Bermuda, Brunei, Chile, Ecuador, France, India, Ireland, Malaysia, Norway, Peru, Philippines, Portugal, Saudi Arabia, South Africa, Thailand, the UK, and more.[58] A growing number of US cities, including Albany, Berkeley, Boulder, Oakland, Philadelphia, San Francisco, and Seattle, are also implementing SSB taxes in various forms.[58]

1.3.2 Features of food and beverage taxes

Health-oriented food and beverage taxes all operate on the same basic economic principle, but have been implemented in a variety of forms. These taxes vary based on three key features: the type of tax, the taxation level, and the range of products that are taxed.

Type of tax

Food and beverage taxes can take several forms, including excise, sales, or value-added tax structures (see Table 1).[66] In the context of health-oriented food and beverage taxes, excise taxes are most common and may take the form of either a specific tax (for example, 1¢/oz or 1¢/g of added sugar) or an *ad valorem* tax (imposed as a percentage of a product's price).[67] A growing number of health organizations recommend that taxes be applied using a specific tax format—either based on volume ('volumetric') or nutrient content ('nutrient-based')—because they are less likely than *ad valorem* taxes to result in consumers choosing less costly but equally unhealthy products.[68,69] The WHO recommends that jurisdictions implement nutrient-based specific taxes to maximize their impact; however, in jurisdictions with limited tax administration or infrastructure, *ad valorem* taxes are often easier to implement.[58,67,68] Specific excise taxes have most often been implemented by targeting products containing nutrient amounts above a single threshold; however, some jurisdictions and researchers are starting to explore the potential benefits of introducing 'tiered' specific taxes based on the volume of a nutrient in a product (often sugar), such as the two-tiered tax recently implemented in the UK.[58]

Table 1. Definitions of common types of taxation

Term	Definition
Excise tax	A tax levied on the manufacture, sale, use, or distribution of a good. May also include a fixed fee or tax levied on an activity or an occupation, such as a privilege fee for selling fountain soda.[66]
Sales tax	A tax levied on the sale of goods and services at the point of purchase.[66]
Value-added tax (VAT)	A tax applying to the production or distribution of commercial goods that is charged as a percentage of price at each stage in the production/distribution chain. It is considered a consumption tax because the ultimate 'cost' of paying the tax through each stage of the production/distribution chain is borne by the consumer at the place of purchase.[66]
Specific tax	A tax or levy assessed based on product volume ('volumetric'), or nutrient volume ('nutrient-based'). For example, $0.66/liter, 1 cent/ounce of sugar.[66]
Ad valorem tax	A tax imposed as a percentage of a given good's value (for example, 20 per cent of price).[66]

The majority of the current evidence on health-oriented taxes has focused on *ad valorem* tax structures. Six studies were identified in the literature review for this dissertation that directly compared the relative effectiveness of different taxation formats. One experimental study compared the potential effects of an excise tax versus a sales tax, both applied to various beverages, snacks, and entrees classified as 'unhealthy'.[70] Results from this study suggested that the excise tax structure reduced caloric intake significantly more than the sales tax. The remaining studies used simulation modelling to compare predicted outcomes of different taxation structures. Two compared the predicted impact of an *ad valorem* tax to an equivalent specific volumetric tax, both concluding that a volumetric tax would result in greater health benefits and reductions in consumption than an *ad valorem* structure.[71,72] A study modelling a $0.01/oz volumetric tax, a $0.01-0.02 tiered tax, and a $0.01/tsp sugar specific tax estimated that the tiered tax would prevent the most cases of disease and save the most money, followed by the sugar-specific tax.[73] A comparison of various levels of tiered and non-tiered taxes projected that revenue would be similar between tiered and non-tiered taxes of comparable magnitudes, but a tiered tax would yield lower SSB intakes.[74] Lastly, a simulation study comparing the potential effects of a volumetric specific tax versus a nutrient-based specific tax found that a 0.04¢/kcal caloric (nutrient-based) tax was projected to cost less, result in a lower tax burden, and reduce per capita SSB intake to a greater extent than a 0.5¢/oz volumetric tax.[75]

Although there are a handful of studies providing evidence to compare different tax structures, there is a need for more experimental evidence on the relative effectiveness of *ad valorem* versus specific (volumetric or nutrient-based) tax structures to help guide policymakers.

Taxation level

Food and beverage taxes also vary in the rate at which they are applied. Among those implemented in real-world settings, the majority have applied taxes equivalent to approximately 10 to 30% of the retail price.[23,58] The consensus among most public health organizations and researchers is that SSB taxes should be applied at a rate of at least 20% to achieve measurable improvements in consumption and health outcomes.[67,76–78]

However, as noted previously, the majority of food and beverage taxes are implemented in the form of an excise tax and applied prior to the point-of-purchase.[66] Therefore, in most cases it is possible for the manufacturer or retailer to absorb all or part of the price increase. This means that the consumer may see a price that is unaffected, or affected to a lesser degree than if the tax was applied directly at the point of sale. The proportion of the tax that the manufacturer passes along to the consumer is known as the 'pass-through' rate. Taxes may be passed through to the consumer at a rate less than the amount of the tax ('undershifting') or greater than the amount of the tax ('overshifting'), if competition in an area is irregular.[79–81] In studies assessing hypothetical taxation measures, it is generally assumed that the full amount of an excise tax will be passed on to the consumer;[82] however, assessments of real-world taxes have found pass-through to be variable across jurisdictions, as discussed below. The degree of pass-through is an important consideration when assessing the effectiveness of food and beverage taxes implemented in the real world.

Taxable products

A final important feature of health-oriented taxes is the range of products that are targeted. In real-world tax policies, there is a high degree of variation in the array of products that are targeted by a tax. Health-oriented taxes may target a particular category of products (e.g., SSBs or energy drinks), one or more individual nutrients of concern (e.g., products containing high levels of sugar, sodium, or saturated fat), or a group of products defined based on a nutrient profiling system (e.g., energy-dense, nutrient-poor "junk" foods).[58,82] As noted, a large majority

of the evidence on health-oriented taxes has thus far focused on beverages, but several studies have explored taxes on food products as well.[70,83,92–101,84,102–111,85–91]

Even in the specific context of SSB tax measures, there are substantial differences in the range of beverages that are targeted: the majority of SSB taxes target high-sugar beverages such as regular carbonated soft drinks, fruit drinks, sports drinks, and flavoured waters; however, taxes vary in whether they also include other beverage categories such as 100% fruit juice, sweetened milk beverages, or beverages containing non-nutritive sweeteners (diet beverages).[66] As discussed previously, the distinction between SSBs and sugary drinks is critical given that fruit juice is one of the most frequently consumed beverages in Canada, particularly among younger age groups. Beverage taxes that exclude 100% fruit juice are likely to miss a key portion of sugar intake. Of all the studies reviewed for this dissertation, only five included 100% fruit juice in their definition of taxed products,[112–116] and only one made direct comparisons between an SSB tax and a sugary drink tax.[23] As an increasing number of organizations and jurisdictions adopt WHO's definition of free sugars (and the associated definition of sugary drinks), there is a need for more evidence on the potential impacts of a tax that includes 100% fruit juice in its range of taxed beverages.

1.3.3 Evidence on the impact of health-oriented taxes

This review of the literature identified evidence on health-oriented taxes from three key research methods: post-implementation, experimental, and simulation studies. The review includes literature published up to and including March 2020.

Post-implementation impact of food and beverage taxes

The review prepared for this dissertation identified 47 studies that explored the outcomes of real-world food and beverage taxes, including their impact on price, purchasing, and dietary intake or consumption. Four studies disclosed potential conflicts of interest due to authors' previous collaboration on projects funded by the food and beverage industry; however, results were largely in line with other studies.[95,117–119]

Mexico provides the richest source of data on real-world outcomes of health-oriented food and beverage taxes at a national level. Following the country's implementation of an 8% tax on non-

essential energy dense foods and a 1 peso per litre (approximately 10%) tax on SSBs in January 2014, 11 published studies have reported on the taxes' impact.[79,93,124,94,95,117,118,120–123] The evidence suggests that the SSB tax resulted in a complete pass-through to consumer prices in urban areas;[79] however, in rural and semi-rural areas, an average price increase of only 0.73 pesos per litre was observed in the first year.[93] The tax passed through completely for non-essential energy dense foods in rural areas.[93] Observations focusing on the nation's urban population following the introduction of the junk food tax found a 5.1% reduction in purchases of non-essential energy dense foods in year one, and a 7.4% reduction in year two.[94,95] A more recent study encompassing both urban and rural populations identified an overall 5.3% reduction in purchases of taxed food (-5.4 g/week per capita) recorded in the 2014 and 2016 waves of the Mexican Income and Expenditure Survey; however, the largest reductions were in urban areas, and no significant reductions were seen in rural areas.[120] Household purchasing data indicates that Mexican households with higher baseline purchasing of taxed beverages showed the largest reductions in taxed beverages and increased purchases of untaxed beverages.[124] Analyses of both household purchasing data and industry sales data suggest that SSB purchases were reduced by approximately 6% in year one and 10% in year two, resulting in an estimated average reduction of 7 to 8% over the two years post-implementation, and small reductions in calories and sugars purchased.[117,118,121–123] These reductions in SSBs have been paired with varying increases in purchases of plain water and other non-taxed beverages.[117,118,121,122]

Fifteen studies from the US have examined outcomes of city-level SSB taxes in Berkeley, Philadelphia, Cook County, Seattle and Oakland.[81,119,133–137,125–132] In Berkeley, where a tax of 1¢/oz (equivalent to approximately 10% of retail price) was implemented in March 2015, one study found that SSB prices increased more than those of nearby cities three months post-implementation,[81] and a second found that tax pass-through rates for SSBs were complete in some, but not all retail outlets.[119] At four months post-implementation, self-reported SSB consumption decreased by 21% in low-income neighborhoods in Berkeley, while increasing by 4% in comparison cities.[125] Another study, however, found that the reductions in self-reported SSB intake at one year post-tax were not statistically significant, possibly due to the markedly low baseline levels of SSB consumption in the city.[119] Sales data showed reduced SSB sales of 9.6% in Berkeley versus an increase of 6.9% in non-Berkeley stores, accompanied by sales of untaxed beverages in Berkeley stores rising by 3.5% versus 0.5% in non-Berkeley stores.[119]

More recently, at 3 years post-implementation, self-reported SSB consumption frequency was estimated to have declined by 0.6 times per day (-52%) and water consumption increased by 1.02 times per day (+29%) in Berkeley, compared to no changes in a comparison city.[126] Five studies have assessed outcomes of Philadelphia's 1.5¢/oz (approximately 20%) SSB tax. Estimates of the tax's pass-through rate range from 43% (in supermarkets) to over 100% (in pharmacies).[127,128] Within the first two months of implementation, the odds of self-reported daily consumption relative to comparison cities was 40% lower for regular soda, 64% lower for energy drinks, and 58% higher for bottled water.[129] Sales of taxed beverages decreased by 1.3 billion ounces (51%) in Philadelphia approximately one year after the tax; however, decreases were partially offset (24%) by increased sales in neighboring zip codes.[128] Additional estimates at one year post-implementation suggest that purchases of taxed beverages were reduced in Philadelphia and increased outside of the city, and that there were minor to moderate reductions in self-reported consumption of taxed beverages.[130,131] Observational evidence from the 1¢/oz SSB tax in Oakland, CA suggests that approximately 60% of the tax was passed through to consumers overall, but that there were no statistically significant changes in prices of taxed fountain drinks in fast-food restaurants.[132,133] Estimates suggest a net non-significant decrease of 11 ounces of taxed beverages per shopping trip, after accounting for increased purchases at stores outside of the city.[132] At 6-months post-tax, Oakland retailers were less likely to feature price promotions on SSBs (taxed) and diet beverages (untaxed) compared to the comparison city.[134] The 1¢/oz SSB tax in Cook County, IL—while only in place for approximately four months before being repealed—was passed through to consumers at an estimated rate of 119% overall,[135] and reduced sales of taxed beverages by 21% after accounting for increased sales in the city's border area.[136] No significant changes were detected in Cook County or its border area for sales of untaxed beverages. In Seattle, the city's 1.75¢/oz SSB tax has been estimated to have a pass-through rate of 59% in the first year following implementation.[137] Taxed beverage sales fell by an estimated 22%, with some substitution detected to other non-taxed beverages and no significant increases in taxed beverage sales in the 2-mile border area of Seattle.[137]

In Chile, three observational studies examined changes in product prices and purchasing following the nation's 8% tax increase on SSBs in 2014.[138–140] Estimates of price increases ranged from approximately 2 to 6% across the targeted SSB products.[138,139] Estimates of changes in SSB purchasing varied, with one study suggesting a 3-4% reduction in monthly purchases of

taxed beverages per capita, and another estimating a 22% reduction in household purchases of taxed beverages.[138,140]

Two published studies have examined outcomes of the UK tiered soft drinks industry levy (£0.18/L for 5-8 g sugar/100 ml, £0.24/L for > 8 g sugar/100 ml) implemented in April 2018.[141,142] Both studies found evidence suggesting significant reductions in the sugars and energy content of beverages following the announcement and implementation of the tax, and price data suggested a pass-through rate of 31%.[141,142] Two additional studies from the UK provide insight into small local tax initiatives. An analysis of a local £0.20 price increase on SSBs sold in Sheffield leisure centre venues found that in the year following the price increase and an associated health promotion campaign, there was a 31% reduction in units of SSB sold per attendance.[143] Similarly, a study examining the potential effects of a £0.10 per beverage levy in a national chain of commercial restaurants across the UK found an 11% reduction in SSBs sold per customer at 12 weeks and a 9% reduction at 6 months post implementation.[144]

In Barbados, a study investigated initial price changes following implementation of the country's 10% SSB tax.[80] Using retail sales data from a large national supermarket chain, the study found that the growth of SSB prices outpaced non-SSB prices in the year following implementation, reaching 5.9% compared to less than 1% growth for non-SSBs. More recently, an analysis of national SSB sales found that average weekly sales of SSBs decreased by 4%, while sales of non-SSBs increased by 5%.[145]

Although the Danish saturated fat tax (approximately $2.70/kg saturated fat) was abolished in 2013, three published studies have assessed outcomes following its implementation.[91,146,147] One study used representative consumer household panel data from before and after its introduction to assess any potential changes in the two years that it was in effect.[91] The study identified a 4.0% reduction in saturated fat intake, and increases in vegetable and sodium intake in most individuals as a result of the tax's implementation. A second study analysed weekly food purchase data between 2008 and 2012, estimating that levels of fats consumption were reduced by 10-15% following the introduction of the tax.[146] Lastly, a study assessing consumers' responses before and after the tax was repealed found that consumers responded similarly to both the price increases and reductions: average SSB purchasing was 13% lower following introduction of the tax, but then rebounded 31% following its repeal.[147]

Two studies were identified that assessed the impact of France's €0.07/L tax on beverages with added sugar or sweetener.[148,149] Estimates from price data suggest that the tax was passed through completely for soft drinks, and partially for fruit drinks and flavoured waters.[148,149] Estimates of purchasing following the tax indicated a small reduction in soft drink purchases at most (0.5L/capita/year), consistent with the low tax rate.[149]

A study assessing the effects of the Hungarian junk food tax found some evidence that the tax improved the dietary habits of the Hungarian population 16 months after its implementation.[92] The study identified a significant (3.4%) reduction in the quantities of processed food consumed, accompanied by a non-significant increase (1.1%) in consumption of unprocessed foods.

In the Philippines, prices of taxed beverages had increased by 16-20% in the month following implementation of their national SSB tax (approximately 12-24¢/L), and sales of taxed beverages in convenience stores had declined an estimated 9%.[150]

An assessment of Portugal's national tiered SSB tax (€0.08/L for < 80 g sugar/L, €0.16/L for > 80 g sugar/L) suggests that sales of taxed beverages dropped by 7%, with a significant proportion of purchases being shifted towards products falling in the lower tax tier.[151] There was also evidence of product reformulation following the tax, leading to a potential 11% reduction of total energy intake from SSBs.[151]

In Saudi Arabia, a large (50%) national tax on SSBs demonstrated near-complete pass-through to consumers, and led to reductions in SSB sales of 33% relative to changes in sales of untaxed beverages.[152]

A study of South Africa's sugar-specific SSB tax (2¢/g sugar) observed significant price increases among taxed beverages compared to untaxed products; however, price increases did not always align as expected with products' sugar content and associated tax liability.[153]

In Catalonia, Spain, estimates suggest prices increased between 5-20% on taxed SSB products, depending on container size, and an 8% reduction in weekly SSB purchases following implementation of a tiered tax (€0.08/L for 5-8 g sugar/100 ml, €0.12/L for > 8 g sugar/100 ml).[154] Self-reported regular consumption of taxed beverages fell by 39%, with no changes in reported consumption of untaxed beverages.[155]

Overall, the evidence currently available on the observed impacts of real-world food and beverage taxes is promising. Differences in effect sizes observed across studies for some jurisdictions may be largely attributable to differences in data collection methods: while sales data provide an objective depiction of beverage purchases, they often omit some purchasing or consumption settings, such as restaurant sales, and may be unable to accurately capture detailed beverage categories.[156] Surveys assessing self-reported beverage consumption can better capture a wide range of beverages and consumption scenarios, but introduce social desirability and recall biases.[156] Further, some studies reporting null effects from self-reported beverage consumption surveys[119,132] may have been insufficiently powered to detect small but meaningful changes in consumption. Despite some heterogeneity across studies, the observational evidence currently available suggests that these taxes are making at least a modest impact on price, purchasing, and consumption. However, given that no health-oriented taxes have been implemented long enough to judge their long-term impact, we must, for now, rely on experimental and simulation modelling methods to estimate potential impact on health outcomes such as obesity and other diet-related NCDs.

Experimental studies

Experimental methods provide a framework for examining the potential outcomes of a tax in a controlled setting. Although the controlled nature of experimental studies makes it difficult to directly apply results to real-world populations, experimental methods provide a cost-effective way to test multiple types and features of taxes at a small scale prior to larger-scale testing or implementation in the real world.

This review identified 20 studies that used experimental methods to explore behavioural responses to health-oriented taxes, including studies from the US,[70,85–90,157] Netherlands,[83,84,104,114] Australia,[112,158] New Zealand,[107,159] Canada*,[113] Singapore[111] and Taiwan.[160] None of the studies disclosed any potential conflicts of interest.

The studies used a range of experimental methods. The majority of the articles assessed hypothetical or self-reported purchase intention (through discrete choice experiments,[112]

* This experimental marketplace, led by the authors in 2016, serves as a 'pilot' for the proposed research.

supermarket simulations,[83–87,104,107,111,114] hypothetical laboratory purchases,[88] or between-group survey tasks[159]). The remaining studies used experimental methods to investigate actual consumer purchases (i.e., by incorporating real monetary consequences and/or actual product purchases) through controlled conveniences store settings[90,158] or experimental purchasing scenarios.[70,89,113,157,160]

Results from the studies assessing hypothetical or self-reported purchase intentions overwhelmingly suggest that price increases are effective at reducing purchases of targeted products or nutrients. Three studies focused on taxes on SSBs, with two reporting significant reductions in hypothetical purchasing of SSBs,[112,114] and one reporting a significant reduction in reported preferences for SSBs, but a non-significant reduction in hypothetical SSB purchases.[159] Eight studies assessed taxes that were applied to a broader range of foods and beverages classified as 'high calorie', 'high energy dense', 'low nutrient dense', 'unhealthy', or containing high levels of particular nutrients, according to various nutrient profiling criteria. All but two[84,104] of these studies found that the taxes—ranging from 12.5 to 50% of product price—resulted in reduced hypothetical purchases of total calories or the targeted foods.[83,85–88,111] One study assessed the healthfulness of purchases in responses to various taxes, finding that specific taxes on saturated fats, sugars and salt were effective at increasing the healthfulness of hypothetical purchases.[107]

Similarly, data from experimental studies examining actual purchasing behaviours consistently found that purchases or sales of targeted products were reduced under the influence of price increases. The taxes tested in these studies—which applied rates ranging from 10 to 100% to SSBs, energy drinks, or various definitions of 'unhealthy' products—were all effective at significantly reducing actual purchases of the targeted products.[70,89,90,113,157,158,160]

Overall, the vast majority of the experimental studies identified a significant reduction in actual or hypothetical consumer purchasing of the products or nutrients targeted by a tax. Only 3 of the 20 studies did not identify statistically significant reductions in consumer purchases under the influence of a price increase.[84,104,159] However, all three of these studies reported non-significant effects in the expected direction, and authors noted that the lack of significance was likely to be attributable to either insufficient power[84,104] or the absence of comparator products.[159]

Simulation studies modelling the potential impact of food and beverage taxes

When real-world data is not available, mathematical simulations are a valuable tool to estimate the potential effects of a tax at a population level. Simulation studies do not estimate the 'effect size' of interventions; rather, they draw on data obtained from experimental studies and post-implementation studies to estimate the potential population impacts of a taxation policy within a particular setting and time period.

The bulk of the evidence identified in this literature review comes from simulation studies. Those identified in this review (n=83) simulated taxes in the US,[73,74,163–172,75,173–182,101,183,184,102,103,105,110,161,162] the UK,[100,108,116,185–190] Australia,[71,72,96,97,106,191,192] South Africa,[193–198] Germany,[199–201] New Zealand,[99,202,203] Chile,[98,109,204] Colombia,[205,206] Mexico,[115,207–209] Brazil,[210] Canada,[23] Denmark,[91] Guatemala,[211] India,[212] Indonesia,[213] Ireland,[214] Netherlands,[215] Norway,[216] Philippines,[217] Portugal,[218] Thailand,[219] and multiple world regions.[220,221] One study reported direct funding from the Union European Soft Drinks Association, predicting that a tax would have only small impacts on calorie consumption.[186] One reported potential conflicts due to two authors' employers potentially benefiting from revenue generated by the studied tax, with results suggesting positive health and financial outcomes.[217] Seven studies disclosed potential conflicts of interest due to authors' previous collaboration on industry-funded projects; however, all predicted positive outcomes of the simulated taxes.[103,165,182,187,188,205,212]

The studies examined a variety of outcomes. A large proportion of the studies explored the potential impacts of a tax on health, disease, or mortality indicators,[23,73,164–166,168,178,182–185,187,96,189,191,192,194–196,198,199,201,202,97,207,209,212,213,215,217,219,220,99,100,103,105,106,115] as well as impacts on food, nutrient or calorie consumption.[23,71,102,103,108–110,116,161,162,164,165,72,166,167,169–173,175,177,178,75,179–181,185–189,193,194,96,199,200,202,205,208,210,212–215,97,216,219,220,98–101] Many studies examined impacts on body mass index (BMI) or weight.[23,71,170,172,173,178,180,184,187–189,191,97,192–194,200,206,207,209,212–214,102,216,218,108,110,162,163,166,169] Other outcomes that were explored included healthcare and implementation costs,[23,73,178,184,185,189,191,192,194,195,198,199,96,215,217,220,97,115,163,164,166,168,174], potential tax revenue,[23,74,191,192,198,199,202,205,215,100,161,163,164,166,170,178,188] projected tax burden on households or individuals,[71,72,75,101,109,170,179,188,192,213] overall cost-effectiveness of the tax policy,[73,96,97,163,166,182,184,192,198,209] productivity gains,[106] and reductions in greenhouse gas

emissions.[100] A large portion of the studies also reported price elasticity estimates as a primary finding.[71,72,170,172,173,177,179–181,186,188,190,75,197,201,203–205,208,210–212,216,98,221,100–102,116,162,167]

The type of intervention simulated varied substantially across the studies identified. Most studies modelled the outcome of a single SSB tax, including *ad valorem* taxes applied as a percentage of product price,[106,108,188,189,191–195,198–200,162,202,205,208,212,214–216,167,170,172–174,180,185] and specific taxes assigned based on volume or nutrient content.[96,115,177,178,182–184,207,213,217–219,161,163,164,166,168,169,171,175] Several studies compared the relative effects of two or more different tax variations.[23,71,102,103,105,109,110,116,179,181,186,187,72,196,206,209,73–75,98–101] A handful of studies modelled the potential outcomes of health-oriented taxes on foods,[96,97,108–110,201,220,98–103,105,106] and several compared the outcomes of a tax to other non-fiscal policy options such as nutrition labelling, advertising regulations, or school-based programs.[97,163,165,169,171,174,177,187,219] Eight of the studies included a focus on healthy food subsidies.[96,99,100,102,105,109,110,165] Lastly, a subset of the studies only calculated and reported price elasticity estimates, without applying them to a specific intervention scenario.[190,197,203,204,210,211,221]

Overall, although it is difficult to summarize results due to the varied outcomes and methods used across the studies, the estimates derived from simulation studies collectively indicate that taxes on SSBs and other unhealthy foods have the potential to produce meaningful improvements in population health indicators and reduce health-care costs.

Results and outputs varied across post-implementation, experimental, and simulation modelling studies assessing food and beverage taxes. Although the body of real-world evidence on SSB taxes is growing rapidly and suggests promising results, there is no real-world evidence in Canada, where no SSB taxes have been introduced. In place of real-world evidence, this review identified several experimental studies that assessed consumers' product selections in response to food and beverage taxes; however, the majority of these studies examined hypothetical or intended purchases rather than actual product selection, and only one was conducted in Canada.[113] Experiments incorporating purchases with real monetary consequences may provide more realistic estimates of consumer behaviour in response to taxes. Studies such as these in a Canadian context would provide valuable effect size estimates for predicting how a health-focused tax might play out in Canada.

1.3.4 Differences across sociodemographic subgroups

An important consideration when implementing a health-oriented tax on foods or beverages is the potential for differential effects across income, ethnicity, education, gender, or age groups. It is critical to thoroughly understand the potential differences in impact across subpopulations so that taxes can be implemented in a way that does not exacerbate (or better yet, reduces) existing health or economic disparities.

Overall, most of the tax literature that has assessed differences across subgroups has found that individuals of lower income tend to be more responsive to price increases than their higher income counterparts.[92,95,108,118,121,122,124,208] Critics of sugar taxes often cite this potential regressive nature as one of the key disadvantages of sugar taxes; however, the evidence to date suggests that although lower income groups are projected to spend more of their annual income on the tax than higher income populations,[71,170,188,192] this percentage of their income is likely to be small, equating to as little as a few dollars per year.[71,170,188,192] Additionally, lower income populations in many settings tend to have higher baseline SSB consumption rates, meaning that they are projected to receive the greatest health benefits at the population level.[71,99,192,199,200,203,206,207,210,103,116,162,168,170,175,178,190] In this sense, sugar taxes are expected to be financially regressive to a marginal degree, but progressive in terms of health outcomes.

Several studies in this review also identified differences across age, gender, ethnicity, and other population subgroups. In general, it was recognized that price responsiveness and health improvements are projected to be greater among younger age groups,[115,162,218,221,164,193,194,199,200,207,212,214] males,[106,164,199,200,212,221] rural populations,[208,212] indigenous populations,[99] and ethnic or racial minorities.[168,169,178]

1.4 Front-of-package nutrition labelling

FOP nutrition labelling is another increasingly common policy strategy being applied in the efforts to reduce diet-related NCDs. FOP nutrition labels aim to complement the existing nutrition information that is generally displayed on the back or sides of packages, such as Canada's Nutrition Facts table (NFt).[222–224] In Canada, the NFt is widely used and trusted by consumers;[225–233] however, evidence suggests that Canadians struggle to understand and apply

the quantitative nutrient information that they display, such as serving size or percent daily values,[225,234,243,235–242] particularly among individuals with lower levels of health literacy.[226,234,237,244,245] Standardized FOP labelling systems aim to provide a single, standardized symbol or rating that delivers quick and simple nutrition information to consumers.[222–224] These labelling systems also offer a solution to reduce consumer confusion related to the clutter of nutrient and health claims that manufacturers display on packaged products, by offering a single government-endorsed label that consumers can trust and refer to.[222]

An increasing number of national and global health institutions are calling for the implementation of FOP nutrition labels, and some have published documents to guide their successful development.[246–249] Recommendations from the Institute of Medicine encourage countries to develop FOP labelling systems that are *simple* (not requiring specific or sophisticated nutritional knowledge to understand), *interpretive* (nutrition information is translated into guidance for readers rather than stated as specific facts), *ordinal* (nutritional guidance is offered using a scaled or ranked approach), and *supported by communication* (the label should use readily remembered names or identifiable symbols).[250] Guidance can also be drawn from labelling research outside of the food realm. Long-established best practices from tobacco and other domains suggest that the salience of a label is a key predictor of the extent to which consumers will notice and attend to the label.[251] To ensure that they stand out from the rest of a package and are noticed by the consumer, labels should be of a sufficient size,[252–258] legibility,[259–261] and incorporate contrast[262–264] and a sizeable border[265] in their design.

1.4.1 Implemented front-of-package labelling systems

A range of FOP labelling systems have been proposed and implemented.[223,224,266] The majority of implemented systems follow either a ‘nutrient-specific’ structure, which focuses on communicating information about the presence or levels of key nutrients (either positive, negative, or both), or a ‘summary indicator’ format, which, instead of focusing on specific nutrients, provides an overall summary or rating of the healthfulness of a food or beverage product based on a predetermined algorithm that considers the nutrient profile of the product.[267] Within these two broad categories, the FOP labelling systems currently implemented include Guideline Daily Amount (‘GDA’) labels, ‘health logos’, ‘traffic lights’, ‘rating systems’, and

'high in' labels (Table 2). The systems, discussed below, include both voluntary and mandatory schemes, and interpret the nutrition information for consumers to various degrees.

Table 2. Categories and types of select front-of-package nutrition labelling systems

Category	Type	Examples of implemented systems
Nutrient-specific	GDA	• 'Facts up Front' (US) • Mandatory FOP GDA (Mexico, Thailand)
	Traffic lights [a]	• Traffic lights for sugar, sodium and fat (Ecuador) • Traffic lights for energy, fat, saturated fat, salt, sugar (UK)
	'High in' labels	• 'High salt' labels (Finland) • 'High in' sugars/sodium/saturated fats/energy (Chile)
Summary indicator	Rating systems	• 'Health Star Rating' (Australia, New Zealand) • 'Nutri-Score' (France, Belgium) • 'NuVal' (US – no longer in use)
	Health logos	• 'Keyhole' symbol (Nordic countries) • 'Healthier Choice' logo (Singapore, Brunei, Thailand, Malaysia)

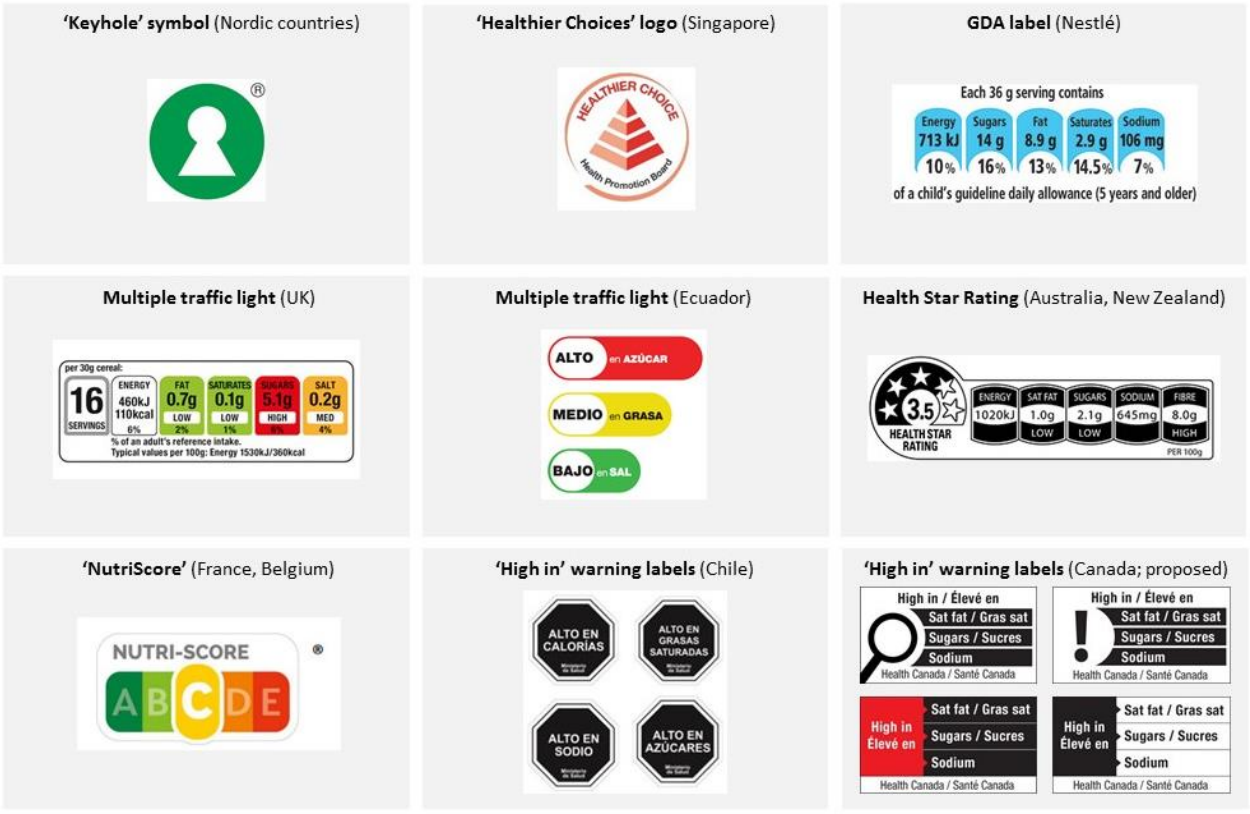
[a] The traffic light format is predominantly used as a nutrient-specific indicator ('multiple traffic lights'); however, the format has also been used as a summary indicator ('single traffic light') to communicate the overall healthiness of a product.

Health logos

Health logos were some of the first FOP nutrition labelling systems to be implemented, having been introduced by non-profit and government agencies as early as the late 1980s (i.e., American Heart Association's 'Heart Guide' and Swedish National Food Administration's 'Keyhole').[267,268] Health logos are summary indicator systems that communicate a product's healthfulness using a single logo, which manufactures are permitted to display on products

meeting a pre-specified nutrient profiling criteria.[267] In recent years, many manufacturers have introduced their own health logos (e.g., Kraft's 'Sensible Solutions' label) in addition to those recommended by government and non-profit agencies.[269,270] Voluntary government-endorsed health logos are in place in numerous countries, including Denmark, Iceland, Lithuania, Norway and Sweden ('Keyhole' logo); Slovenia ('Little Heart' logo); Finland ('heart' symbol); Nigeria ('Heart Check' logo); Belgium, Czech Republic, the Netherlands, and Poland ('Choices' logo); United Arab Emirates ('Weqaya' heart logo); and Singapore, Brunei, Thailand and Malaysia ('Healthier Choice' logo).[223,224,266] Example images of several prominent FOP labels are provided in Figure 1.

Figure 1. Examples of implemented FOP nutrition labels



GDA systems

GDA labelling systems—also referred to as the 'Daily Intake Guide' or 'Facts up Front' in other countries—are nutrient-specific labels that provide information on levels of energy and/or nutrients contained in a product.[267] GDA labels often display both the amount (e.g., per serving

or per 100 g) and the percent daily value (%DV) of each nutrient, and may include negative nutrients, positive nutrients, or both.[267] These FOP labelling systems provide no interpretation or recommendations concerning the healthfulness of a product; they simply provide a summary of key nutrients in a more accessible location for consumers. Currently, GDA systems are predominantly implemented on a voluntary basis by food manufacturers, such as the 'Facts up Front' system in the US.[271] However, there are government-mandated GDA labels currently in place in Mexico, where most packaged foods and beverages must display saturated fats, other fats, total sugars, sodium, and energy; and in Thailand, where packaged snack foods must display energy, sugar, fat and sodium information.[223,224,266] GDA labels are traditionally monochromatic; however, colour-coded GDA symbols also exist. For the purposes of this review, 'colour-coded GDA' systems will be encompassed under the category of 'traffic light labels', discussed below.

Traffic light labels

Traffic light labels are nutrient-specific systems that use a familiar tricolour system (red, yellow/amber, green) to indicate when a product contains high, moderate or low levels of specific positive or negative nutrients.[267] Traffic light labels may also include text indicators such as 'high', 'medium' or 'low', and may or may not display information on nutrient levels or %DV.[267] These systems are most often used as 'multiple traffic lights' (MTLs) to communicate levels of several different nutrients; however, they are also infrequently used as summary indicator systems to indicate the overall healthfulness of a product or to communicate levels of one specific nutrient of concern, known as a 'simple' or 'single' traffic light (STL). A number of countries currently have traffic light schemes in place, including voluntary government-endorsed labels in the UK and South Korea (MTLs for energy, sugars, fats, saturated fats, and/or sodium), and mandatory traffic light schemes in Ecuador (MTLs for fats, sugars and salt), Bolivia (MTLs for saturated fat, added sugars and sodium) Iran (MTLs for sugars, salt, total fats, trans fats, and energy) and Sri Lanka (STL for total sugars in beverages).[223,224,266,272]

Rating systems

Rating systems are summary indicator labels that provide an overall rating of the healthfulness of a product, for example by using stars, a numeric rating, colour coding, or a letter grade.[223,267] Rating systems do not present any specific nutrition facts to consumers, instead interpreting the

nutritional value of the product for them. There are currently voluntary rating systems in place in Australia and New Zealand ("Health Star Rating" (HSR)); as well as in France, Belgium and Spain (five-colour "Nutri-Score" letter rating).[223,224,273,274] Colour-coded rating labels are also currently under consideration in Germany, Ireland, Portugal and Poland; however, they are not yet implemented.[266,275] An additional nutrition rating system worth noting is NuVal. Although this system is an on-shelf nutrition rating system rather than a FOP labelling system, it is often examined alongside FOP labels in the literature.[276–279] NuVal is a numeric rating system that assigned products a value of 0 to 100 based on a proprietary algorithm.[276,277] The system, however, is no longer in use.[280]

'High in' labels

Perhaps the labelling system gaining the most momentum in recent years, 'high in' labels are nutrient-specific FOP systems that are placed on foods containing high levels of nutrients of public health concern.[223,266] The first mandatory FOP 'high in' nutrient labels were implemented in Finland in 1993, where packaged foods high in sodium are required to display a label denoting high salt content.[224] More recently, Chile has implemented mandatory octagonal 'high in' labels that are required to be displayed on foods high in sugars, sodium, saturated fats and total energy, followed by Peru and Israel with similar mandatory labels.[223,224,266,281] In addition to those already implemented, mandatory 'high in' labels for sugars, sodium and saturated fats are currently being pushed forward in Indonesia, Mexico, Brazil and Canada.[269,282–284] In the US, similar labels—but with a more traditional 'warning label' format akin to tobacco warning labels—have been proposed specifically for SSBs at the state level in California, Hawaii, New York, Washington and Vermont, and at the city level in Baltimore and Maryland.[266]

In summary, FOP labelling systems have been implemented in a myriad of ways, and there is no consistent format that is agreed upon across countries. A majority of existing FOP labelling systems are voluntary in nature, but a growing number of jurisdictions are beginning to implement mandatory systems in recognition of the fact that voluntary implementation often results in slow and inconsistent uptake of the label by manufacturers, resulting in potential confusion and positivity bias towards products not yet displaying the label.[285,286] Whether or not jurisdictions are able to implement FOP labelling systems as a mandatory policy depends a great

deal on several outside factors, including the structure of existing laws and policies, the current political climate, and the degree of influence from industry groups.[287,288]

1.4.2 Evidence of the impact of FOP labelling systems

A substantial amount of evidence is available on the impact of FOP labelling systems on consumer perceptions and behaviours, which can be categorized into 'pre-implementation' and 'post-implementation' research. Pre-implementation research incorporates studies such as experimental tasks, surveys or focus groups that have explored the potential effects of FOP labels prior to them being implemented in a real-world setting. Post-implementation research includes those studies that have assessed real-world outcomes of FOP labelling systems that have been implemented in a particular setting. This review incorporates literature identified in a previous comprehensive review completed in March 2018,[289] as well as studies published from that date up to and including March 2020.

Pre-implementation research

The large majority of existing research on FOP nutrition labels is pre-implementation research. In this review, 157 pre-implementation studies were identified. Nine studies reported past or current industry affiliation for at least one author, with some indicating strong support for an industry-proposed labelling system or suggesting that FOP labels may have negative or null effects,[279,290–292] while others reported positive impacts of at least one non-industry-led FOP system.[293–297] The following sections summarize the pre-implementation evidence, organized by outcome.

Consumer attention and salience

First, this review identified 16 studies that assessed salience and consumer attention to FOP nutrition labels.[293,298,307–312,299–306] The majority of these studies used eye-tracking methodology to characterize participants' attention to and awareness of the labels in the context of a product package. Eye-tracking studies from Uruguay, Chile, Europe, and the US tested a variety of FOP labels, and found overall positive results: in comparison to no label or a standard NFt, FOP labels increased participants' attention to nutrition information and reduced response times when answering questions about the nutrient content of products; FOP labels received significantly

more attention than back-of-package NFts when consumers were evaluating products.[293,298,307,299–306]

Studies that compared salience and attention across different FOP label designs found an array of results. One found that a MTL label resulted in faster information processing compared to a GDA label,[301] one found no differences in likelihood of viewing a MTL or GDA FOP label,[303] and another found that participants needed significantly less time to evaluate simpler FOP labelling schemes ('healthy choice' tick logo or HSR) compared to more complex FOP labelling formats (GDA label).[293] A study from Uruguay identified both Nutri-Score and 'high in' labels as producing greater attentional capture than a HSR label.[308] Another study showed that a health logo attracted marginally more attention than a MTL label; [300] however, another found that participants spent more time looking at products with colour-coded or monochrome GDA labels (and were more likely to choose those products) compared to those displaying a 'Choices' logo.[309] Lastly, seven studies identified that nutrient warning labels elicited the shortest response times and greatest attentional capture compared to NFts, GDAs, or other FOP nutrition labels,[304–307,310,311] with one concluding that black (vs. red) and larger sized nutritional warnings showed the greatest attentional capture.[312]

Consumer support and preferences

Second, 36 studies in this review assessed consumer support and preferences for FOP nutrition labels.[279,294,320–329,296,330–339,313,340–345,314–319] Cross-sectional surveys and focus groups from Canada, Australia, South Korea, Chile and South Africa have all found strong support and very low rates of opposition for FOP nutrition labels in general.[294,313,322,314–321] Several studies have also explored preferences between different types of FOP labels, reporting a variety of conclusions. Several studies have identified that consumers preferred a MTL compared to other FOP labels;[279,294,323–329] however, other studies have similarly identified the HSR[330–332] or the NFt[322] as most favoured. More recent studies assessing newer FOP systems have found consumers to prefer nutrient warning labels[296] or Nutri-Score[333] labels over other formats, while others have reported similarly favourable responses across a variety of FOP labels.[334,335] Qualitative data from interviews and focus groups generally reveal that consumers prefer labels with simple, directive information that they can process easily and quickly, such as those that use simplified graphic information, rather than those dominated by text or numerical

information.[324,336–341] Preferences for label formats often varied by country,[342] sociodemographic groups,[343,344] and product category.[345] Overall, the existing literature demonstrates strong public support for the implementation of FOP nutrition labels; however, there is no one FOP format that is consistently preferred.

Consumer understanding – self-reported and objective

Consumer understanding—whether self-reported or objectively measured using functional tasks—has been examined in many studies in the literature. In this review, 11 studies were identified that examined self-reported consumer understanding,[296,327,354,346–353] and 39 assessed objective understanding of FOP nutrition labels.[278,290,326,334,335,346,352,355–359,291,360–369,295,370–378,299,300,308,310,323,325]

Results for self-reported understanding varied substantially across studies. Most studies comparing FOP labels to traditional NFts found significantly higher ratings of ease of understanding for FOP labels.[346–349] Among studies that compared self-reported understanding across different FOP formats, results varied. Several studies found consumers report higher comprehension of simple FOP formats that incorporate fewer details (e.g., HSR, 'high in' labels, or logos),[349–353] whereas other studies reported the opposite.[327,354] One study found that participants reported greater understanding of both HSR and MTL labels compared to NFt only;[348] however, another reported that HSR received the poorest ratings of understanding compared to 'high in', MTL, or NFt.[296]

Studies assessing consumers' objective understanding of different FOP nutrition labels used functional tasks to measure participants' accuracy in correctly identifying one or more 'healthful' foods from a range of options. Again, most studies comparing FOP labels to a control or NFt condition found that the presence of any FOP label on food products significantly increased objective understanding of the product's healthiness or nutrient content compared to the control.[278,299,358–365,300,310,334,335,346,355–357] Among studies that compared objective understanding across different FOP labelling formats, most identified simple, interpretive FOP labels (e.g., STL, HSR, 'high in' labels) as objectively easier to understand than more complex label formats,[300,310,369–372,325,326,352,359,365–368] and several others found the slightly more detailed MTL format led to the highest objective understanding.[290,291,295,323,346,355,367,373,374] Three studies

identified Nutri-Score as the most effective in tasks assessing objective understanding,[334,335,362] while one found Nutri-Score and MTL labels equally outperformed warning symbols, HSR, and GDA.[364] One study from Canada examined a variety of 'high in' label formats, and found that 'high in' text descriptors, red colour, and intuitive 'warning' symbols (e.g., stop signs, exclamation marks, and 'caution' triangles) were most effective at communicating high levels of nutrients of concern.[361] A study from the US found that participants who viewed 3-star labels rated the healthfulness of products more accurately than participants who saw STL labels,[375] and a study from Uruguay found that a HSR rating performed worse than Nutri-Score or 'high in' labels in terms of altering perceived healthiness.[308] One study found that a GDA label with more information improved accuracy and comprehension compared to GDA formats with less information,[290] and another found equally high objective understanding with both GDA and MTL formats.[376] A small number of studies found no significant differences in objective understanding between various FOP labels tested.[357,377] Results often varied according to the task assigned in the study (i.e., rating or ranking of overall healthiness versus identification of specific nutrients, or tasks with time restrictions versus those without).[278,378]

Product selection tasks and purchase intentions

Consumer product selection tasks and purchase intentions are another key portion of the FOP literature. Hypothetical product selection or 'choice' tasks use similar methods as applied in assessing consumers' objective understanding, but instead ask participants to select a product that they would prefer (or hypothetically 'purchase'), with no reference to healthfulness or nutrition. A total of 55 such studies were identified in this review.[159,278,351,360,363,371,379–384,297,385–394,304,395–404,307,405–414,308,415–419,323,327,335,341]

In this review, most studies compared purchase intentions across different FOP labelling systems. Again, most of these studies found that simplified, interpretive label formats were more successful at promoting healthful hypothetical food choices compared to more complex labels.[304,308,383–392,323,393,335,351,371,379–382] However, two studies found opposite results, with more healthful hypothetical purchases as a result of more detailed FOP labels,[327,394] and three found no differences across FOP conditions.[297,363,395] One study identified the semi-interpretive MTL format as best promoting more healthful purchase intentions.[396] Six studies specifically assessed the effects of SSB FOP labels on consumers' intention to purchase SSBs, most of which found

that warning labels—whether graphic or text—significantly reduced intention to buy SSBs compared to no FOP labels;[159,397–400] however, one in-person experiment in which warning labels were placed on actual beverage containers found that neither a pictorial warning label nor a calorie information label impacted participants' SSB selections.[401]

Most studies that examined the overall influence of FOP labels on purchase intentions found that the presence of a FOP label led to healthier product selections compared to a control condition, or that the FOP labels tested worked in the expected direction (e.g., lower star ratings led to fewer purchases and higher star ratings resulted in more purchases).[307,341,408–413,380,384,402–407] In contrast, several studies found no significant effects of various FOP labels (including the GDA, STL, MTL, HSR, NuVal, or Nordic Keyhole symbol) on consumers' purchase intentions or product selections.[278,360,414–416] One study found no effect overall of the Nutri-Score system on hypothetical product purchases, but did identify significant effects in one specific product category.[417] Interestingly, one study found that the presence of FOP labels consistently led to reduced purchase intentions regardless of the nutritional status of the products,[418] while another found that FOP labels led to increased purchase intentions across the board, again regardless of the nutritional status of the products.[419]

Sales and purchasing behaviour

Lastly, a limited number of studies (20 in this review) have examined the effect of FOP nutrition labels on actual consumer purchasing or consumption behaviour, whether through sales data or experimental purchasing scenarios.[89,113,423–432,292,331,348,387,389,420–422]

An experimental marketplace study in Canada* randomized participants to see products with either no FOP label, a HSR, a 'high sugar' symbol, or a text-based health warning. Participants were asked to make a real purchase with $5 that was provided to them. The study found no significant effects of labelling; however, there was a non-significant trend for the high sugar symbol in reducing the likelihood of selecting a sugary drink and in encouraging participants to select drinks with less free sugar.[113] In the US, consumers randomized to see STL or numeric calorie labels purchased lunches in an online ordering system with 10% fewer calories than those

* This experimental marketplace, led by the authors in 2016, serves as a 'pilot' for the proposed research.

who saw no labels.[387] In the UK, shoppers in an online grocery store made purchases of similar healthfulness if they received tailored health feedback than if they only saw MTL labels.[420]

Two studies based in Singapore used an experimental online grocery store to assess the impacts of various FOP formats. One study found that both MTL and Nutri-Score labels improved the healthfulness scores of participants' purchases. Nutri-Score led to purchases with higher Nutri-Score ratings, but the MTL was better at reducing the calories and sugars purchased from beverages.[389] Another found that 'lower-calorie' symbols, whether defined within or across product categories, had potential to positively influence purchasing patterns.[421]

In New Zealand, a study assigned participants to see either a MTL, HSR, or a control NFt condition through a smartphone app that they used to scan barcodes while on real shopping trips. The study found no significant differences in mean healthiness of packaged foods purchased overall; however, among participants who used the labelling intervention more than average, those assigned to the MTL or HSR conditions purchased significantly healthier packaged foods than those in the control condition.[348] Across all label conditions, when participants purchased a product after viewing the label, these purchases were significantly healthier than products where labels were viewed but the product was not subsequently purchased.[422] A study from Australia used a similar smartphone app intervention to compare HSR, MTL, GDA, and a modified NFt label that included 'warning' text.[331] Only the NFt + warning text condition led to significantly healthier packaged food purchases than the control. Another study from Australia monitored changes in real online food purchases in response to MTL labelling in a major Australian online grocery store. The study found no significant changes in sales in the intervention store compared to a comparison store over a 10-week period.[292]

Although not directly equivalent to FOP labelling, several studies have also explored the effect of traffic light labelling on foods purchased or selected in restaurant, cafeteria, or laboratory buffet settings. In these studies, the labels were positioned next to or near the products, but not directly applied to the product packaging itself. Most such studies identified in this review found significant reductions in purchasing or consumption of 'red' products, accompanied by increases in 'green' products and associated reductions in calories purchased.[89,423–426] A study assessing the impact of Nutri-Score labels in a Columbian university cafeteria found an increase in spending on healthier items, with no change for less healthy items.[427] One study found no

significant differences in sales of 'red' or 'green' items between the intervention and control sites,[428] and another found that improvements in purchases were only significant among participants who reported noticing the labels.[429] Similarly, two studies in the US placed SSB warnings on shelves in a hospital cafeteria and in a life-size experimental convenience store, and found that warning labels reduced the share of sugary drinks purchased compared to baseline.[430,431] In an in-lab consumption study, Australian participants sampled fewer snacks when a physical activity calorie equivalent label was present compared to no label.[432]

Post-implementation impact of FOP nutrition labels

The body of post-implementation evidence is limited in comparison to pre-implementation research. This review identified 23 studies that included post-implementation research on voluntary (14) and mandatory (9) FOP nutrition labelling systems. Four studies were directly supported by industry funding or through industry funding to one of the authors; these studies tended to focus on and support industry-led FOP systems.[433–436]

Voluntary FOP nutrition labelling systems

Evidence on voluntary FOP nutrition labels comes from evaluations of systems in Australia, Sweden, Belgium, Netherlands, UK, Mexico, US and Europe-wide.

In Australia, post-implementation research has examined the voluntary HSR system. About one third of Australian adults were aware of the HSR system after its implementation, and lower awareness was observed among older adults and those with a high BMI compared to younger adults and those with a lower BMI.[437,438] In general, Australians reported seeing the HSR as simple, easy to understand, and useful for a quick comparison across products; however, there was little confidence in the HSR due to a perceived lack of transparency in the criteria used to determine the number of stars.[439] Most respondents understood how to use the HSR system; however, the studies indicated that improvements were required in terms of understanding that the labelling system should not be used to compare products in unrelated categories.[437,438]

Studies assessing the Keyhole FOP logo system in Sweden found that overall, almost all consumers reported being aware of the symbol, and most understood its meaning; however, very few reported using the logo when shopping.[433,440] One study asked respondents to choose the

healthiest of three ready-to-eat meals, and found that more than half of respondents selected the one product displaying the Keyhole symbol.[433]

One study assessed breakfast cereals in Belgium in the year prior to implementation of the voluntary Nutri-Score system. The study detected some reformulation of these breakfast cereal products in anticipation of the FOP implementation, including small reductions in sugars and sodium, and small increases in fibres and protein content.[441]

In the Netherlands, a study assessing the voluntary Choices FOP logo found that 88% of respondents were familiar with the logo after its introduction, and that the top reasons for using the logo were attention to 'weight control' and 'product information'.[434,435] In addition, the presence of the Choices logo on products was found to increase the volume share of eligible products purchased, particularly in food groups with a mix of both healthy and unhealthy food products.[442]

Studies from the UK have examined the industry's use and consumers' understanding of the voluntary MTL and GDA labelling systems in place there. An analysis of 2,021 foods for sale in the UK found that 14% displayed the voluntary GDA label, but only 8% displayed the full recommended MTL system.[443] Qualitative interviews with adults in the UK found that when products displayed different formats of the GDA-based labels, comparisons between products was challenging,[444] and that many consumers were confused by the array of different voluntary FOP systems appearing on packages.[445] One survey found that almost all respondents from the UK were able to correctly answer questions about the MTL system,[433] and a small pre-post study found no significant impact of the label's introduction on the healthfulness of consumer purchases of sandwiches and ready-to-eat meals.[446]

One study of consumers across Europe examined awareness and use of a voluntary GDA FOP label in use by some manufacturers at the time.[433] The study found that awareness of the GDA labels varied by country, with the highest awareness reported in the UK (90%), and the lowest in Sweden (40%). The study also found that the proportion of respondents who reported looking at the GDA label for nutrition information ranged across countries, from approximately 10% in Sweden to just over 40% in the UK. In the same study, respondents self-reported their understanding of the GDAs around 'average' or 'fairly well' (between 5.3 and 7.1 on a scale from '1 – not at all' to '10 – extremely well').

Lastly, one study examined the post-implementation impact of the now-defunct NuVal on-shelf nutrition labelling system.[276] The study assessed changes in sales data following an update to the NuVal nutrient profiling system, which altered the NuVal score of many foods. Results suggested that a 1-point increase in the NuVal score was associated with a 0.49% increase in sales.

Mandatory FOP nutrition labelling systems

The limited post-implementation evidence on mandatory FOP nutrition labelling systems comes from assessments of the MTL system implemented in Ecuador, the mandatory 'high in' labelling system implemented in Chile, and the mandatory GDA labels in Mexico.

In Ecuador, several studies have examined consumers' awareness, reported use, and understanding of the FOP MTL labels. Data from focus groups indicate that overall, the majority of children, youth and adult participants recognized and were aware of the MTL symbols; however, adult males were less likely to report using the MTL labels, and adolescents interested in health and adult women were most likely to use the labels to select products.[447,448] In the same study, nearly all participants were able to identify that the label provided information on the content of fat, sugar, and salt, and several demonstrated understanding that the information might contribute to reducing obesity and other NCDs.[447,448] In a survey of women from two different ethnic populations in a low socioeconomic status (SES) area of Ecuador, 32% of the dominant population and 5% of Indigenous women reported using the MTL nutrition information to guide their purchases and consumption.[449] Only 43% and 12% of women of the dominant population and Indigenous women, respectively, demonstrated an understanding of the MTL system.[449]

Evidence from Chile provides insight into the perceptions and impact of the mandatory octagonal 'high in' labels for sugars, sodium, saturated fats and calories. A survey conducted at 6-months post-implementation among Chilean adults found that the vast majority of respondents (92%) rated the labelling system as 'good' or 'very good'.[450] In the same survey, most respondents (92%) indicated that the labels influence their product choices, with 68% reporting 'I choose foods with fewer warnings', 10% reporting 'I don't buy foods with warning labels', and 14% reporting 'I buy less than I would if the product did not have a warning label'. In a different survey among respondents aged 15 years and older, 87% of respondents were aware of

the new labels, and 37% agreed that the labels led them to modify their product selection (31% neutral; 33% disagreed), with 26% indicating that they had stopped consuming specific products because they displayed 'high in' warning labels.[450] A third survey of adolescents and mothers of preschoolers found that 81% of adolescents and 91% of mothers associated the presence of the FOP 'high in' labels with unhealthy foods. Compared to responses from a pre-implementation survey, a greater proportion of mothers indicated that 'logos or nutritional information' were the most important aspect (28% in 2016 vs. 35% in 2017), while 'brand' decreased in importance, and 'price' remained in third place.[450] There were no changes in aspects considered among adolescents, with 'logos or nutritional information' in third place (11%) after 'price' and 'brand' (27%). When asked how they determine if a food is healthy, 23% of adolescents and 26% of mothers of preschoolers reported basing this on the absence of FOP 'high in' labels.[450] One year post-implementation, Chilean mothers understood the goals of the policy and the meaning of the labels, but their reported frequency and reason for using the labels was mixed.[451] In particular, it was reported that children were often the strongest supporters of the policy and promoters of change within their families. A before-and-after study found that respondents were more likely to consider food labelling 'the most effective intervention introduced to date to promote healthy nutrition', but there were no significant changes in self-reported or objectively measured understanding of the labels.[452]

One study estimated the impacts of Chile's Law of Food Labelling and Advertising overall, finding that volume of 'high in' beverage purchases decreased by 24%, calories from 'high in' beverages decreased (28%), calories from non-'high in' beverages increased (11%), and calories from total beverage purchases decreased 8% overall post-regulation. However, the specific effects of FOP labelling could not be parsed out from the other marketing and school policy components of the regulation.[453] Lastly, an analysis of a sample of the Chilean food supply in the year preceding implementation detected minimal industry reformulation in anticipation of the labelling regulations: no more than 5% average change in energy or critical nutrient content was seen in any food category, and less than 2% of products overall would have avoided at least one label with reformulation.[454]

In Mexico, one study has explored consumers' perceptions of the country's mandatory GDA system. Most focus group respondents were aware of the GDA labels, but reported infrequent use because interpretation was too complicated.[353]

Simulations of the potential impact of FOP nutrition labelling systems

This review also identified a small number of studies that used simulation modelling methods to predict the potential impact of FOP nutrition labelling systems on longer term health outcomes. Similar to those used in the realm of food and beverage taxes, these simulations use inputs generated from pre-implementation experimental studies and post-implementation assessments of FOP labels implemented in the real-world. In one of the studies identified, one author worked in the food and beverage industry at the time of publication; however, the pattern of results was similar to the other FOP label simulations reviewed.[455]

One study assessed the potential impact of warning labels on SSBs in three American cities. Following the assumption that the warning labels would be implemented at all retailers and that they would reduce purchasing of SSBs by 8%, obesity prevalence would be reduced among adolescents in all three cities (-1.7% in Baltimore, -4.1% in San Francisco, and -2.2% in Philadelphia).[456] A similar simulation model at the national level in the US predicted that SSB warning labels would reduce average SSB intake by 25 kcal/day and total energy intake by 31 kcal/day, resulting in average BMI reductions of 3.1%.[457] A simulation study focusing on the population of Mexico examined the potential effects on nutrient and energy intake if commonly consumed processed foods were replaced with those that meet a FOP logo nutrition criteria. The simulation predicted significant reductions in energy, saturated fats, trans fats, total sugars and sodium intakes, and a significant increase in fibre intake after replacing foods using the nutrition labelling criteria.[455] In France, a simulation study modelled the potential impacts of various FOP labelling systems on disease and mortality rates, predicting that a Nutri-Score label would avoid the most diet-related NCD deaths, followed by HSR, GDA and MTL systems.[458] A simulation of the Australian population estimated the potential cost-effectiveness of the Australian HSR FOP system as a result of product reformulation, including models for both voluntary and mandatory implementation scenarios. The study predicted small changes in mean population energy intake as a result of product reformulation (voluntary: -0.98 kJ/day; mandatory: -11.81 kJ/day), resulting in small predicted reductions in mean body weight and increased health-adjusted life

years.[459] Lastly, a study simulated the potential impacts of an MTL label in Canada, assuming that Canadians avoided all foods labelled with red traffic lights when possible.[460] Under this optimistic scenario, it was predicted that over 11,500 deaths due to diet-related NCDs could be prevented per year.

Related to simulation modelling studies, two studies also estimated the extent to which a FOP labelling system would appear in a given food supply. In Chile, prior to implementation of the country's mandatory nutrient warnings, it was estimated that two thirds of the products in the national food supply contained critical nutrients indicative of at least one 'high in' warning, and under the final (stricter) planned phase of nutrient cut-offs, only 17% of foods would have no warning labels if no reformulation occurred.[461] In Columbia, an analysis of the food supply in Bogotá indicated that 80% of foods would be required to display a nutrient warning according to Pan American Health Organization nutrient profiling criteria, versus 66% under the Chilean FOP labelling model.[462]

The findings on FOP nutrition labels varied across post-implementation, pre-implementation, and simulation modelling studies. Real-world post-implementation evidence is beginning to emerge from countries where FOP labelling regulations are in place; however, most of this early evidence has focused on consumer awareness, perceptions, and understanding, while few studies have assessed impacts on consumer purchases or consumption. There is no post-implementation evidence in Canada, where a FOP label has not yet been implemented. This review identified a substantial body of pre-implementation research that sheds light on the various potential impacts of FOP labels, including a handful of studies in Canadian contexts; however, the evidence on more novel FOP systems—such as the 'high in' symbols proposed in Canada—is limited compared to more established labelling systems. Additional evidence from experimental studies incorporating realistic purchase scenarios would provide valuable estimates of the potential impacts of FOP labelling in Canada.

1.4.3 Differences across sociodemographic subgroups

Similar to taxation strategies, there is evidence that FOP labelling may result in varied outcomes across sociodemographic subgroups due to differences in use, interpretation, and comprehension. The literature on traditional nutrition labels (such as the NFt) suggests that these labels are more

poorly understood by individuals of lower education and income levels compared to those of higher SES.[225,326,463] One key goal of most FOP labelling systems is to reduce the gap in understanding between groups of different literacy levels and SES.[223]

In this review, 65 studies reported results across sociodemographic groups; 23 of these found no significant differences in outcomes across sex, age, ethnicity, education, income, or occupational subgroups.[290,296,359,365,399,403,414,422,424,425,431,453,326,464–466,327,329,330,332,350,353,358] Two studies focused specifically on low-income populations, but did not provide comparisons to other populations.[324,467]

The remaining 40 studies that did find differences across sociodemographic groups reported a range of results. Studies reported that higher BMI was associated with being more likely to favour a STL label,[344] less likely to be aware of the Australian HSR system,[437,438] more likely to purchase high-in sugar products,[388] and more likely to purchase 'red' foods in a laboratory test of STL labels.[89] In one study, participants reporting a desire to lose weight placed a higher emphasis on saturated fats when assessing MTL labels, whereas those who did not report a desire to lose weight emphasized sugars.[468] Gender differences were also identified in some studies: men were more likely to favour a 'colour range' logo,[343] less likely to use an MTL system,[448] less likely to understand the meaning of the Keyhole symbol,[440] and demonstrated higher understanding of FOP labels than women in a menu creation task.[378] Conversely, in other studies, women demonstrated a greater capacity to identify healthier products,[362] purchased less sugar,[388] and showed greater understanding and appropriate use of MTL and nutrient warning labels[306,341,349,410] compared to men. In terms of age differences, older adults favoured a detailed 'colour range' logo[343] and were less likely to favour an MTL,[333] were less skilled at ranking food products using FOP labels,[362,376] reported lower awareness of the Australian HSR,[437,438] were more likely to purchase high-sugar products,[388] and demonstrated poorer understanding of FOP labels in a menu creation task.[378] Younger consumers preferred an exclamation symbol,[339] reported less frequent use of MTL labels,[448] and were less likely to rank FOP labels highly among other considerations when purchasing food or beverage products.[450] Parents were more likely to support MTL labelling and showed a greater capacity to identify healthier products than non-parents,[316,362] and mothers were more likely to associate the presence of FOP 'high in' labels with unhealthy foods.[450]

Income or SES differences were also identified in some studies. Several studies identified individuals of lower income to show poorer understanding[378,469] and lower responsiveness[341,352] to various FOP labels; however, another study showed greater responsiveness to FOP labels (in terms of changing healthfulness perceptions) among low-income respondents.[374] One study demonstrated that MTL and nutrient warnings were significantly less effective than the GDA among individuals with low incomes.[335] In others, higher SES respondents were less likely to select an SSB,[401] more likely to report using warning labels,[451] and more likely to improve the healthfulness of their food selections in response to HSR labels than lower SES respondents.[470] Lower SES children were more likely to adjust their response (via emojis) to products with MTL and nutrient warning labels,[471] but less likely to respond to warning labels in terms of traditional healthfulness ratings.[352] Studies identified individuals with lower education as being more likely to favour simple FOP label formats,[343] less likely to prefer the MTL,[333] less skilled at identifying or ranking healthier products using FOP labels,[362] and less willing to pay for products with lower levels of nutrients of concern flagged by MTL labels.[356] Latinos with higher education levels showed higher odds of understanding FOP labels in one study.[349] Those with lower nutrition knowledge or health literacy were more likely to favour a STL format,[343] showed a slight preference for symbols incorporating pictures,[339] were less skilled at ranking food products using FOP labels,[376] had lower understanding of a GDA system,[469] and tended to rate products healthier overall, regardless of FOP label.[297] In contrast, two other studies found the strongest impact of a Nutri-Score or MTL label to be among individuals with limited or no nutrition knowledge.[368,410]

Reported health or nutrition behaviours and attitudes also emerged as a significant variable in some studies. Individuals who reported lower adherence to nutritional recommendations were more likely to prefer a Nutri-Score label[333] and less likely to be influenced by a physical-activity-equivalence FOP label.[472] Those who reported average or above average dietary habits were more likely to be impacted by an MTL labelling format,[410] and more likely to make more healthful choices in the presence of nutrient warning labels.[403] Individuals who were more willing to compromise pleasure for health, or were more future-oriented (vs. focused on immediate consequences) were more likely to place greater importance on and be influenced by nutrient warning labels.[393,473]

Only two studies in this review specifically identified ethnicity as having a significant effect on FOP label use. A study from Ecuador found that Indigenous women were less likely to report using the MTL label to guide their purchasing and consumption of packaged food items, and were less likely to exhibit understanding of the label compared to non-Indigenous Ecuadorian women.[449] A cross-sectional survey in the US and Mexico found that among whites and Latinos, self-reported understanding of HSR and MTL labels was lower than NFts, but understanding was similar across these labels among Mexicans.[349] Whites reported a higher understanding of FOP labels overall compared to Latinos, whereas Latinos reported higher use.

1.5 Rationale

To date, there is substantial evidence to suggest that health-oriented food and beverages taxes can be effective tools to reduce purchasing and consumption of products of public health concern, particularly for sugary beverages; however, the evidence on which tax format may be most effective is less robust. There are also numerous studies assessing outcomes of FOP nutrition labels, which largely suggest that they are easier to use and understand than traditional back-of-package nutrition information and that consumers deem them acceptable—particularly if their design is simple, salient, and interpretive. However, it remains unclear which FOP systems are superior.

In Canada, imminent policy decisions and growing pressure from health organizations is generating a need for evidence to guide how sugar taxes and FOP labelling systems might be best implemented in a Canadian context. The government has not made any official commitments to implement a national food or beverage tax; however, there is growing pressure from Canadian health advocacy groups for the government to consider a sugary drink tax,[14,16,23,474] and media reports in 2016 suggested that such policies have been considered at the federal level.[475] Most pressingly, in February 2018 Health Canada published a regulatory consultation for their proposed FOP 'high in' nutrition labels in Canada Gazette Part I, and the regulations are expected to be further solidified in Gazette Part II in the coming months.[476]

To support successful implementation of these two strategies in Canada, more evidence is needed in certain areas. First, the bulk of the taxation research has focused on SSB taxation strategies, but there is little evidence on whether a tax on high-sugar foods might act similarly to

a tax on sugary beverages. In addition, there has been little research focused on the potential differential effects of a tax on sugary drinks (including 100% fruit juice) versus a traditional SSB tax. There are also very few studies that have compared the relative outcomes of tiered versus non-tiered specific taxes. Lastly, this review shows that there is limited evidence available on how consumers might respond to sugar taxes in a Canadian setting.

In terms of FOP nutrition labels, there is a wealth of evidence on several of the FOP label formats that have been in use for longer, such as MTLs and GDAs; however, the evidence is more sparse for newer systems such as France's Nutri-Score system or the 'high in' labels that are to be implemented in Canada. Few studies have explicitly compared nutrient-specific versus summary indicator FOP labelling formats, and again, there is insufficient evidence on consumer responses to FOP labels specifically in a Canadian setting.

In general, limited research has assessed the behavioural outcomes of these two major policy options using actual purchasing scenarios, rather than stated preference or hypothetical purchasing tasks. There is a need for more robust experimental evidence using actual purchasing tasks to inform future simulation modelling efforts.

This thesis uses real purchasing tasks to generate experimental evidence of Canadian consumers' responses to various sugar taxes and FOP labelling strategies. The evidence generated from this project will be useful for current and future policy development, and can be used to inform future simulation modelling efforts to estimate the potential effects of sugar taxes or FOP labelling strategies in the Canadian population. The proposed project will provide specific evidence on the relative efficacy of *ad valorem* versus tiered specific tax formats, sugary drink versus SSB taxes, and nutrient-specific (MTL and 'high in' labels) versus summary indicator (HSR and Nutri-Score) FOP labelling systems. The project will also contribute to the evidence base on the differential effects of tax and labelling policies across different population subgroups, including age, sex, health literacy, ethnicity, education, income adequacy, and BMI. Although the proposed project will provide important evidence on behavioural outcomes, it will not assess other important consequences of sugar taxes and FOP labelling systems, such as product reformulation.

1.6 Research questions

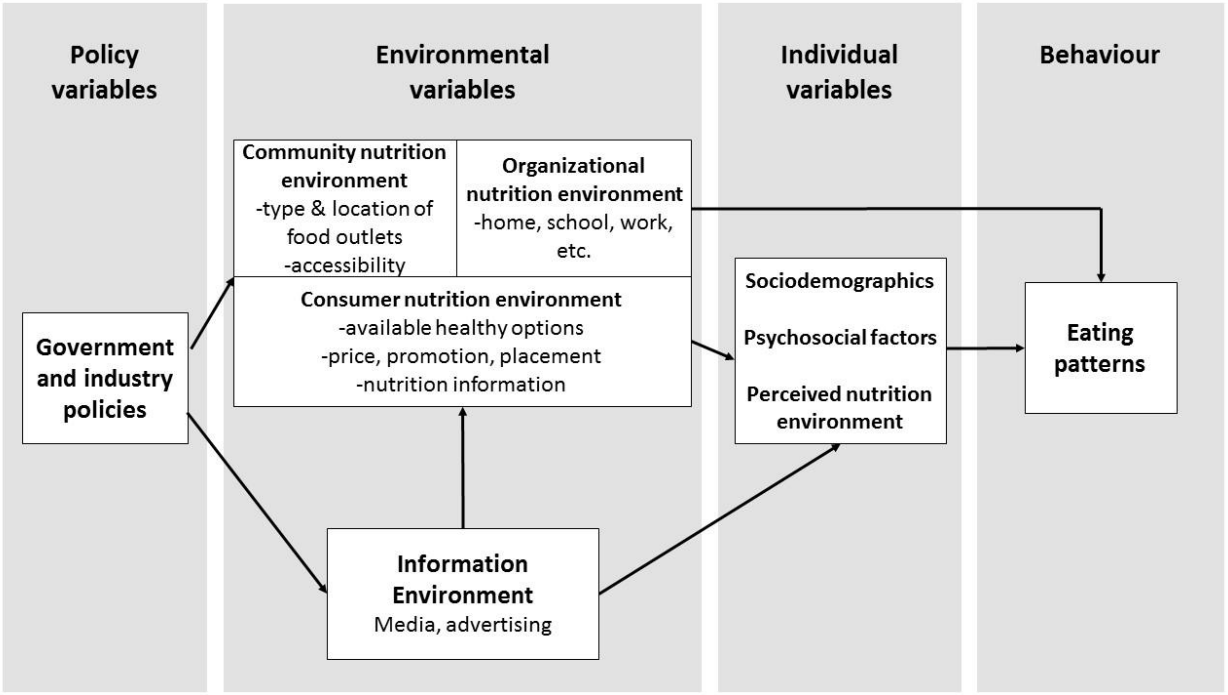
The current study examines the following specific research questions:

1. Do different FOP labels and sugar taxes influence consumer purchases of sugars, sodium, saturated fats, or energy?
2. Do different sociodemographic or individual characteristics moderate the effects of FOP labels and sugar taxes on participants' purchasing of sugars, sodium, saturated fats, or energy?
3. How do consumers' purchases of specific product categories vary across different FOP labelling systems?
4. How do consumers' purchases of specific product categories vary across different sugar taxation formats?

1.7 Conceptual framework

The current research draws from several theoretical frameworks. First, the study was broadly based on the model of dietary behaviour developed by Glanz and colleagues, which highlights the interactions between policy, food environment, and individual-level variables.[477] The model helps to describe how government policies and population-level nutrition interventions—such as the taxes and labelling policies targeted in this project—shape the food environment, which in turn influences dietary behaviour at the individual level. Individual-level variables, including food security, literacy, BMI and SES, can mediate or moderate the effects of the food environment on dietary behaviour. Figure 2, adapted from Glanz et al., provides a visual depiction of the interactions between policy, environment, and individual factors.

Figure 2. Conceptual framework for evaluation of nutrition policies, adapted from Glanz et al. 2005[477]



Second, this project draws from specific economic frameworks that were first used to guide the assessment of tobacco taxes, but which can be applied in the assessment of other fiscal measures such as the sugar taxes in this study.[478] These economic frameworks highlight price as the primary 'proximal' variable of interest, purchasing behaviours as downstream outcomes, and moderators such as product availability, geographic location, frequency of use, and income level as factors that may have an influence at various points along the pathway.

Chapter 2: General methods

2.1 Study design

An experimental marketplace was conducted from March 12 to May 20, 2018. An experimental marketplace is an approach commonly used in the field of behavioural economics and marketing to study actual consumer behaviour, and provides the opportunity to manipulate price and other variables of interest to assess their influence on consumers' purchases.[85,479,480] In these studies, participants are provided with a sum of money and presented with multiple products available for purchase. If the participant does not spend the entire sum of money, they are permitted to keep the remainder, along with the product they selected. In this way, participants spend real money and incur a financial cost for their purchases, leading to more realistic product selections.

2.2 Data collection setting

The current experimental marketplace took place in large shopping centres in three Canadian cities. Spaces and/or kiosks were rented in high-traffic areas of Yonge Eglinton Centre in Toronto (March 12 – April 22), Conestoga Mall in Waterloo (March 19 – April 29), and CF Fairview Park Mall in Kitchener (April 30 – May 20). Data collection stations were set up at each location that included signs to advertise the study; tables; a small refrigerator; and lockable cabinets to store the product inventory, change, iPads, and other study supplies. Figure 3 shows images of two data collection stations. Two research assistants were stationed at each data collection site at all times for the full opening hours of the shopping centres.

Figure 3. Data collection sites at Yonge Eglinton Centre (left) and Conestoga Mall (right)

2.3 Participants and recruitment

Participants aged 13 years and older were recruited using convenience sampling. Research assistants approached potential participants to ask if they were interested in participating in a study on food and beverage purchasing patterns. All interested participants were asked to provide their age prior to giving informed consent and beginning the study. Additional consent from a parent or guardian was required for all participants under 16 years; if a parent or guardian was not present, the shopper was not permitted to participate. Aside from age, no additional eligibility criteria were applied. Response rate was tracked by recording numbers of "refusals" (see Refusal Tracking Sheet in Appendix A). Refusals were counted when a passerby was directly asked to participate in the study but declined, either through a verbal refusal or a non-response. Throughout data collection, research assistants recorded any potential data quality concerns on Survey Tracking Sheets (Appendix A).

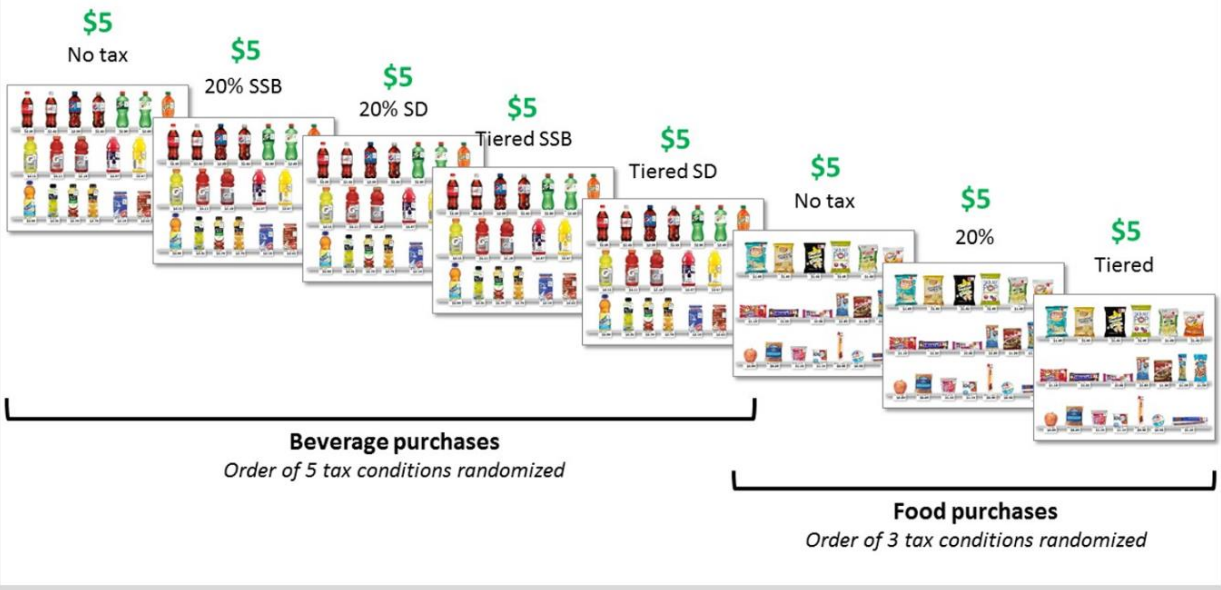
A total of 3,702 participants completed the study. After data cleaning, 118 participants were removed due to data quality concerns reported by the research assistants (e.g., significant cognitive difficulties or distraction, visual impairment, substantial influence from peers), resulting in a final sample size of 3,584. The study was reviewed by and received ethics clearance from the Office of Research Ethics at the University of Waterloo (ORE# 22494).

2.4 Purchasing tasks

Prior to initiating the real purchasing tasks, all participants were guided through two 'practice' purchasing tasks (see Survey Document in Appendix B) to ensure that they understood how the purchasing and random selection process would work.

The experimental purchasing tasks were delivered in the format of a 5 (FOP label condition) × 8 (tax condition) between-within group experiment. A visual depiction of the purchasing task design is shown in Figure 4.

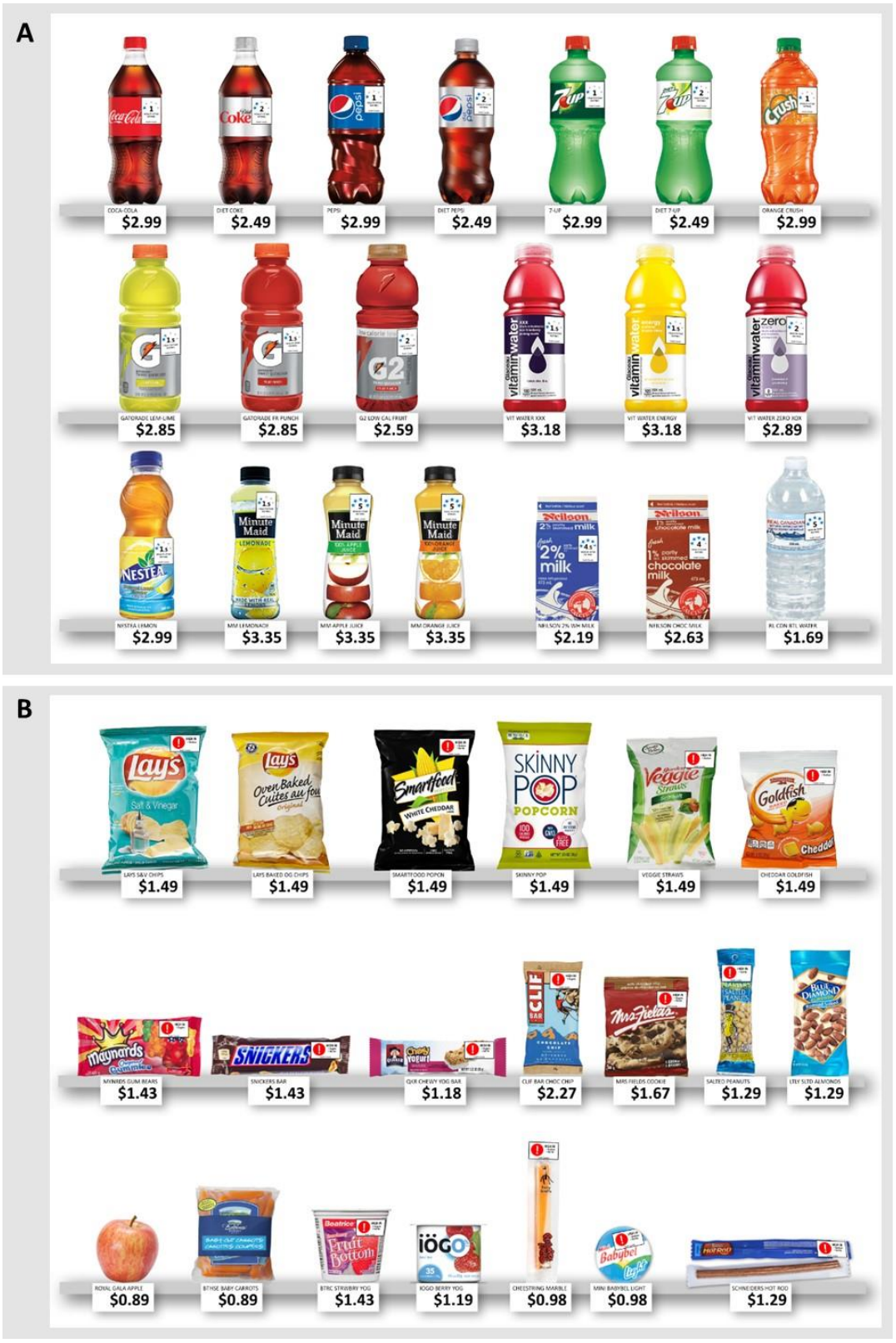
Figure 4. Purchasing tasks design



Each respondent completed eight consecutive purchasing tasks, with one randomly assigned FOP labelling scheme applied to the products throughout all eight tasks. The products available for purchase (first beverages, and then snack foods) were displayed to participants on large print-outs. A budget of $5 was provided for each task. At the end of the experiment, the computer randomly selected one of the respondent's eight selections to be their real purchase, and the respondent was given the actual food or beverage item and any change from that task.

Participants were randomly assigned to one of five FOP label conditions. Within their assigned label condition, participants completed eight consecutive purchasing tasks, which each corresponded to a different tax condition. In each of the eight purchasing tasks, participants were shown a selection of beverage or snack food products on a large (62.5 × 50 cm) laminated print-out, which was designed to replicate the appearance of a grocery or convenience store shelf (Figure 5). A new print-out was shown for each purchasing task, reflecting the appropriate label and tax condition for that purchase. In the first five purchases, participants selected from 20 different beverage products. In the last three purchases, participants selected from 20 different snack food products. The order of the tax conditions was randomized within the five beverage tasks and within the three food tasks.

Figure 5. Example product shelf images showing two combinations of FOP and taxation conditions: (A) beverages with *health star rating* labels and *tiered sugary drink* tax, (B) foods with *high in* labels and *20%* sugar tax



Prior to each of the eight purchasing tasks, research assistants emphasized the following points to each participant: (1) they had a budget of $5.00 to purchase one item, (2) the labels may be different from what they've seen in the past, (3) the prices may have changed since the last task, and (4) they would receive their change from the $5.00 and the actual food or beverage product from one of the eight purchases. The script was adjusted 14 days into data collection to add the prompt that the labels may be different than what participants have seen in the past. Research assistants were instructed to not engage in discussion or answer questions about nutrition, dietary intake, or food policies. See Appendix A for the full research assistant script. For each task, participants made their selection on an iPad after viewing the large shelf image. Participants did not know which purchase selection they would receive (along with any change from the $5.00) until the end of the experiment and were instructed to treat all eight tasks as real purchases.

2.4.1 Remuneration

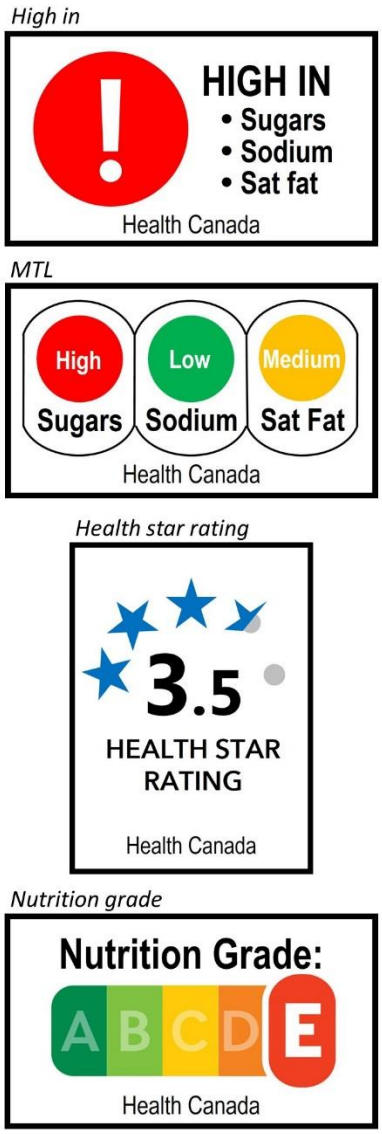
After participants had completed all purchasing tasks and subsequent survey items, the survey program randomly selected one of their eight purchasing tasks. Research assistants gave participants their actual food or beverage product and their change from the $5.00 corresponding to that purchase.

2.5 Experimental conditions

2.5.1 Front-of-package label conditions

Five FOP label conditions were tested, including both nutrient-specific and summary indicator formats. The FOP label conditions were *no label* (control); a *high in* system labelling foods high in sugars, sodium or saturated fats; a multiple traffic light system (*MTL*) for sugars, sodium and saturated fats; a health star rating (*HSR*) label; and a five-colour *nutrition grade* label. Figure 6 provides an example of each FOP label.

Figure 6. Images of label conditions, excluding *no label* (control). From top to bottom: *high in*, *MTL*, *HSR*, and *nutrition grade*.



The *high in* system was modelled after early iterations of Health Canada's proposed FOP symbols for foods high in sugars, sodium and saturated fats, with nutrient thresholds based on Health Canada's proposed guidelines.[222] The *MTL* system was loosely based on the UK's voluntary traffic light labelling system.[481] To ensure comparability with the *high in* system, *MTL* labels were displayed only for sugars, sodium and saturated fats. Criteria for 'high', 'medium' and 'low' were based on the UK's regulations; [481] however, in two cases in which the *MTL* was incongruent with the *high in* labels, the *MTL* was adjusted to match Health Canada *high in* labels. The *HSR* label design and scoring system were modeled after Australia and New Zealand's

Health Star Rating system.[482] The *nutrition grade* system was designed based on France's Nutri-Score system.[483] Due to differences in criteria and scoring algorithms across the two summary indicator systems, the *nutrition grade* scores were adjusted to match those of the *HSR* for the purposes of this study (i.e., 0.5 to 1 stars = 'E' nutrition grade; 1.5 to 2 stars = 'D'; 2.5 to 3 stars = 'C'; 3.5 to 4 stars = 'B'; 4.5 to 5 stars = 'A'). The FOP labels were not applied to fresh fruits or vegetables (i.e., the apple and carrots) to align with most real-world FOP nutrition labelling systems. Appendix C (Table C1) provides details on how the FOP labels were assigned to each of the beverage and food products.

2.5.2 Sugar tax conditions

Five beverage-based sugar tax conditions were tested: *no tax* (control), a 20% *ad valorem* tax on SSBs (*20% SSB*), a 20% *ad valorem* tax on sugary drinks (*20% SD*), a tiered specific tax on SSBs (*tiered SSB*), and a tiered specific tax on sugary drinks (*tiered SD*). Beverages were categorized as SSBs if they contained added sugars, as previously defined.[7] Beverages were categorized as sugary drinks if they contained free sugars, as defined by WHO.[6] *20% SSB* and *20% SD* taxes were applied to beverages containing more than 5 g of added or free sugars (respectively) per 100 ml. *Tiered SSB* and *tiered SD* taxes applied a 10% price increase to beverages containing 5 to 8 g, or a 20% price increase to beverages containing more than 8 g of added or free sugars per 100 ml (modelled after the SSB tax implemented in the UK[58]).

The study also tested three food-based sugar tax conditions: *no tax* (control), a 20% *ad valorem* tax on high-sugar foods (*20%*), and a tiered specific tax on high-sugar foods (*tiered*). Here, the *20%* tax was assigned to all foods containing more than 10 g of total sugars per 100 g; the *tiered* tax applied a 10% price increase to foods containing 10 to 20 g of total sugars per 100 g, and a 20% price increase to foods containing more than 20 g of total sugars per 100 g. Appendix C provides details on how the taxes were assigned to each product (Table C2), as well as details of nutrient content for all products (Table C3).

2.6 Survey measures

Upon finishing the purchasing tasks, participants completed a series of questions independently on the iPad. Survey items collected self-reported data on a range of health behaviours and

sociodemographic characteristics, summarized below. The full survey document is provided in Appendix B.

2.6.1 Label noticing

Immediately after completing the purchasing tasks, each participant was asked, "In all of the previous purchasing tasks, did you notice any nutrition labels or symbols on the front of the food and beverage packages?", with response options "Yes", "No", "Don't know", or "Refuse to answer".

2.6.2 Beverage frequency

To estimate frequency of sugary drink consumption, respondents completed a single-item beverage frequency question:[484] "During the PAST 7 DAYS, how many sugary drinks did you have? (This includes pop, fruit drinks, fruit juice, sports drinks, vitamin waters, energy drinks, chocolate milk, tea/coffee with more than 5 teaspoons of sugar, and specialty coffees.) Do NOT count diet or sugar-free drinks. Do NOT include today." Participants responded by entering a number in an open text box.

2.6.3 Eating efforts

A survey item was used to assess eating efforts related to the nutrients targeted by the taxes and FOP labels tested in the purchasing tasks. The item asked, "Have you made an effort to consume more or less of the following in the past year?" with response options "Consume LESS", "Consume MORE", "No effort made", "Don't know", or "Refuse to answer". This was asked for calories, saturated fat, sugar/added sugar, and salt/sodium.

2.6.4 Health literacy

The Newest Vital Sign (NVS) tool,[485] adapted for use in a self-administered survey, was used to estimate health literacy. Participants were shown an image of an NFt for a pint of ice cream, and were asked to answer a series of questions about the information contained in the table. Research assistants were instructed to not aide the participants with the tasks; however, participants were permitted to use a calculator if they wished.

2.6.5 Sociodemographic measures

Participants' sex (male, female) was recorded by the research assistant during eligibility screening. Participants' age was requested verbally and recorded by the research assistant at the beginning of the study during eligibility screening. Participants self-reported aboriginal status, ethnicity, highest level of education achieved, income adequacy, and height and weight independently on the iPad following the purchasing tasks. Self-reported height and weight were used to calculated BMI, which was categorized into "underweight", "normal weight", "overweight" and "obesity" using the WHO thresholds.[486] BMIs for participants 19 years of age or younger were calculated using growth charts as recommended by Centers for Disease Control and Prevention (CDC) and WHO guidelines.[487,488]

2.6.6 Plan for consumption

Upon conclusion of the survey and after the participant had received their food or beverage product and change, participants were asked to respond to the following item on the iPad: "Do you plan to…", with response options "Eat (or drink) your purchased item now", "Save it for later", "Don't know", and "Refuse to answer".

Chapter 3: Taxes and front-of-package labels improve the healthiness of beverage and snack purchases: a randomized experimental marketplace

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Authors: Rachel B Acton BSc[1], Amanda C Jones PhD[2], Sharon I Kirkpatrick PhD[1], Christina A Roberto PhD[3], David Hammond PhD[1]

[1] School of Public Health & Health Systems, University of Waterloo, 200 University Ave. W., Waterloo, ON Canada N2L 3G1

[2] Department of Public Health, University of Otago Wellington, 23A Mein St., Newtown, Wellington 6021 New Zealand

[3] Department of Medical Ethics and Health Policy, Perleman School of Medicine, University of Pennsylvania, 423 Guardian Drive, Philadelphia, PA 19104

3.1 Overview

Background: Sugar taxes and front-of-package (FOP) nutrition labelling systems are strategies to address diet-related non-communicable diseases. However, there is relatively little experimental data on how these strategies influence consumer behavior and how they may interact. This study examined the relative impact of different sugar taxes and FOP labelling systems on beverage and snack food purchases.

Methods: A total of 3,584 Canadians 13 years and older participated in an experimental marketplace study using a 5 (FOP label condition) × 8 (tax condition) between-within group experiment. Participants received $5 and were presented with images of 20 beverages and 20 snack foods available for purchase. Participants were randomized to one of five FOP label conditions (no label; 'high in' warning; multiple traffic light; health star rating; nutrition grade) and completed eight within-subject purchasing tasks with different taxation conditions (*beverages*: no tax, 20% tax on sugar-sweetened beverages (SSBs), 20% tax on sugary drinks, tiered tax on SSBs, tiered tax on sugary drinks; *snack foods*: no tax, 20% tax on high-sugar foods, tiered tax on high-sugar foods). Upon conclusion, one of eight selections was randomly chosen for purchase, and participants received the product and any change.

Results: Compared to those who saw no FOP label, participants who viewed the 'high in' symbol purchased less sugar (-2.5 g), saturated fat (-0.09 g), and calories (-12.6 kcal) in the beverage purchasing tasks, and less sodium (-13.5 mg) and calories (-8.9 kcal) in the food tasks. All taxes resulted in substantial reductions in mean sugars (-1.4 to -4.7 g) and calories (-5.3 to -19.8 kcal) purchased, and in some cases, reductions in sodium (-2.5 to -6.6 mg) and saturated fat (-0.03 to -0.08 g). Taxes that included 100% fruit juice ('sugary drink' taxes) produced greater reductions in sugars and calories than those that did not.

Conclusions: This study expands the evidence indicating the effectiveness of sugar taxation and FOP labelling strategies in promoting healthy food and beverage choices. The results emphasize the importance of applying taxes to 100% fruit juice to maximize policy impact, and suggest that nutrient-specific FOP 'high in' labels may be more effective than other common labelling systems at reducing consumption of targeted nutrients.

Keywords: front-of-package labels; health warnings; taxes; sugar tax; experimental marketplace; sugar-sweetened beverages

3.2 Background

Diet-related non-communicable diseases are among the leading causes of premature death and disability worldwide.[1] Diets high in processed foods and low in fruits, vegetables and whole grains remain dominant in developed countries, and are supplanting more traditional diets in lower income countries.[2,3] Several strategies have emerged to improve dietary intake at a population level, including the use of fiscal measures and front-of-package (FOP) nutrition labelling.[4,5]

Food and beverage taxes aim to increase the price of less healthy food and beverage products. Although some jurisdictions have applied health-oriented taxes to foods—such as those high in calories, sugars, sodium, or saturated and trans fats[6]—most have focused on beverages high in sugars, which are typically defined one of two ways.[7] Sugar-sweetened beverages (SSBs) are beverages containing 'added sugar' (any sugars added during processing or preparation[8]), such as regular soft drinks, sports drinks, flavoured waters, and fruit drinks.[9] In contrast, sugary drinks are defined based on the World Health Organization (WHO) criteria for 'free sugars' (i.e., all added sugars, plus those naturally present in honey, syrups, fruit juices, and fruit juice concentrates[7]), and therefore include all beverages under the umbrella of SSBs, plus 100% juice products. This study presented in this manuscript compares policies that target SSBs versus those that target the broader definition of sugary drinks.

To date, the vast majority of beverage taxes have been applied to SSBs. Mexico, UK, Ireland, France, South Africa, and Chile, as well as several US cities (e.g., Berkeley, Philadelphia, Boulder, Seattle) have all implemented SSB taxes.[6,10–17] Evidence from experimental studies, observational assessments of real-world taxes, and simulation modelling suggests SSB taxes applied at a rate equivalent to at least 20% of a products' price are likely to be an effective means of reducing purchasing and consumption of high-sugar beverages, as well as a strong incentive for product reformulation.[18–25] However, given their relative novelty, the optimal design of SSB taxes to reduce SSB consumption and encourage product reformulation while also generating revenue for investment in other health promotion efforts remains unclear. For example, the range of beverages subject to taxation varies considerably across jurisdictions: several exclude sugar-sweetened milks, some include diet beverages, and the vast majority exclude 100% fruit juice. Additionally, policies vary in the type of tax (e.g., excise, sales). Excise taxes apply price

increases at the point of the manufacture, sale, or distribution of a good, whereas sales taxes are levied at the point of purchase.[26] Under the umbrella of excise taxes, the most common in the context of SSB taxes, price increases may be applied in a 'specific' format—either based on product volume or nutrient volume—or in an '*ad valorem*' format, applied as a percentage of the product's price (e.g., 20%).[26] Some research suggests a specific excise tax based on beverage volume or sugars content may be preferable to a sales tax or *ad valorem* excise tax—both of which constitute a percentage price increase. Specific taxes create a higher relative price increase in cheaper goods, reducing the potential for consumers to choose less costly but equally unhealthy items.[25–27] Another emerging tax model is a tiered tax, which is a specific tax that applies varying price increases to products based on two or more predefined levels of sugar content or product volume. The UK's excise beverage tax uses this tiered model based on beverage sugar content,[14] while Mexico's SSB regulations assign a specific excise tax, roughly equivalent to 1 cent per ounce of beverage.[10] To the authors' knowledge, no experimental studies have directly compared the effectiveness of sugary drink taxes based on product volume (i.e., *ad valorem* excise) versus those based on sugar content (i.e., tiered) on consumer purchasing and consumption, and few have compared taxes that define SSBs in different ways.

FOP nutrition labels are another policy measure to promote healthy eating. FOP labelling systems seek to provide simple, interpretive information on the front of packaged food and beverage products to help consumers quickly and easily evaluate their healthfulness.[28] An increasing variety of these labelling systems are being implemented internationally.[28] FOP labelling systems can broadly be categorized as 'nutrient-specific' systems that provide information on one or more specific nutrients (e.g., Chile's 'high in' nutrient warnings, UK's traffic light labels) or 'summary indicator' systems that provide a score or rating of the overall nutrient profile of a product (e.g., Australia and New Zealand's Health Star Rating, France's five-colour Nutri-Score).[28] Reviews of the existing evidence suggest that FOP nutrition labels may be an effective approach to help consumers choose healthier products; however, there is no consensus as to which FOP label system may be most effective.[29–32] Further, a majority of existing research has focused on the first generation of FOP labelling systems, such as star ratings, traffic light symbols, and guideline daily amount labels. There is less evidence on more recent FOP systems such as 'high in' warning labels and France's five-colour Nutri-Score system.

Canada is currently finalizing regulations for a mandatory nutrient-specific FOP labelling system. Similar to Chile's system, the new policy will require all packaged foods and beverages to display a 'high in' symbol if they exceed thresholds for sugars, sodium, or saturated fats.[33] In addition, health advocacy groups are increasingly calling for a national sugary drink tax in Canada.[34,35] There is a need for evidence comparing the relative effectiveness of different taxation strategies and FOP labelling formats—as well as how these policy measures interact when applied in combination—to help inform the implementation of FOP labelling and tax policies in Canada and other countries. Additionally, it is unknown whether policies have similar impacts on purchasing and consumption of foods compared to beverages.

The current study, which utilized an experimental marketplace, sought to test the relative impact of (1) different food and beverage sugar taxes, and (2) different formats of nutrient-specific and summary indicator FOP nutrition labels on Canadian consumers' purchasing of sugars, sodium, saturated fats, and calories. Purchases were assessed using a range of beverage and snack food products typically available at a convenience or corner store, which provided a wide range of nutrient profiles. The study examined five primary research questions: (1) Does a tax on SSBs impact purchases of sugars, sodium, saturated fats and calories differently than a tax on sugary drinks?; (2) Does a tiered specific excise tax based on sugar content impact purchases differently than an *ad valorem* tax?; (3) Do nutrient-specific FOP nutrition labels (e.g., 'high in' warnings, multiple traffic lights) impact purchases differently than summary indicator FOP systems (e.g., health star ratings, 5-colour nutrition scores)?; (4) Do sugar taxes and FOP labels have similar impacts on purchases when applied to foods compared to beverages?; and (5) Do the effects of sugar taxes and FOP labelling systems interact when applied in combination?

3.3 Methods

3.3.1 Study design

The study was conducted from March to May 2018. Ethical approval was granted by the Office of Research Ethics at the University of Waterloo (ORE #22494).

An experimental marketplace is an approach commonly used in the field of behavioural economics and marketing to study actual consumer behaviour, and provides the opportunity to manipulate price and other variables of interest to assess their influence on consumers'

purchases.[36,37] Participants are provided with a sum of money, and presented with multiple products available for purchase. If the participant does not spend the entire sum of money, they are permitted to keep the remainder, along with the product they selected. In this way, participants spend real money and incur a financial cost for their purchases, leading to more realistic product selections.[36,37]

3.3.2 Study protocol

Participants and recruitment

Participants aged 13 years and older were recruited using convenience sampling from large shopping centres in three Canadian cities (Kitchener, Waterloo, and Toronto) within the province of Ontario. Youth are an important subpopulation to include in diet-related research due to their higher consumption of nutrients of concern and differed interactions with tax and labelling policies compared to older populations.[38–41] Research assistants were stationed at booths in high-traffic areas in the shopping centres, and approached potential participants to ask if they were interested in participating in a study on food and beverage purchasing patterns. All interested participants were asked to provide their age prior to giving written informed consent and beginning the study. Additional written informed consent from a parent or guardian was required for all participants under 16 years; if a parent or guardian was not present, the shopper was not permitted to participate. Participants completed the study at the booth with the research assistant, immediately following consent.

Purchasing tasks

The experimental purchasing tasks were delivered in the format of a 5 (FOP label condition) × 8 (tax condition) between-within group experiment. A visual depiction of the purchasing task protocol is available in [Chapter 2, Figure 4]. Participants were randomly assigned to one of five FOP label conditions. Within their assigned label condition, participants completed eight consecutive purchasing tasks, which each corresponded to a different tax condition. In each of the eight purchasing tasks, participants were shown a selection of beverage or snack products on a large (62.5 × 50 cm) laminated print-out, which was designed to replicate the appearance of a grocery or convenience store shelf (Figure 1). A new print-out was shown for each purchasing task, reflecting the appropriate label and tax condition for that purchase. In the first five

purchases, participants selected from 20 different beverage products. In the last three purchases, participants selected from 20 different snack food products. The order of the tax conditions was randomized within the five beverage tasks and within the three food tasks. At the end of the survey, the program randomly selected one of the eight purchasing tasks to be the actual purchase, and the participant received the product selected with that task.

Prior to each of the eight purchasing tasks, research assistants emphasized the following points to each participant: (1) they had a budget of $5.00 to purchase one item, (2) the labels may be different from what they've seen in the past, (3) the prices may have changed since the last task, and (4) they would receive their change from the $5.00 and the actual food or beverage product from one of the eight purchases. Research assistants were instructed to not engage in discussion or answer questions about nutrition, diet, or food policies. For each task, participants made their selection on an iPad after viewing the large shelf image. Participants did not know which purchase selection they would receive (along with any change from the $5.00) until the end of the experiment and were instructed to treat all eight tasks as real purchases.

Upon completion of the eight purchasing tasks, each participant was asked "In all of the previous purchasing tasks, did you notice any nutrition labels or symbols on the front of the food and beverage packages?", with response options "yes", "no", "don't know", or "refuse to answer".

Experimental conditions

Five FOP label conditions were tested, including two nutrient-specific labels and two summary indicator systems. The FOP label conditions were *no label* (control); a *high in* warning system labelling foods high in sugars, sodium or saturated fats; a multiple traffic light system (*MTL*) for sugars, sodium and saturated fats; a *health star rating* label; and a five-colour *nutrition grade* label (Figure 2).

The *high in* warning system was modelled after early iterations of Health Canada's proposed FOP warning symbols for foods high in sugars, sodium and saturated fats, with nutrient thresholds based on Health Canada's proposed guidelines.[33] The *MTL* system was loosely based on the UK's voluntary traffic light labelling system.[42] To ensure comparability with the *high in* system, *MTL* labels were displayed only for sugars, sodium and saturated fats. Criteria for 'high', 'medium' and 'low' were based on the UK's regulations;[42] however, in two cases in which the

MTL was incongruent with the *high in* warning labels, the *MTL* was adjusted to match Health Canada *high in* warnings. The *health star rating* label design and scoring system were modeled after Australia and New Zealand's Health Star Rating system.[43] The *nutrition grade* system was designed based on France's Nutri-Score system.[44] Due to differences in criteria and scoring algorithms across the two summary indicator systems, the *nutrition grade* scores were adjusted to match those of the *health star rating* for the purposes of this study (i.e., 0.5 to 1 stars = 'E' nutrition grade; 1.5 to 2 stars = 'D'; 2.5 to 3 stars = 'C'; 3.5 to 4 stars = 'B'; 4.5 to 5 stars = 'A'). The FOP labels were not applied to fresh fruits or vegetables (i.e., the apple and carrots) to align with most real-world FOP nutrition labelling systems. See [Appendix C, Table C1] for details on the FOP labels assigned to all food and beverage products.

Five beverage-based sugar tax conditions (Table 1) were tested: *no tax* (control), a 20% *ad valorem* tax on SSBs (*20% SSB*), a 20% *ad valorem* tax on sugary drinks (*20% SD*), a tiered specific tax on SSBs (*tiered SSB*), and a tiered specific tax on sugary drinks (*tiered SD*). Beverages were categorized as SSBs if they contained added sugar, as previously defined.[8] Beverages were categorized as sugary drinks if they contained free sugar, as defined by WHO.[7] *20% SSB* and *20% SD* taxes were applied to beverages containing more than 5 g of added or free sugars (respectively) per 100 ml. *Tiered SSB* and *tiered SD* taxes applied a 10% price increase to beverages containing 5 to 8 g, or a 20% price increase to beverages containing more than 8 g of added or free sugars per 100 ml (modelled after the SSB tax implemented in the UK[45]). The study also tested three food-based sugar tax conditions: *no tax* (control), a 20% *ad valorem* tax on high-sugar foods (*20%*), and a tiered specific tax on high-sugar foods (*tiered*). Here, the *20%* tax was assigned to all foods containing more than 10 g of total sugars per 100 g; the *tiered* tax applied a 10% price increase to foods containing more than 10 to 20 g of total sugars per 100 g, and a 20% price increase to foods containing more than 20 g of total sugars per 100 g. The SSB and SD tax formats were not applicable to the snack food purchases. [Appendix C] provides details on how the taxes were assigned to each product [Table C2], as well as nutrition information of all products [Table C3].

Sociodemographic measures

Following the purchasing tasks and using the iPad, participants provided information on their previous 7-day sugary drink consumption using a brief single-item beverage frequency measure

("During the past 7 days, how many sugary drinks did you have?").[46] Participants also reported their age, sex, ethnicity, education, income adequacy ("Thinking about your total monthly income, how difficult or easy is it for you to make ends meet?"), and height and weight. Self-reported height and weight were used to calculated body mass index (BMI), which was categorized into "underweight", "normal weight", "overweight" and "obese" using the WHO thresholds.[47] BMIs for participants 19 years of age or younger were calculated using growth charts as recommended by CDC and WHO guidelines.[48,49] All survey items were completed after the experiment to minimize influence on participants' behaviours in the purchasing tasks.

Remuneration

After participants had completed all survey items, the survey program randomly selected one of their eight purchasing tasks. Research assistants gave participants their actual food or beverage product and their change from the $5.00 corresponding to that purchase.

3.3.3 Outcome variables

Four primary outcomes were explored: grams of sugars purchased, milligrams of sodium purchased, grams of saturated fats purchased, and number of calories purchased per task. All four outcomes were measured based on the total amount of sugars, sodium, saturated fats, or calories in the entire package of the product selected in each purchasing task; all products were single-serving sized and expected to be consumed in one sitting. All four nutrient outcomes were assessed for both foods and beverages. Although sugars and calories were the principal nutrients of concern for the beverages, several presented beverages contained substantial amounts of sodium (i.e., sports drinks) and saturated fat (i.e., milks). The impacts of the sugar-based taxes on purchasing were explored for all four nutrient outcomes (including sodium and saturated fats) so as to capture any potential 'spillover' effects of sugar-based taxes.[50] Secondary outcomes included potential interaction effects between FOP labelling and taxes, as well as participants' reported noticing of the FOP nutrition labels.

3.3.4 Analyses

Chi square tests (for categorical variables) and one-way ANOVAs (for linear variables) were used to test for sociodemographic differences between experimental conditions (FOP label

format). Separate two-tailed repeated-measures ANOVAs were used to investigate the effects of labelling and tax on the amount of sugars, sodium, saturated fats, and calories purchased; foods and beverage purchases were analysed separately, resulting in a total of eight ANOVAs. Repeated-measures ANOVAs were used to account for the repeated nature of the purchasing tasks. All ANOVAs included a *tax condition* × *label condition* interaction. In the case that an ANOVA violated the assumption of sphericity,[51] Greenhouse-Geisser corrections[52] were applied to the results. All statistical analyses were conducted using SPSS software (version 25.0; IBM Corp., Armonk, NY; 2017). The significance threshold was set at 0.05 for all tests. No adjustments for multiple comparisons were applied. It has been suggested that experiments based on distinct, conceptually sound *a priori* hypotheses and which have discrete, separate experimental arms should not apply adjustments for multiple comparisons.[53–55] Results should be interpreted by the strength and magnitude of the effect sizes, *p*-values, and confidence intervals.

3.4 Results

Sample characteristics are presented in Table 2. A total of 3,702 participants (96.7% of those who consented) completed the study; 118 participants were removed due to data quality concerns reported by the research assistants (e.g., significant cognitive difficulties or distraction, visual impairment, substantial influence from peers), resulting in a final sample size of 3,584. Participants spent an average of 17.3 minutes to complete the purchasing tasks and subsequent survey items.

There were no significant differences in sociodemographic measures across the between-group (FOP label format) experimental conditions (Table 2).

3.4.1 Label noticing

Among participants who were assigned to view products with a FOP label, 51.5% reported noticing any nutrition labels or symbols on the food and beverage packages. Table 3 presents the proportion of participants who reported noticing nutrition labels or symbols across each label condition.

3.4.2 Beverage purchasing tasks

Mean amounts of sugars, sodium, saturated fats and calories purchased in the beverage tasks are presented in Figure 3. Repeated-measures ANOVA results are presented in Table 4, including pairwise comparisons between all tax and labelling conditions. There were no significant two-way interactions between tax and labelling condition for any of the four outcomes in the beverage tasks.

Taxes

Participants purchased fewer grams of sugars and calories in all tax conditions (*20% SSB, 20% SD, tiered SSB, tiered SD*) compared to the *no tax* control condition (Table 4). The *20% SD* tax condition resulted in less sugars and calories purchased compared to the *20% SSB* and *tiered SSB* conditions. Participants purchased fewer calories in the *tiered SD* condition compared to the *20% SSB* and *tiered SSB* taxes.

For the *20% SSB, 20% SD*, and *tiered SSB* tax conditions, participants' beverage purchase selections contained less sodium compared to the *no tax* control condition. The *20% SSB* tax resulted in less sodium purchased in comparison to the *20% SD, tiered SSB,* and *tiered SD* tax conditions. The *20% SD* and *tiered SSB* conditions resulted in less sodium purchased compared to the *tiered SD* condition.

Participants purchased fewer grams of saturated fats in the *20% SSB* and *tiered SSB* tax conditions compared to the *no tax* control condition. The *20% SSB* tax condition also resulted in fewer grams of saturated fats purchased compared to the *20% SD* condition. Participants purchased fewer grams of saturated fats in the *tiered SSB* condition compared to the *20% SD* and *tiered SD* taxes.

FOP labelling

Participants assigned to the *high in* label condition purchased beverages containing less sugars, saturated fats, and calories compared to the *no label* control condition (Table 4). There were no significant differences in amount of sodium purchased between any of the labelling conditions in the beverage purchasing tasks.

3.4.3 Food purchasing tasks

Mean grams of sugars, sodium, saturated fats, and calories purchased in the food purchasing tasks are presented in Figure 4. Repeated-measures ANOVA results for the food tasks are presented in Table 4. There were no significant two-way interactions between tax and labelling condition for any of the four outcomes in the food tasks.

Taxes

Participants selected snack foods with less sugars, saturated fats, and calories in both the *20%* and *tiered* conditions compared to the *no tax* control. The *tiered* food tax resulted in a higher amount of sodium purchased in comparison to the control condition.

FOP labelling

There were no significant differences in the amount of sugars or saturated fats in the snack food purchase selections between any of the FOP labelling conditions. Participants assigned to the *high in* and *MTL* conditions purchased less sodium and fewer calories compared to the *no label* control condition, as did those assigned to the *MTL* compared to the *nutrition grade*. Participants who viewed the *health star rating* also purchased fewer calories than those in the *no label* control condition.

3.5 Discussion

The findings suggest that sugar-based taxes and FOP nutrition labels can influence purchasing behaviour for beverage and snack purchases. As expected, the sugar-based taxes had the greatest impact on amounts of sugars and calories purchased. Within the beverage purchasing tasks, participants purchased products with up to 19% less sugars (− 4.7 g) and up to 18% fewer calories (− 19.8 kcal) compared to no tax. There were also substantial reductions in the foods purchased: sugar levels were 14 to 15% lower (− 1.4 to − 1.5 g) and calories were 3 to 4% lower (− 5.3 to − 6.7 g) under the tax conditions versus no tax. Although all tax formats for both beverages and foods affected the amounts of sugars and calories purchased, reductions were greatest when the tax was applied to 100% juice products in the ‘sugary drinks’ conditions as opposed to only sugar-sweetened beverages. Modelling studies suggest that including 100%

juice in sugary drink taxes substantially increases the population-level health and economic impact of sugary taxes, mainly because fruit juice is one of the most frequently consumed sugary drinks in Canada and other Western countries.[34,56]

Although the taxes tested were based on sugar content, they also resulted in reductions in sodium and saturated fats purchased. For beverages, reductions in both sodium and saturated fats were as large as 9% (− 6.6 mg sodium; − 0.04 g saturated fat), and were driven mainly by switching away from sports drink and milk products, respectively. Similar reductions in saturated fat were observed among food purchases. As is the case in the broader food supply, the high-sugar foods presented in this study were often high in sodium and saturated fats as well,[57] leading to 'spillover' effects of sugar taxes. However, participants purchased foods higher in sodium under the tax vs. no-tax conditions. These results suggest potential trade-off effects for snack foods: in order to avoid more expensive sugary foods, participants may have been more likely to switch to alternative snacks containing more sodium. To our knowledge, very little research has examined the compensatory effects of sugar taxes on purchases of other nutrients of concern such as sodium or saturated fats. Given an increasing focus on overall dietary patterns rather than isolated nutrients or foods,[58] research with this expanded focus is an important contribution to the literature. The potential 'spillover' or compensatory effects of sugar taxes—whether positive or negative—should be key considerations for policymakers implementing sugar-based taxes.

Few differences were observed among taxes assigned based on product price (20% *ad valorem* tax conditions) and those assigned based on sugars content (tiered specific tax conditions). Although these tax structures may have similar impacts on consumer behaviour, they may have a different impact on industry behaviour, in terms of product reformulation. A tiered specific tax—based on either product volume or sugar content—may be more effective than a single-level *ad valorem* tax in motivating manufacturers to reduce sugar content, since tiered taxes offer intermediate sugar thresholds that may be easier to achieve.[25] Reports from the UK suggest that their tiered SSB tax has incentivized manufacturers to produce lower-sugar product formulations in efforts to avoid the levy.[59] Further research assessing the more novel tiered tax formats would be beneficial for policymakers considering a tax strategy.

For the FOP labels, the nutrient-specific *high in* warning performed most consistently in terms of reducing amounts of energy and the nutrients of interest. Participants in the *high in* condition

purchased beverages with 11% less sugar (− 2.5 g), 18% less saturated fat (− 0.1 g), and 12% fewer calories (− 12.6 kcal) compared to the control condition. Similarly, in the food purchasing tasks, the *high in* warning produced an 8% reduction in sodium (− 13.5 mg) and a 5% reduction in calories (− 8.9 kcal) purchased. Although these reductions may appear modest at an individual level, they may translate to substantial reductions at a population level. The *MTL* and *health star rating* formats produced less consistent reductions in sodium and calories, while the *nutrition grade*—modelled after France's Nutri-Score system—had minimal effects, resulting in similar outcomes to the control condition in all cases. Given the focus in this study on nutrient-specific outcomes, it is perhaps not surprising that the nutrient-specific FOP formats produced the greatest reductions in the targeted nutrients. It is also notable that 'high in' labels were most likely to be noticed compared to the other FOP labels, which highlights the importance of the general design and 'salience' of labels to engage consumers' attention.[60] These results reflect similar findings from a range of experimental studies investigating nutrient-specific FOP warnings.[61–66] The poor performance of the five-colour nutrition grade in this study is in contrast to more promising results from France on the Nutri-Score system;[67] however, these differences may be due to the focus of the current study's outcomes on specific nutrients of concern rather than overall nutritional quality. The findings may also indicate that the Nutri-Score system may require more public education than more intuitive symbols such as the *high in* labels. Future research should compare the impacts of different FOP formats on purchasing of both targeted nutrients and broader outcomes related to overall diet quality and implications for health.

No interaction effects were observed between the tax and FOP labelling conditions. However, the findings demonstrate that taxation and FOP labels have independent effects, which remained in the presence of the other policy. In other words, FOP labels had an effect above and beyond the effects of taxation, and vice versa. The cumulative effects of the tax and label interventions were considerable, suggesting greater public health benefit when both policies are implemented.

Several limitations should be noted. First, the study did not use a systematic sampling method, limiting generalizability to the larger Canadian population. However, the sample provided a large age range and good variability across sociodemographic characteristics, with notable similarities to the Canadian population in the proportion of participants identifying as Indigenous.[68] This study used an experimental marketplace design to replicate authentic purchasing behaviours as

closely as possible; however, it may not represent how consumers interact with price and labels in real world settings, in which other influences (e.g., family members' or peers' preferences) may come in to play. Additionally, participants did not make purchases with their own money, which may have led to more carefree spending. Both policy measures tested in this study were presented to participants without an associated description or explanation. Only about half of the participants reported noticing the FOP labels when they were present, which is substantially lower than rates of consumer awareness in countries with existing mandatory FOP labelling systems.[69–71] Notably, over a quarter of the participants randomized to the control condition (who were shown no FOP labels) reported seeing 'nutrition labels or symbols', suggesting that even fewer of the other participants may have actually noticed the FOP labels of interest, even if they reported so. Therefore, effect sizes may be greater under real world conditions, in which consumers are more likely to be aware of a FOP labelling system. Strengths of the study include the use of a randomized between-within experimental design, and behavioural outcomes with 'real' monetary consequences. Indeed, few studies to date have combined the high internal validity provided by an experimental design with actual purchase tasks.

3.6 Conclusions

The study findings provide empirical support for the effectiveness of sugar taxes and FOP nutrition labels to help reduce consumption of sugars, sodium, saturated fats, and calories. Results suggest that including 100% fruit juice in the scope of taxed beverages leads to greater reductions in sugar consumption, and that sugar taxes may help to reduce consumption of sodium and saturated fats in addition to sugars and calories. Among FOP label designs, nutrient-specific FOP 'high in' warnings produced the most consistent reductions in nutrients of concern, reinforcing the approach taken in Chile and regulatory proposals in Canada and Brazil. Further 'post-implementation' research is required to understand how such interventions, on their own and in combination, affect overall diet quality at the population level.

Table 1. Summary of sugar tax conditions

Beverage purchases	
1	No tax (control)
2	20% SSB
3	20% SD
4	Tiered SSB
5	Tiered SD
Food purchases	
6	No tax (control)
7	20%
8	Tiered

SSB, sugar-sweetened beverage; SD, sugary drink

Table 2. Sociodemographic characteristics of sample (N=3,584) and test results for differences across conditions

Characteristic	%	Test for differences
City		$\chi^2 = 5.7$ ($p = .684$)
Kitchener	17.5	
Toronto	41.2	
Waterloo	41.4	
Age (years)		$\chi^2 = 25.8$ ($p = .058$)
13-18	15.3	
19-25	31.0	
26-35	20.6	
36-45	11.9	
>45	21.3	
Gender		$\chi^2 = 0.8$ ($p = .940$)
Male	44.0	
Female	56.0	
Weekly beverage frequency		$F = 1.0$ ($p = .404$)
Number of sugary drinks (*mean*)	4.0	
Ethnicity		$\chi^2 = 7.3$ ($p = .839$)
White	44.9	
Other/mixed	50.3	
Indigenous	3.3	
Not stated	1.6	
Education		$\chi^2 = 1.9$ ($p = .985$)
High school or less	26.6	
CEGEP/Trade School/College (partial or complete)	11.7	
University (partial or complete)	61.7	
Income adequacy		$\chi^2 = 8.2$ ($p = .416$)
'Very difficult' or 'Difficult'	19.5	
'Neither easy nor difficult'	41.4	
'Easy' or 'Very easy'	39.1	
BMI classification		$\chi^2 = 12.3$ ($p = .726$)
Underweight	3.3	
Normal weight	46.0	
Overweight	22.8	
Obese	12.1	
Not reported	15.8	

CEGEP, Collège d'enseignement général et professionnel (general and vocational college); BMI, body mass index

Table 3. Participant responses to "In all of the previous purchasing tasks, did you notice any nutrition labels or symbols on the front of the food and beverage packages?", by label condition (N=3,584)

	Label Condition				
Response	**No FOP label (control)** %	**High in** %	**MTL** %	**Health star rating** %	**Nutrition grade** %
	n=726	n=714	n=709	n=718	n=717
Yes	28.4	58.3	45.0	52.5	50.3
No	71.2	40.3	53.7	46.0	48.1
Don't know	0.4	1.4	1.3	1.5	1.5

FOP, front-of-package; MTL, multiple traffic light.

Table 4. Repeated-measures ANOVA results for sugars, sodium, saturated fats, and calories in beverage and food purchase selections within an experimental marketplace with varied tax and FOP label conditions (N=3,584)

	Sugars	**Sodium**	**Saturated fats**	**Calories**
BEVERAGE PURCHASES				
Main Effects Model Statistics				
Tax condition	F (3.95, 14126.96) = 68.55*	F (3.98, 14233.92) = 10.01*	F (3.97, 14219.73) = 3.45*	F (3.96, 14158.14) = 71.78*
Label condition	F (4, 3579) = 1.63	F (4, 3579) = 0.89	F (4, 3579) = 1.74	F (4, 3579) = 2.50*
Tax condition × Label condition	F (15.79, 14126.96) = 0.45	F (15.91, 14233.92) = 1.23	F (15.89, 14219.73) = 1.23	F (15.82, 14158.14) = 0.44
Pairwise comparisons: Tax conditions	*Mean difference* g (95% CI)	*Mean difference* mg (95% CI)	*Mean difference* g (95% CI)	*Mean difference* kcal (95% CI)
no tax – 20% SSB	3.68 (3.02, 4.34)*	6.62 (4.27, 8.97)*	0.03 (0.01, 0.06)*	14.47 (11.84, 17.09)*
no tax – 20% SD	4.77 (4.10, 5.45)*	2.51 (0.04, 4.97)*	-0.001 (-0.03, 0.03)	19.78 (17.11, 22.46)*
no tax – tiered SSB	3.61 (2.97, 4.25)*	3.51 (1.08, 5.93)*	0.04 (0.01, 0.07)*	14.27 (11.73, 16.82)*
no tax – tiered SD	4.22 (3.56, 4.87)*	0.02 (-2.50, 2.54)	0.01 (-0.02, 0.03)	17.42 (14.81, 20.02)*
20% SSB – 20% SD	1.09 (0.48, 1.70)*	-4.11 (-6.45, -1.77)*	-0.03 (-0.06, -0.01)*	5.32 (2.82, 7.82)*
20% SSB – tiered SSB	-0.07 (-0.69, 0.55)	-3.12 (-5.50, -0.73)*	0.01 (-0.02, 0.04)	-0.19 (-2.66, 2.28)
20% SSB – tiered SD	0.54 (-0.08, 1.15)	-6.60 (-9.05, -4.15)*	-0.02 (-0.05, 0.01)	2.95 (0.46, 5.45)*
20% SD – tiered SSB	-1.16 (-1.77, -0.55)*	1.00 (-1.41, 3.40)	0.04 (0.01, 0.07)*	-5.51 (-7.99, -3.03)*
20% SD – tiered SD	-0.55 (-1.16, 0.05)	-2.49 (-4.88, -0.09)*	0.01 (-0.02, 0.03)	-2.36 (-4.75, 0.02)
tiered SSB – tiered SD	0.61 (-0.01, 1.22)	-3.48 (-5.89, -1.08)*	-0.03 (-0.06, -0.01)*	3.15 (0.69, 5.60)*
Pairwise comparisons: Label condition	*Mean difference* g (95% CI)	*Mean difference* mg (95% CI)	*Mean difference* g (95% CI)	*Mean difference* kcal (95% CI)
no label – high in	2.50 (0.56, 4.45)*	5.35 (-1.27, 11.97)	0.10 (0.02, 0.18)*	12.62 (4.65, 20.59)*
no label – MTL	1.18 (-0.77, 3.13)	3.92 (-2.71, 10.55)	0.08 (-0.01, 0.16)	7.36 (-0.62, 15.34)
no label – health star rating	1.53 (-0.42, 3.47)	4.87 (-1.74, 11.48)	0.06 (-0.02, 0.14)	7.03 (-0.93, 14.98)
no label – nutrition grade	1.22 (-0.72, 3.16)	1.73 (-4.88, 8.35)	0.03 (-0.05, 0.11)	5.16 (-2.80, 13.12)
high in – MTL	-1.32 (-3.28, 0.64)	-1.43 (-8.09, 5.23)	-0.02 (-0.10, 0.06)	-5.26 (-13.28, 2.75)
high in – health star rating	-0.98 (-2.93, 0.98)	-0.48 (-7.12, 6.16)	-0.04 (-0.12, 0.04)	-5.59 (-13.58, 2.40)
high in – nutrition grade	-1.28 (-3.23, 0.67)	-3.62 (-10.25, 3.02)	-0.07 (-0.15, 0.02)	-7.47 (-15.34, 0.62)
MTL – health star rating	0.35 (-1.61, 2.30)	0.95 (-5.70, 7.60)	-0.02 (-0.10, 0.06)	-0.33 (-8.34, 7.67)
MTL – nutrition grade	0.04 (-1.92, 1.99)	-2.19 (-8.84, 4.47)	-0.05 (-0.13, 0.03)	-2.20 (-10.21, 5.80)
health star rating – nutrition grade	-0.31 (-2.26, 1.64)	-3.13 (-9.76, 3.50)	-0.03 (-0.11, 0.06)	-1.87 (-9.85, 6.11)
FOOD PURCHASES				
Main Effects Model Statistics				

Tax condition	F (1.99, 7125.23) = 50.02*	F (2, 7158) = 2.64	F (2.00, 7145.09) = 5.12*	F (2, 7158) = 15.04*
Label condition	F (4, 3579) = 0.28	F (4, 3579) = 2.24	F (4, 3579) = 1.48	F (4, 3579) = 2.87*
Tax condition × Label condition	F (7.96, 7125.23) = 0.84	F (8, 7158) = 0.61	F (7.99, 7145.09) = 1.19	F (8, 7158) = 0.99
Pairwise comparisons: Tax conditions	*Mean difference* g (95% CI)	*Mean difference* mg (95% CI)	*Mean difference* g (95% CI)	*Mean difference* kcal (95% CI)
no tax – 20%	1.54 (1.20, 1.88)*	-3.93 (-8.08, 0.22)	0.08 (0.03, 0.13)*	6.71 (4.20, 9.21)*
no tax – tiered	1.37 (1.04, 1.71)*	-4.42 (-8.59, -0.26)*	0.05 (0.01, 0.10)*	5.31 (2.77, 7.85)*
20% – tiered	-0.16 (-0.48, 0.16)	-0.49 (-4.58, 3.60)	-0.03 (-0.08, 0.02)	-1.40 (-3.94, 1.15)
Pairwise comparisons: Label condition	*Mean difference* g (95% CI)	*Mean difference* mg (95% CI)	*Mean difference* g (95% CI)	*Mean difference* kcal (95% CI)
no label – high in	0.24 (-0.64, 1.12)	13.42 (0.78, 26.05)*	0.12 (-0.01, 0.26)	8.97 (1.10, 16.84)*
no label – MTL	-0.04 (-0.92, 0.85)	15.03 (2.37, 27.69)*	0.12 (-0.02, 0.25)	11.43 (3.55, 19.31)*
no label – health star rating	0.33 (-0.55, 1.21)	11.50 (-1.12, 24.12)	0.10 (-0.03, 0.23)	8.05 (0.19, 15.91)*
no label – nutrition grade	0.28 (-0.60, 1.16)	2.27 (-10.35, 14.89)	0.02 (-0.12, 0.15)	2.23 (-5.63, 10.09)
high in – MTL	-0.27 (-1.16, 0.61)	1.61 (-11.10, 14.32)	-0.004 (-0.14, 0.13)	2.46 (-5.46, 10.38)
high in – health star rating	0.09 (-0.79, 0.97)	-1.92 (-14.59, 10.75)	-0.02 (-0.16, 0.11)	-0.92 (-8.81, 6.97)
high in – nutrition grade	0.04 (-0.84, 0.92)	-11.15 (-23.82, 1.53)	-0.11 (-0.24, 0.03)	-6.74 (-14.63, 1.16)
MTL – health star rating	0.36 (-0.52, 1.25)	-3.53 (-16.22, 9.17)	-0.02 (-0.15, 0.12)	-3.38 (-11.28, 4.53)
MTL – nutrition grade	0.31 (-0.57, 1.20)	-12.76 (-25.45, -0.06)*	-0.10 (-0.24, 0.03)	-9.20 (-17.10, -1.29)*
health star rating – nutrition grade	-0.05 (-0.93, 0.83)	-9.23 (-21.89, 3.43)	-0.08 (-0.22, 0.05)	-5.82 (-13.70, 2.07)

95% CI, 95% confidence interval; SSB, sugar-sweetened beverage; SD, sugary drink; MTL, multiple traffic light.

*$p < .05$

Figure 1. Example product shelf images showing two combinations of FOP and taxation conditions: (A) beverages with *health star rating* labels and *tiered SD* tax, (B) foods with *high in* labels and *20%* sugar tax

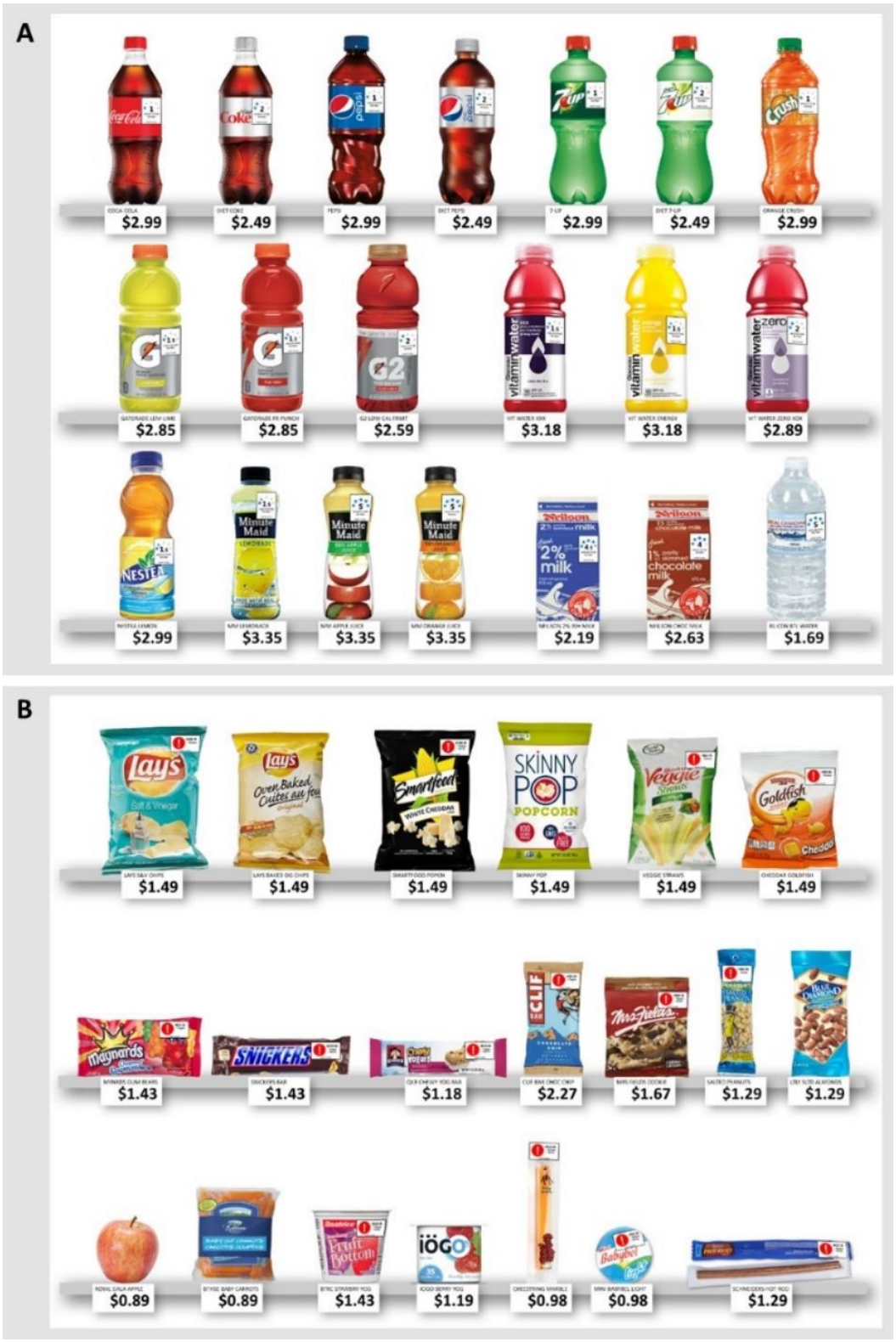
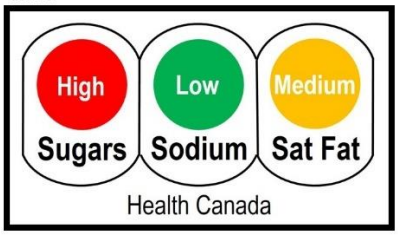


Figure 2. Images of label conditions, excluding *no label* (control). From top to bottom: *high in*, *MTL*, *health star rating*, and *nutrition grade*.

High in

MTL



Health star rating

Nutrition grade

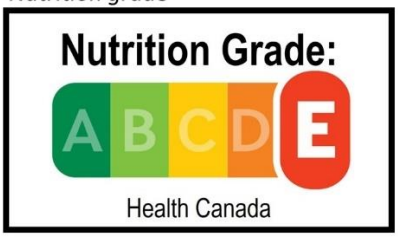


Figure 3. Sugars, sodium, saturated fats, and calories in purchased beverages within an experimental marketplace in which (A) tax conditions and (B) FOP label conditions varied. Error bars represent 95% confidence intervals for the mean estimates. [a,b,c] Values with differing superscript letters indicate tests for which $p < .05$ in a repeated-measures ANOVA

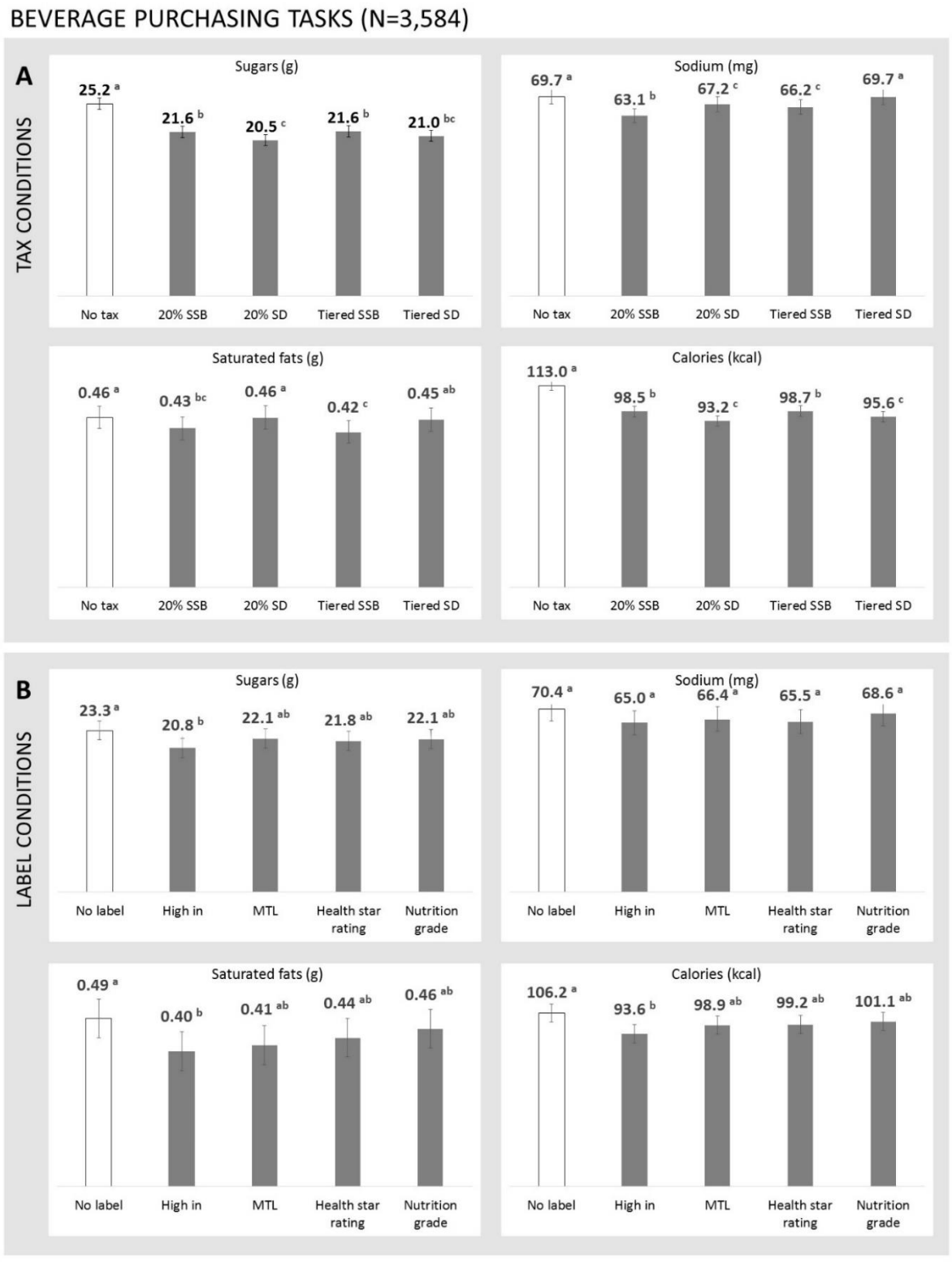
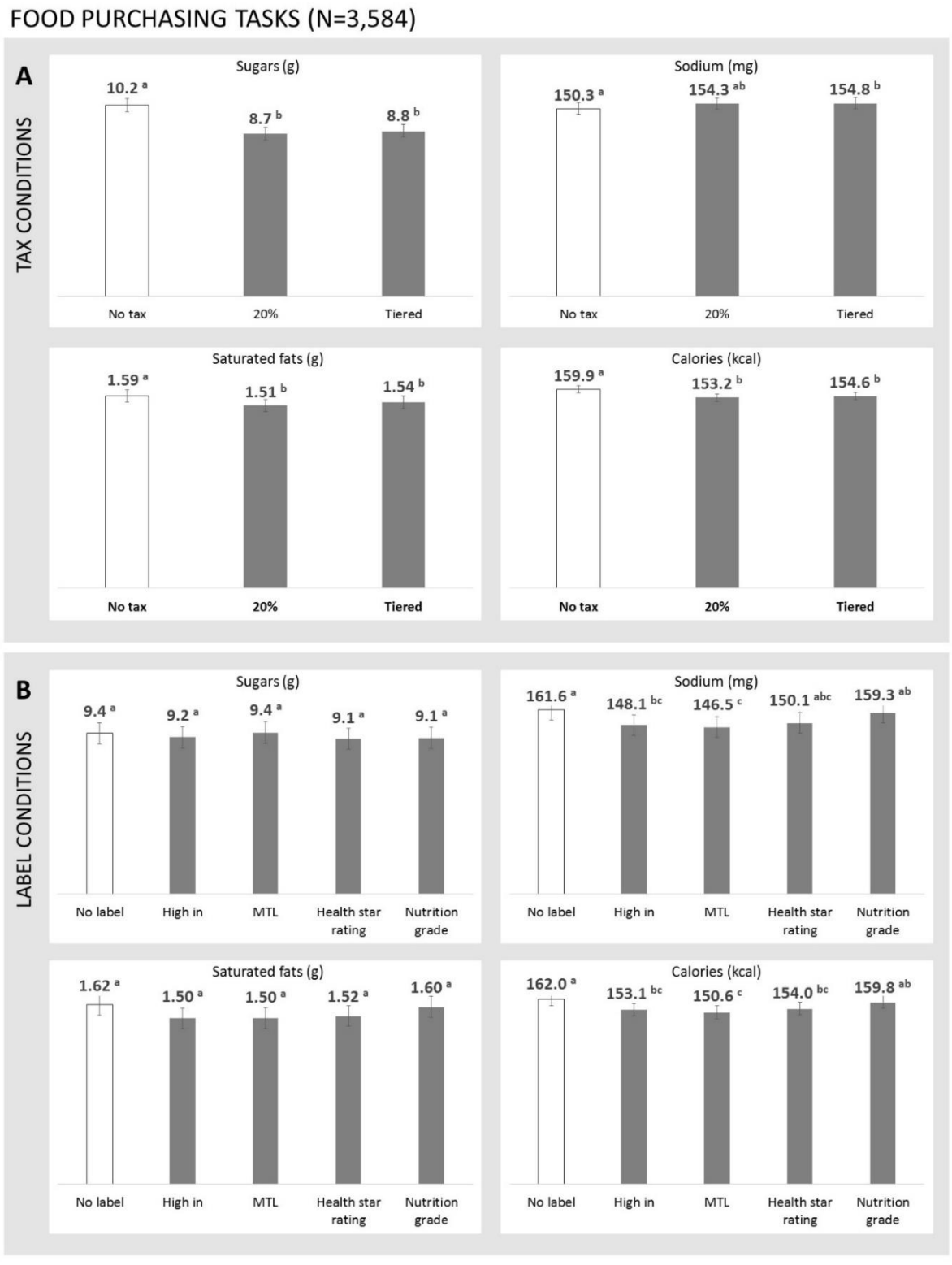


Figure 4. Sugars, sodium, saturated fats, and calories in purchased foods within an experimental marketplace in which (A) tax condition and (B) FOP label conditions varied. Error bars represent 95% confidence intervals for the mean estimates. [a,b,c] Values with differing superscript letters indicate tests for which $p < .05$ in a repeated-measures ANOVA



Chapter 4: Exploring the main and moderating effects of individual-level characteristics on consumer responses to sugar taxes and front-of-pack nutrition labels in an experimental marketplace

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Authors: Rachel B Acton BSc[1], Sharon I Kirkpatrick PhD[1], David Hammond PhD[1]

[1] School of Public Health & Health Systems, University of Waterloo, 200 University Ave. W., Waterloo, ON Canada N2L 3G1

4.1 Overview

Intervention: This study examined whether the impacts of sugar taxes and front-of-pack (FOP) nutrition labels differ across sociodemographic subgroups.

Research question: What are the main and moderating effects of individual-level characteristics on the nutrient content of participants' purchases in response to varying taxation levels and FOP labels?

Methods: Data from an experimental marketplace were analysed. A final sample of 3,584 Canadians aged 13 years and older received $5 to purchase an item from a selection of 20 beverages and 20 snack foods. Participants were randomized to view products with one of five FOP labels and completed eight within-subject purchasing tasks with different tax conditions. Linear mixed models were used to estimate the main and interaction effects of 11 individual-level variables on participants' purchasing of sugars, sodium, saturated fats and calories.

Results: Participants who were younger, male, and more frequent consumers of sugary drinks tended to purchase products containing more sugars, sodium, saturated fats and calories. Sex and age moderated the relationship between tax condition and sugars or calories purchased: female participants were more responsive to a tax that included fruit juice compared to males, and younger participants were more responsive to all sugar tax conditions compared to older participants. Reported thirst and education level also moderated the relationship between tax condition and calories purchased.

Conclusion: Few individual-level characteristics moderated the effects of sugar taxes on nutrients purchased in this study. The results thus suggest that sugar taxes and FOP labelling policies may produce similar effects across key sociodemographic groups.

Keywords: nutrition policy; health policy; taxes; nutrition labeling; socioeconomic factors; effect modifiers

4.2 Introduction

The growing burden of non-communicable diseases has prompted a global movement towards policy-level strategies to improve dietary patterns at the population level.[1] Two such strategies include taxes on high-sugar products and front-of-package (FOP) nutrition labelling systems.[2] There is growing evidence to suggest both sugar taxes and FOP nutrition labels can be effective at improving the healthiness of diets;[3,4] however, uncertainty remains regarding whether their impacts are consistent across different subpopulations.[5,6]

4.2.1 Sugar taxes

Taxes on sugary products are one of many health-focused fiscal strategies implemented around the globe, with taxes on sugar-sweetened beverages (SSBs) being the most common and most studied.[7,8] Evidence from taxes in Mexico, Berkeley, and Philadelphia suggest that such measures can increase prices and reduce purchases of taxed beverages.[9–11] However, our understanding of whether these taxes produce differential effects across population subgroups is nascent.

The majority of studies assessing the impacts of sugar taxes do not disaggregate their analyses by demographic characteristics. Among those that do, the focus tends to be on income or socioeconomic status (SES) because those of lower SES are likely to be affected by the tax to a greater extent compared to those of higher SES.[12] Aside from income, there is little evidence on the extent to which individual-level characteristics—such as age, sex, ethnicity, or dietary intake patterns—may moderate the effects of sugar taxes. Limited observational evidence from real-world policies provides some insight into differences by rurality, dietary intake, and obesity status. In Mexico, reductions in SSB purchases were higher among individuals living in urban versus rural areas following implementation of a national 1 peso/litre SSB tax.[13] Observational evidence from Mexico's national 8% tax on non-essential energy dense foods, as well as from a £0.10/beverage SSB tax implemented within a national chain of restaurants in the UK, suggest that impacts were greater among individuals with higher baseline consumption or preference for the taxed products.[14,15] Lastly, an observational study of Chile's modest 8% tax increase on SSBs found that patterns in purchasing did not differ by household obesity status.[16]

4.2.2 Front-of-package nutrition labels

FOP nutrition labelling is another policy strategy being implemented in an attempt to make healthy choices easier for consumers.[5] Countries have implemented FOP labels in a variety of formats, ranging from *nutrient-specific*, such as the UK's multiple traffic light (MTL) system or Chile's 'high in' warning labels, to *summary indicator* systems, such as Australia and New Zealand's Health Star Ratings or France's Nutri-Score system.[5,17] Although there is a large and growing body of evidence examining consumers' perceptions, understanding, and behavioural responses to FOP nutrition labels, only a small proportion of studies report results across relevant individual-level characteristics.[18,19]

The results of FOP labelling studies that have examined differences in impacts by demographic characteristics are mixed. Although some studies have reported that participants with higher body mass index (BMI),[20] lower income,[21] and lower education status[22] are less responsive to FOP labels, other studies have reported the opposite.[23,24] The heterogeneity in findings appears to be driven by differences in FOP label design. Labels that present predominantly quantitative information—such as Guideline Daily Amount labels—tend to show greater disparities in understanding across SES or literacy levels compared to other more interpretive systems such as Health Star Ratings, Nutri-Score, or nutrient-specific warning symbols.[25] Results also vary based on the country or setting in which the research was conducted, as well as the measures used to assess responses.[25] The most consistent evidence on demographic differences relates to overall nutrition label use: consumers who are female, white, those with higher education and income status, and those trying to lose, gain or maintain weight, as well as those with an existing chronic disease tend to be more likely to read or use nutrition labels.[26–30]

For both sugar taxes and FOP nutrition labels, a large portion of the literature examines participants' self-reported preferences and/or hypothetical purchases or uses simulation modelling[5,6] rather than objective measures of behavioural responses. Studies examining participants' self-reported preferences or hypothetical purchases provide important contributions to our understanding of consumer preferences, but do not capture actual product purchasing behaviours. Experimental research assessing behavioural outcomes can offer important insights into how the impacts of sugar tax and FOP labelling strategies are influenced by individual-level characteristics.

In a previous study by the research team, data from a randomized experimental marketplace were analyzed to investigate the impacts of various sugar taxes and FOP nutrition labels on consumers' purchasing of sugars, sodium, saturated fats and calories in beverages and snack foods.[31] Participants who viewed a 'high in' symbol on products purchased less sugar, saturated fat, and calories from beverages, and less sodium and calories from snack foods. All of the sugar taxes tested for both beverages and snack foods resulted in substantial reductions in sugars and calories purchased, and in some cases, reductions in sodium and saturated fat. The analyses presented here expand upon these findings, shedding light on possible differential effects across sociodemographic groups. The main objective of the current study was to identify whether key sociodemographic and behavioural characteristics moderated the effects of the sugar taxes and FOP nutrition labels on participants' purchasing of the abovementioned nutrients of concern. Secondary objectives included identifying the main effects of these individual-level characteristics, and examining the price paid and tax paid by participants to estimate the degree of financial regressivity (greater financial burden for lower income groups) of the sugar taxes tested.

4.3 Methods

4.3.1 Study Design

An experimental marketplace provides the opportunity to manipulate price and other variables of interest to assess their influence on consumers' purchases. In such studies, participants are given a pre-specified amount of money to spend and shown a range of products available for purchase. Following their selection, participants keep any remaining funds, along with the product they selected. Thus, participants spend real money and incur a financial cost for their purchases, leading to more realistic product selections compared to hypothetical purchase scenarios. The study protocol is described below, with additional details available elsewhere.[31]

4.3.2 Study Protocol

Data collection was conducted from March to May 2018. Ethical approval was granted by the Office of Research Ethics at the University of Waterloo (ORE #22494).

Participants and recruitment

Participants aged 13 years and older were recruited from large shopping centres in three Canadian cities (Kitchener, Waterloo, and Toronto) using convenience sampling. Research assistants recruited potential participants from stations in high-traffic areas in the shopping centres. All interested participants were required to provide their age prior to giving informed consent and participating in the study. Additional consent from a parent or guardian was required for participants under the age of 16 years; if a parent or guardian was not present, the shopper was not permitted to participate.

Participants completed the study in the same location immediately following consent. A total of 3,702 participants completed the study. Data for 118 participants were omitted due to data quality concerns, including significant cognitive difficulties or distraction, visual impairment, or substantial influence from peers, as reported by the research assistants. The final analytic sample thus includes 3,584 individuals.

Purchasing tasks

The purchasing tasks were administered via a 5 (FOP label condition) × 8 (tax condition) between-within group experiment. Participants were randomly assigned to one of five FOP label conditions and completed eight consecutive purchasing tasks, each corresponding to a different tax condition. In each of the eight purchasing tasks, research assistants showed participants a selection of beverage or snack food products on a large laminated print-out, designed to resemble a grocery or convenience store shelf. A unique shelf image was shown in each purchasing task to reflect the appropriate label and tax condition for that purchase. For the first five purchasing tasks, participants selected from 20 beverage products. For the last three purchases, participants selected from 20 snack food products. The order of the tax conditions was randomized within the five beverage tasks and within the three food tasks. For each task, participants made their selection on an iPad after viewing the shelf image. Following completion of all survey items, the survey program randomly selected one of the eight purchasing tasks to be ‘real’. Research assistants provided participants with the product and their change from the $5.00 corresponding to that purchase. Participants were unaware of which beverage or snack food selection they would receive until the end of the experiment, and were therefore instructed to treat all eight tasks as actual purchases.

Prior to each purchasing task, research assistants emphasized the following points to participants: (1) they had a budget of $5.00 to purchase one item, (2) the labels may be different from what they have seen in the past, (3) the prices may have changed since the last task, and (4) they would receive their change from the $5.00 and the actual food or beverage product from one of the eight purchases.

Experimental conditions

Five FOP label conditions were tested: *no label* (control); a *high in* system labelling foods high in sugars, sodium or saturated fats; a multiple traffic light system (*MTL*) for sugars, sodium and saturated fats; a *health star rating* label; and a five-colour *nutrition grade* label (Figure 1).

Five beverage-based sugar tax conditions were tested: *no tax* (control), a 20% tax on SSBs (*20% SSB*), a 20% tax on sugary drinks (*20% SD*), a tiered tax on SSBs (*tiered SSB*), and a tiered tax on sugary drinks (*tiered SD*). Beverages were categorized as SSBs if they contained added sugars (any sugars added during processing or preparation), such as regular soft drinks, sports drinks, flavoured waters, and fruit drinks.[32] Beverages were categorized as sugary drinks if they contained free sugars, defined by the World Health Organization (WHO) as all added sugars, plus those naturally present in honey, syrups, fruit juices, and fruit juice concentrates.[33] Sugary drinks therefore encompass all beverages under the umbrella of SSBs, plus 100% fruit juice products. The *20% SSB* and *20% SD* taxes were applied to beverages containing more than 5 g of added or free sugars, respectively, per 100 ml. The *tiered SSB* and *tiered SD* taxes applied a 10% price increase to beverages containing 5 to 8 g, versus a 20% price increase to beverages containing more than 8 g of added or free sugars per 100 ml. This tiered tax design was modelled on the SSB tax implemented in the United Kingdom.[34] Three food-based sugar tax conditions were tested: *no tax* (control), a 20% tax on high-sugar foods (*20%*), and a tiered tax on high-sugar foods (*tiered*). In this case, the *20%* tax was assigned to all snack food products containing more than 10 g of total sugars per 100 g. The *tiered* sugary food tax applied a 10% price increase to snack foods containing 10 to 20 g of total sugars per 100 g and a 20% price increase to foods containing more than 20 g of total sugars per 100 g.

Sociodemographic & health behaviour measures

Information on 11 individual-level characteristics was collected. Prior to beginning the purchasing tasks, participants were queried about (1) age, (2) sex, (3) current hunger, and (4) current thirst. Following the purchasing tasks and using the iPad, participants then provided information on (5) previous 7-day sugary drink (SD) consumption; (6) efforts to modify intake of sugars, sodium, saturated fats and calories in the previous year; (7) ethnicity; (8) education status; (9) income adequacy; (10) health literacy; and (11) height and weight to calculate BMI. The above characteristics were explored due to their demonstrated associations with dietary intake.[35–38]

Current hunger and thirst were reported on 5-point Likert scales ranging from 'not at all hungry/thirsty' to 'extremely hungry/thirsty'. Previous 7-day SD consumption was collected using a single-item beverage frequency measure,[39] which asked, "During the past 7 days, how many sugary drinks did you have? (This includes pop, fruit drinks, fruit juice, sports drinks, vitamin waters, energy drinks, chocolate milk, tea/coffee with more than 5 teaspoons of sugar, and specialty coffees.) Do not count diet or sugar-free drinks. Do not include today". Efforts to modify intake of sugars, sodium, saturated fats and calories were assessed with an item that asked "Have you made an effort to consume more or less of the following in the past year?", for 'calories', 'saturated fat', 'sugar/added sugar', and 'salt/sodium'. Income adequacy was reported using the question, "Thinking about your total monthly income, how difficult or easy is it for you to make ends meet?", with responses on a 5-point Likert scale ranging form 'very difficult' to 'very easy'. Health literacy was estimated using a computerized version of the Newest Vital Sign tool.[40] Self-reported height and weight were used to calculate BMI, which was categorized into 'underweight', 'normal weight', 'overweight' and 'obesity' using the WHO thresholds.[41] BMI for participants 19 years of age or younger was calculated using growth charts, as recommended by the US Centers for Disease Control and Prevention and WHO guidelines.[42,43]

4.3.3 Outcome variables

To assess the impacts of the sugar taxes and FOP labels on participants' purchases, four nutrient outcomes were examined: grams of sugars, milligrams of sodium, grams of saturated fat, and number of calories purchased. These nutrient outcomes were defined as the total amount of sugars, sodium, saturated fat, or calories in the entire package of the product selected in each

purchasing task. Each outcome variable was assessed for beverages and snack foods separately. 'Price paid' and 'tax paid' were included as secondary outcomes to explore the potential financial regressivity for the taxes tested in our study. 'Price paid' was defined as the tax-inclusive cost (CAN$) of the product selected within each purchasing task; 'tax paid' was defined as the portion of the product price (CAN$) coming from tax, if any.

4.3.4 Statistical analyses

All statistical analyses were pre-specified and conducted using SPSS software (version 25.0; IBM Corp., Armonk, NY; 2017). Likert-scale data were verified to be normally distributed. To account for the possibility of falsely detecting a significant result among multiple comparisons, we controlled for the false discovery rate (FDR) using the Benjamini-Hochberg procedure and a conservative FDR of 0.05.

Main effects

Eight linear mixed models (LMMs) were fitted, corresponding to eight continuous outcomes: sugars, sodium, saturated fats, and calories purchased from beverages; and sugars, sodium, saturated fats, and calories purchased from snack foods. LMMs were used to account for the repeated nature of the purchasing tasks. All models used a compound symmetry covariance matrix and specified *tax condition* as the repeated measure. In each model, variables included *tax condition*, *label condition*, and each of the 11 individual-level characteristics of interest to assess their main effects on the eight outcomes.

Interaction effects

Statistical tests for two-way interactions were used to assess whether any of the 11 individual-level variables moderated the effects of the sugar taxes or FOP labels on each of the eight nutrient outcomes. First, as a conservative test for inclusion, we tested two-way interactions for each of the 11 variables of interest separately in LMMs for each outcome of interest. All two-way interactions that were significant at $p < .05$ were added to the final model for each of the 8 nutrient outcomes. Final models also included variables for *tax condition, label condition,* and the 11 individual-level characteristics.

Financial regressivity

To investigate the potential financial regressivity of the sugar taxes tested, outcomes of *price paid* and *tax paid* were examined. First, mean values for *price paid* and *tax paid* were reported by tax condition and by level of reported income adequacy. Second, two separate LMMs (one for beverage purchases and one for snack food purchases) were fitted with *price paid* as the outcome, and another two with *tax paid* as the outcome. All LMMs specified tax condition as the repeated measure, used a compound symmetry covariance matrix, and included variables for *tax condition*, *label condition*, and the 11 individual-level characteristic variables, with *income adequacy* the key variable of interest.

4.4 Results

Individuals in the sample were 56.0% female, with a mean age of 32.9 years (standard deviation 16.3) (Table 1). Almost half (44.9%) identified as White, almost two-thirds (61.7%) had completed some university education, and 41.4% indicated it was neither easy nor difficult to make ends meet. Almost half (46.0%) were considered 'normal weight' based on self-reported heights and weights.

4.4.1 Main effects of individual-level variables

After adjustment for multiple comparisons, eight of the 11 individual-level variables showed a significant effect on at least one outcome of interest (Table 2). Overall, sex, age, hunger, *weekly SD consumption*, and reported *efforts to modify intake* demonstrated the most consistent association with nutrients purchased across the beverages and snack foods. Compared to females, males purchased beverages with more sodium and saturated fat, and snack foods with more sugars, saturated fats and calories. With increasing age, participants purchased beverages with less sodium and snack foods with less sugar and calories. Participants who reported being 'not at all' hungry at the time of the study purchased snack foods with less sodium, saturated fats and calories compared to those who reported being 'very' or 'extremely' hungry. As reported sugary drink consumption increased, participants purchased beverages with more sugars, sodium and calories, and snack foods with more sodium, saturated fat and calories. Lastly, compared to participants who reported no efforts to modify their intake, those who reported making an effort

to consume less sugars/added sugars or calories in the past year purchased beverages with less sugars and beverages and foods with fewer calories, respectively.

4.4.2 Interactions between individual-level variables and nutrition policies

Seven two-way interactions were identified as significant between the individual-level variables and *tax condition* (Figure 2). No significant interactions were identified with *label condition*, and no interactions were significant for the sodium or saturated fats outcomes. Full interaction results can be found in [Appendix D].

A two-way interaction was present between *sex* × *tax condition* for the amount of sugar purchased from beverages (Figure 2). In particular, female participants reduced their purchases of sugars from beverages to a greater extent in the *tiered SD* tax condition (vs. *no tax, 20% SSB*, and *tiered SSB*) than male participants. An interaction was also identified between *age* × *tax condition* for sugars purchased in the beverages: the negative association between age and sugars purchased was less pronounced when any of the four sugary beverage taxes were applied compared to when no tax was present.

Interactions between *sex* × *tax condition* and *age* × *tax condition* for calories purchased from beverages were similar to those for sugars. The *tiered SD* tax condition led to greater differences between male and female participants, in that female participants were more responsive to the tax; and the negative association between *age* and calories purchased was less pronounced for the four tax conditions compared to the no tax control. Participants' reported level of *thirst* also interacted with *tax condition* for calories purchased from beverages. Those who reported being 'slightly or moderately' thirsty reduced their purchases of calories from beverages to a greater extent in the *tiered SSB* tax condition (vs. *no tax*) than those who reported being 'not at all' thirsty.

Within the snack food purchases, two-way interactions were identified between *age* × *tax condition* for sugars purchased, and *education* × *tax condition* for calories purchased. Again, compared to *no tax*, the negative relationship between *age* and sugars purchased was less pronounced when either of the two sugary food taxes were present. In terms of *education*, participants reporting partial or complete university education reduced their purchases of calories

from snack foods to a greater extent in the *tiered* tax condition (vs. *no tax*) than those reporting a trade school/college education.

4.4.3 Financial regressivity of sugar taxes

Table 3 presents the mean *price paid* and *tax paid* by participants across tax conditions and by income adequacy level. In LMMs assessing *price paid* and *tax paid* as outcomes, *income adequacy* was a predictor of *price paid* in the snack food purchases: participants reporting lower income adequacy ('very difficult' or 'difficult' to make ends meet) purchased snack foods with slightly lower prices (-$0.04, 95% CI [-0.06, -0.01], p = .006) compared to those reporting a higher income adequacy ('easy' or 'very easy' to make ends meet). Income adequacy was not a significant predictor of *price paid* in the beverage purchases or of *tax paid* in the beverage or food purchases.

4.5 Discussion

Our findings shed light on whether purchasing of sugars, sodium, saturated fats and calories in beverages and snack foods differs across sociodemographic or health behaviour subgroups and whether these individual-level characteristics moderate the effects of sugar taxes and FOP labels on purchasing. The patterns of purchasing observed overall are consistent with research suggesting that younger, male individuals are more likely to consume higher amounts of negative nutrients compared to their female and older counterparts,[35,44,45] and that higher consumption of sugary drinks is often associated with other indicators of poor diet quality.[36,46–48] In this study, participants who were male, younger, and reported more frequent consumption of sugary drinks were more likely to purchase products containing higher amounts of the nutrients of concern. Additionally, in line with expectations, participants who reported trying to consume less of a nutrient in the past year were more likely to purchase products containing lower amounts of that nutrient.

Further, the findings suggest that a small number of sociodemographic and health behaviour characteristics play a moderating role on the relationship between the nutrition policies tested and the nutrient content of participants' purchases. Participants' *sex*, *age*, *education level* and reported *thirst* influenced purchases in response to the sugar taxes tested. In general, it appeared

that the taxes targeting sugary drinks (i.e., those including fruit juice) were more effective in reducing sugars and calories purchased among female participants than male participants. *Age* also demonstrated moderating effects: the sugary beverage taxes reduced purchasing of sugars and calories to a greater extent among younger participants compared to their older counterparts. As a result, the discrepancy in the amount of sugars and calories purchased between younger and older participants was reduced, although not eliminated, when the taxes were present. Young shoppers are a key target group for population-level nutrition interventions due to their high consumption of nutrients of concern,[44,45,49] and their strong response to the taxes may suggest an important advantage of these policies for reaching this group. Participants' *education* moderated the effect of tax on the calorie content of their snack purchases: when no tax was present, university-educated participants purchased products with more calories on average than participants with a trade school education; however, when the tiered sugary food tax was in place, this relationship was reversed. Participants' reported level of *thirst* also emerged as a significant moderating effect on the number of calories purchased from beverages. No moderating effects were identified for the FOP labelling conditions in this study. This may be due, in part, to the between-subject nature of the FOP labelling conditions and the resulting limited statistical power.

No interactions were observed between the policies tested and key variables of interest—such as income and health literacy—that are often a focus when assessing the equity of population-wide nutrition policies. The absence of such moderating effects suggests that the effects of the taxes and FOP labels were consistent regardless of participants' income adequacy or health literacy status. Income is a key variable of interest—particularly in discussions of sugar taxation policies—due to the potential for financially regressive effects, even when the health effects may be progressive.[12,50] Interestingly, models assessing *price paid* identified that participants with lower income adequacy purchased snack food products with slightly lower prices than those with higher income adequacy, with no differences in *tax paid*. The extent to which these data reflect actual financial consequences of sugar taxes in the real world is limited by the controlled nature of the study: participants were required to purchase a product, which disregards an important possible response to taxation (that is, to not purchase a product at all). The results, nevertheless, are provocative in the context of existing literature suggesting regressive effects.[12]

Ideally, given evidence of poorer dietary intake among low SES and low literacy groups,[51] nutrition policies should aim to produce greater impacts among these populations to reverse existing inequities. Given that many existing nutrition and obesity interventions have proven to be less effective for low SES and low literacy individuals,[52,53] the consistency of the sugar taxes and FOP labels across groups in this study supports these policies as a strong starting point for promoting equity. With increasing interest in taxes for both sugary beverages and foods,[54] the equity of these policies will be an important area for further investigation. It should also be noted that this study did not consider the policies' influence on other broader outcomes, such as individuals' relationships with foods. For example, labelling and taxation have the potential to stigmatize certain foods and beverages, including those most accessible to populations with lower SES. Such possible unintended consequences of these policies, beyond financial regressivity, warrant attention in the interest of promoting overall healthy eating and well-being among populations.

Several limitations of the current study should be noted. Non-probability recruitment methods were used, which limit the representativeness of the sample to the larger Canadian population; however, the study sample provided good variability across sociodemographic and health behaviour characteristics. An experimental marketplace design was used to replicate genuine purchasing behaviours; however, it may not represent how consumers interact with price and labels in real world settings, in which other unmeasured influences may come into play. In addition, participants did not spend their own money, which may have generated more carefree purchases. Both policy measures tested were presented to participants without any description or explanation. Subsequently, the impact of the policies (and the potential to detect any moderating effects) may be diminished in comparison to real-world conditions in which consumers may be more likely to be aware of a tax or FOP labelling system. Our analysis exploring price paid and tax paid was intended to provide additional insight into how income level may influence the way consumers respond to taxes, but these data may not be directly applicable to real-world financial outcomes of sugar taxes. Although our study featured purchases with real money and real financial consequences, results must be interpreted in the context of the controlled nature of the purchases and the limited range of products available for purchase. Despite these limitations, results from the current study provide important evidence on the consistency of the effects of sugar tax and labelling policies across key subpopulations and can be used in conjunction with

other types of data—such as real-world evidence from other jurisdictions—to inform future policy.

4.5.1 Conclusions

The current study identified several individual-level characteristics that may moderate the effects of sugar tax and FOP labelling policies; however, the policies' effects were largely consistent across subgroups, including key socioeconomic indicators such as income and health literacy. In particular, the FOP nutrition labels tested showed uniform effects across all subgroups, suggesting that their impacts on consumer purchases are likely to be consistent regardless of an individual's literacy skills or education level. As more countries adopt sugar taxes and FOP labelling systems, it is ever more important to ensure these policies are producing effects that do not exacerbate—and preferably improve—existing health and economic disparities across populations.

Table 1. Sociodemographic and health behaviour characteristics of sample participating in an experimental marketplace (N=3,584)

Characteristic	%
Sex	
Female	56.0
Male	44.0
Age	
Mean = 32.9 years (s.d. 16.3)	
13-18	15.3
19-25	31.0
26-35	20.6
36-45	11.9
>45	21.3
Hunger	
"Not at all hungry"	26.4
"Slightly hungry" or "moderately hungry"	61.7
"Very hungry" or "extremely hungry"	11.9
Thirst	
"Not at all thirsty"	10.0
"Slightly thirsty" or "moderately thirsty"	68.4
"Very thirsty" or "extremely thirsty"	21.7
Weekly sugary drink consumption	
Mean = 4.0 sugary drinks (s.d. 5.3)	
0	20.6
1-3	36.4
4-7	23.0
8-14	8.9
>14	3.7
Don't know	7.3
Efforts to modify intake ('Have you made an effort to consume more or less of the following in the past year?')	
Calories	
"Consume less"	54.9
"Consume more"	10.4
"No effort made" or "don't know"	34.7
Saturated fat	
"Consume less"	54.7
"Consume more"	4.2
"No effort made" or "don't know"	41.2
Sugar/added sugar	
"Consume less"	70.5
"Consume more"	3.5
"No effort made" or "don't know"	26.0
Salt/sodium	
"Consume less"	50.1
"Consume more"	3.7
"No effort made" or "don't know"	46.2

Health literacy (NVS score)	
High likelihood of limited literacy (0-1)	19.2
Possibility of limited literacy (2-3)	27.0
Adequate literacy (4-6)	53.9
Ethnicity	
White	44.9
Other, mixed, not stated	51.8
Indigenous	3.3
Education	
High school or less	26.6
CEGEP/Trade School/College (partial or complete)	11.7
University (partial or complete)	61.7
Income adequacy ('Thinking about your total monthly income, how difficult or easy is it for you to make ends meet?')	
'Very difficult' or 'Difficult'	19.5
'Neither easy nor difficult'	41.4
'Easy' or 'Very easy'	39.1
BMI classification	
Underweight	3.3
Normal weight	46.0
Overweight	22.8
Obesity	12.1
Not reported	15.8

BMI, body mass index; CEGEP, Collège d'enseignement général et professionnel (general and vocational college); NVS, Newest Vital Sign; s.d., standard deviation

Table 2. Main effects of 11 individual-level characteristics on the amounts of sugars, sodium, saturated fats and calories purchased in beverages and snack foods in an experimental marketplace (N=3,584).

	Beverage purchases								Snack food purchases							
	Sugars (g)		*Sodium (mg)*		*Saturated fat (g)*		*Calories (kcal)*		*Sugars (g)*		*Sodium (mg)*		*Saturated fat (g)*		*Calories (kcal)*	
	β (95% CI)	*p*	β (95% CI)	*p*	β (95% CI)	*p*	β (95% CI)	*p*	β (95% CI)	*p*	β (95% CI)	*p*	β (95% CI)	*p*	β (95% CI)	*p*
Sex																
Male	1.09 (-0.22, 2.40)	.10	20.48 (15.86, 25.09)	<.0001†	0.08 (0.02, 0.14)	.009†	5.77 (0.25, 11.29)	.04	2.61 (2.01, 3.22)	<.0001†	-0.09 (-8.88, 8.71)	.98	0.21 (0.12, 0.30)	<.0001†	13.84 (8.23, 19.45)	<.0001†
Female*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Age	-0.06 (-0.10, -0.01)	.01	-0.25 (-0.41, -0.09)	.002†	0.01 (-0.01, 0.01)	.07	-0.12 (-0.31, 0.06)	.19	-0.06 (-0.08, -0.03)	<.0001†	-0.38 (-0.68, -0.08)	.01	-0.01 (-0.01, 0.01)	.13	-0.33 (-0.52, -0.14)	.001†
Hunger																
Not at all	-0.52 (-2.83, 1.80)	.66	-7.87 (-16.05, 0.31)	.06	-0.07 (-0.17, 0.03)	.16	-3.33 (-12.90, 6.24)	.50	0.42 (-0.65, 1.50)	.44	-28.65 (-44.24, -13.07)	<.001†	-0.30 (-0.46, -0.13)	<.001†	-13.72 (-23.44, -4.00)	.006†
Slightly or moderately	0.54 (-1.50, 2.58)	.61	-0.87 (-8.08, 6.34)	.81	-0.01 (-0.09, 0.09)	.98	3.46 (-4.98, 11.90)	.42	-0.43 (-1.38, 0.52)	.37	-15.24 (-28.97, -1.51)	.03	-0.23 (-0.38, -0.09)	.002†	-9.31 (-17.88, -0.74)	.03
Very or extremely*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Thirst																
Not at all	-0.64 (-3.17, 1.89)	.62	1.28 (-7.66, 10.22)	.78	0.19 (0.08, 0.30)	.001†	3.90 (-6.57, 14.37)	.47	-0.14 (-1.31, 1.04)	.82	-11.35 (-28.37, 5.68)	.19	-0.10 (-0.28, 0.08)	.26	-12.48 (-23.11, -1.86)	.02
Slightly or moderately	-1.04 (-2.62, 0.54)	.20	0.85 (-4.72, 6.43)	.76	0.10 (0.03, 0.17)	.006†	-1.09 (-7.62, 5.45)	.74	-0.40 (-1.14, 0.33)	.28	8.18 (-2.45, 18.80)	.13	0.07 (-0.04, 0.18)	.22	1.15 (-5.48, 7.78)	.73
Very or extremely*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Weekly SD consumption	0.64 (0.51, 0.76)	<.0001†	1.07 (0.64, 1.51)	<.0001†	0.01 (-0.01, 0.01)	.39	2.62 (2.11, 3.13)	<.0001†	-0.01 (-0.06, 0.06)	.95	2.06 (1.23, 2.89)	<.0001†	0.01 (0.01, 0.02)	.001†	0.93 (0.41, 1.45)	<.001†
Efforts to modify intake‡																
Consume less	-4.30 (-5.79, -2.81)	<.0001†	-1.76 (-6.40, 2.88)	.46	-0.02 (-0.08, 0.04)	.49	-18.29 (-24.10, -12.48)	<.0001†	-0.87 (-1.56, -0.18)	.01	-10.89 (-19.73, -2.05)	.02	-0.08 (-0.18, 0.01)	.09	-8.73 (-14.62, -2.83)	.004†
Consume more	1.60 (-2.38, 5.59)	.43	4.57 (-7.80, 16.95)	.47	-0.04 (-0.19, 0.11)	.62	-7.08 (-16.71, 2.55)	.15	0.50 (-1.35, 2.35)	.60	-10.08 (-33.65, 13.49)	.40	-0.06 (-0.30, 0.19)	.65	-8.71 (-18.48, 1.07)	.08
No effort made*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Health literacy																
High likelihood of limited literacy	1.02 (-0.90, 2.90)	.29	-5.93 (-12.59, 0.74)	.08	-0.10 (-0.18, -0.01)	.02	4.15 (-3.61, 11.90)	.29	0.60 (-0.27, 1.48)	.18	7.33 (-5.37, 20.02)	.26	0.19 (0.06, 0.33)	.005†	5.71 (-2.16, 13.58)	.16
Possibility of limited literacy	1.19 (-0.30, 2.69)	.12	-0.76 (-6.06, 4.54)	.78	-0.01 (-0.07, 0.06)	.87	5.60 (-0.58, 11.78)	.08	0.31 (-0.38, 1.01)	.38	2.60 (-7.50, 12.69)	.61	0.09 (-0.01, 0.20)	.08	1.67 (-4.60, 7.94)	.60
Adequate literacy*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ethnicity																
White	-3.66 (-7.54, 0.22)	.07	-4.95 (-18.66, 8.75)	.48	-0.06 (-0.24, 0.11)	.46	-19.18 (-35.22, -3.14)	.02	0.10 (-1.70, 1.90)	.91	-6.90 (-33.01, 19.21)	.60	-0.09 (-0.36, 0.19)	.54	-5.53 (-21.82, 10.75)	.51
Other, mixed, not stated	0.33	.87	-6.17	.38	-0.12	.16	-3.84	.64	-0.20	.83	-8.18	.54	-0.08	.57	-7.36	.38

	(-3.54, 4.20)		(-19.84, 7.51)		(-0.29, 0.05)		(-19.54, 12.16)		(-2.00, 1.60)		(-34.23, 17.87)		(-0.36, 0.19)		(-23.60, 8.89)	
Indigenous*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Education																
High school or less	0.58	.49	-1.14	.70	-0.02	.67	0.56	.87	0.26	.49	13.53	.02	0.01	.88	4.68	.18
	(-1.04, 2.20)		(-6.87, 4.59)		(-0.09, 0.06)		(-6.15, 7.27)		(-0.49, 1.02)		(2.62, 24.44)		(-0.11, 0.12)		(-2.13, 11.50)	
CEGEP/Trade School/College	-0.52	.62	-2.96	.42	0.01	.84	-1.92	.66	0.31	.53	0.07	.99	0.04	.56	3.96	.37
	(-2.57, 1.53)		(-10.20, 4.28)		(-0.08, 0.10)		(-10.42, 6.57)		(-0.64, 1.26)		(-13.72, 13.85)		(-0.10, 0.19)		(-4.66, 12.58)	
University*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Income adequacy																
Very difficult or difficult	-0.28	.76	-4.25	.19	0.01	.80	-0.68	.86	-0.59	.17	-4.41	.48	-0.02	.74	-10.26	.008†
	(-2.08, 1.52)		(-10.61, 2.11)		(-0.07, 0.09)		(-8.13, 6.78)		(-1.42, 0.25)		(-16.53, 7.71)		(-0.15, 0.11)		(-17.83, -2.70)	
Neither easy nor difficult	-0.38	.60	-0.54	.83	0.04	.27	-0.23	.94	-0.42	.22	-2.05	.68	-0.05	.33	-4.10	.18
	(-1.80, 1.04)		(-5.56, 4.47)		(-0.03, 0.10)		(-6.11, 5.65)		(-1.07, 0.24)		(-11.60, 7.51)		(-0.15, 0.05)		(-10.07, 1.86)	
Easy or very easy*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
BMI classification																
Underweight	2.57	.20	5.04	.48	0.13	.13	11.15	.18	-1.27	.17	0.45	.97	-0.18	.21	-9.86	.24
	(-1.35, 6.50)		(-8.84, 18.92)		(-0.04, 0.31)		(-5.15, 27.44)		(-3.09, 0.56)		(-25.99, 26.89)		(-0.46, 0.10)		(-26.40, 6.68)	
Normal weight	-0.41	.70	5.39	.14	0.09	.04	1.59	.71	0.37	.44	-6.00	.39	-0.04	.59	-1.84	.67
	(-2.43, 1.62)		(-1.78, 12.55)		(0.01, 0.18)		(-6.81, 9.98)		(-0.57, 1.31)		(-19.64, 7.64)		(-0.18, 0.11)		(-10.36, 6.68)	
Overweight	-1.32	.25	6.17	.13	0.05	.37	-2.12	.66	0.22	.68	-7.50	.33	-0.11	.16	-3.58	.46
	(-3.57, 0.94)		(-1.80, 14.14)		(-0.05, 0.14)		(-11.45, 7.21)		(-0.83, 1.27)		(-22.67, 7.67)		(-0.28, 0.05)		(-13.06, 5.89)	
Obese	-2.54	.05	3.35	.47	0.02	.77	-8.46	.12	-0.70	.25	3.45	.70	0.07	.48	-6.56	.24
	(-5.11, 0.04)		(-5.75, 12.44)		(-0.10, 0.13)		(-19.12, 2.21)		(-1.89, 0.50)		(-13.88, 20.78)		(-0.12, 0.25)		(-17.38, 4.26)	
Not reported*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

*Reference category
†Significant following a Benjamini-Hochberg adjustment assuming a false discovery rate of 0.05
BMI, body mass index; CI, confidence interval; SD, sugary drink.

Table 3. Mean price paid and tax paid in an experimental marketplace, by participant income adequacy level and by tax condition.

Income adequacy level	Tax condition	Mean price paid (s.d.)	Mean tax paid (s.d.)
BEVERAGE PURCHASES			
'Very difficult' or 'Difficult'	No tax	$2.33 (0.42)	--
	20% SSB tax	$2.50 (0.57)	$0.19 (0.24)
	20% SD tax	$2.49 (0.60)	$0.22 (0.25)
	Tiered SSB tax	$2.46 (0.55)	$0.16 (0.22)
	Tiered SD tax	$2.49 (0.57)	$0.21 (0.23)
'Neither easy nor difficult'	No tax	$2.33 (0.41)	--
	20% SSB tax	$2.49 (0.56)	$0.19 (0.24)
	20% SD tax	$2.51 (0.60)	$0.23 (0.25)
	Tiered SSB tax	$2.49 (0.53)	$0.17 (0.22)
	Tiered SD tax	$2.51 (0.57)	$0.21 (0.23)
'Easy' or 'Very easy'	No tax	$2.30 (0.42)	--
	20% SSB tax	$2.48 (0.56)	$0.18 (0.24)
	20% SD tax	$2.50 (0.58)	$0.22 (0.25)
	Tiered SSB tax	$2.47 (0.53)	$0.17 (0.22)
	Tiered SD tax	$2.49 (0.57)	$0.20 (0.23)
SNACK FOOD PURCHASES			
'Very difficult' or 'Difficult'	No tax	$1.27 (0.27)	--
	20% tax	$1.30 (0.31)	$0.06 (0.11)
	Tiered tax	$1.32 (0.31)	$0.06 (0.11)
'Neither easy nor difficult'	No tax	$1.29 (0.28)	--
	20% tax	$1.34 (0.32)	$0.06 (0.12)
	Tiered tax	$1.34 (0.32)	$0.06 (0.12)
'Easy' or 'Very easy'	No tax	$1.28 (0.29)	--
	20% tax	$1.34 (0.33)	$0.07 (0.12)
	Tiered tax	$1.34 (0.34)	$0.07 (0.12)

s.d., standard deviation; SSB, sugar-sweetened beverage; SD, sugary drink.

Figure 1. Sample images of front-of-pack nutrition labelling conditions (excluding a *no label* control), applied to beverage and snack food products in an experimental marketplace. Clockwise from top left: *high in*, *health star rating*, *nutrition grade*, *multiple traffic light.*

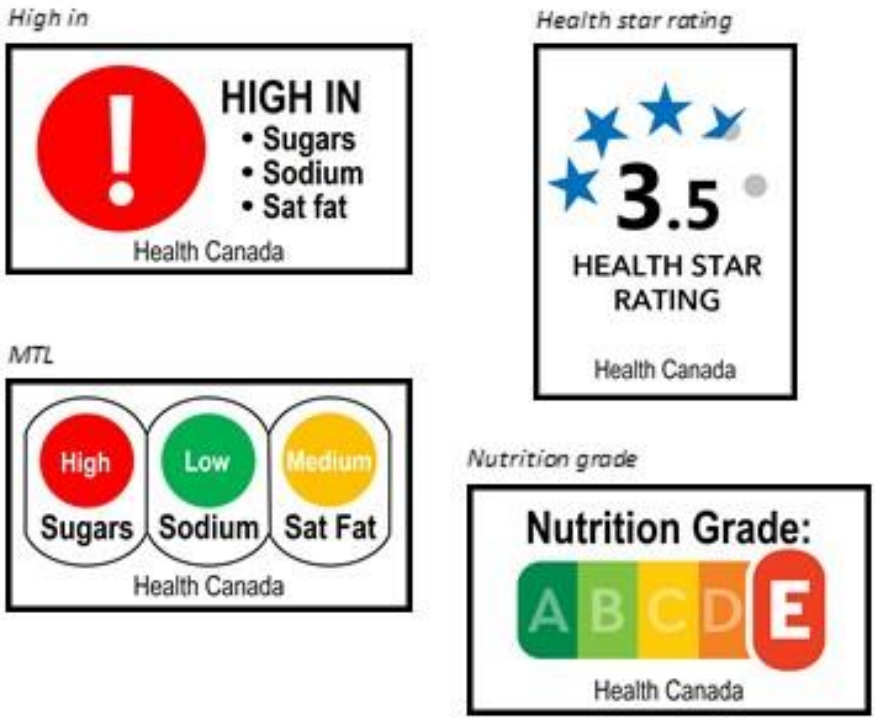
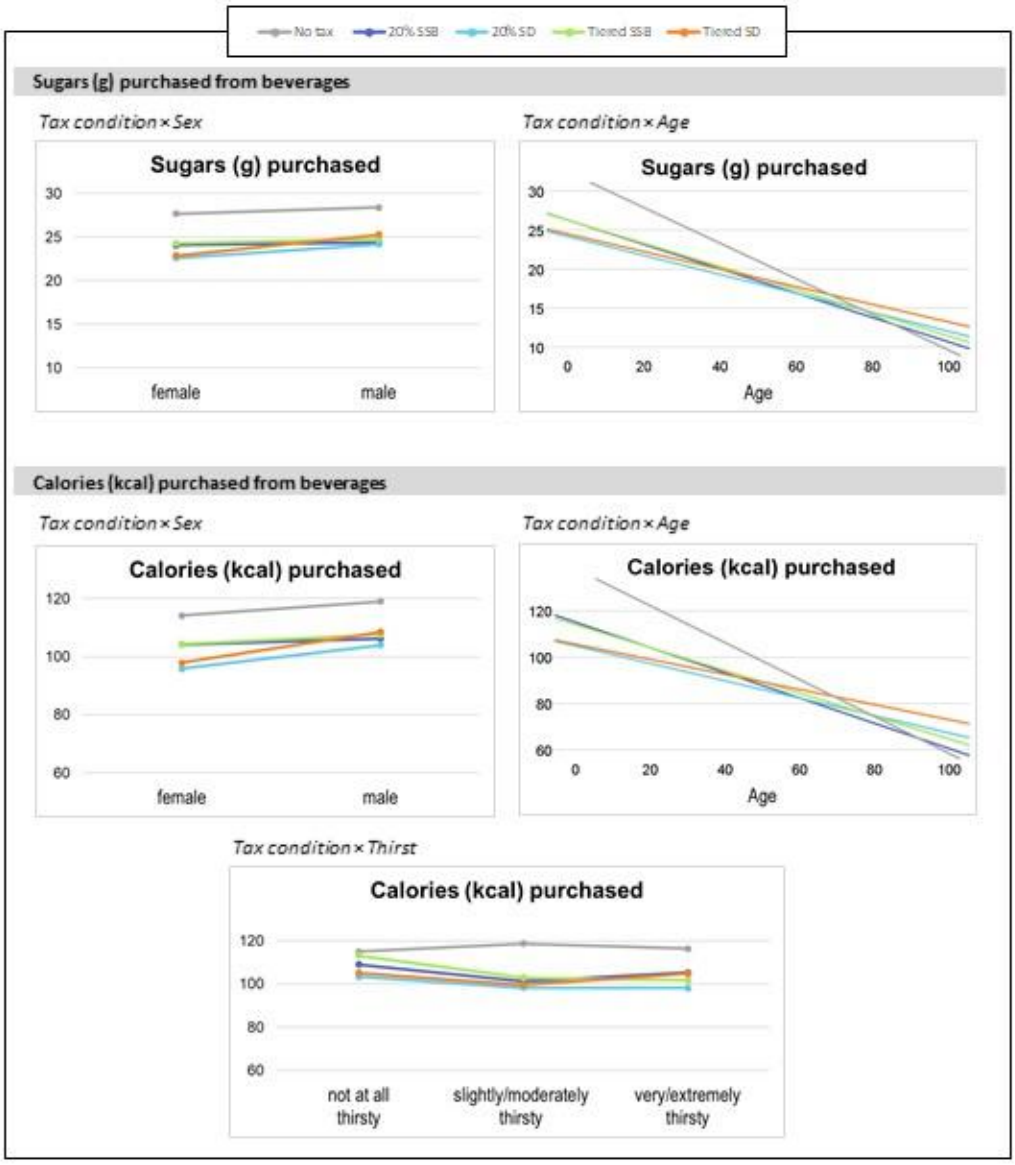
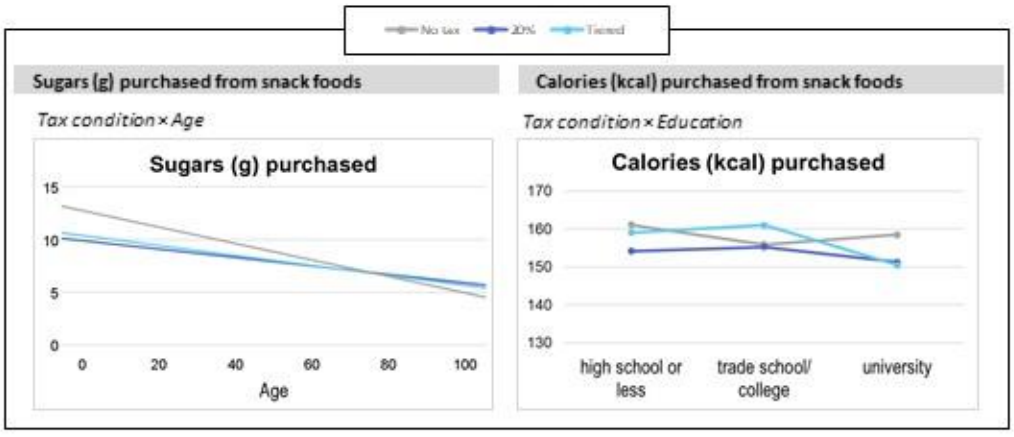


Figure 2. Graphical representation* of two-way interactions between individual-level characteristics and tax condition for sugars and calories purchased in beverages and snack foods in an experimental marketplace.





*Values presented for categorical variables (sex, thirst, education) are estimated marginal means. Values for continuous variables (age) represent lines of best fit for predicted values derived from the associated linear mixed model.

Chapter 5: Comparing the effects of four front-of-package nutrition labels on consumer purchases of five common beverages and snack foods

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Authors: Rachel B Acton BSc[1], Sharon I Kirkpatrick PhD[1], David Hammond PhD[1]

[1] School of Public Health & Health Systems, University of Waterloo, 200 University Ave. W., Waterloo, ON Canada N2L 3G1

5.1 Overview

Objective: Front-of-package (FOP) nutrition labelling systems differ in how they rate and assess food and beverage products, including their focus on 'negative' versus 'positive' nutrients. This study examined the impact of four common FOP labels on consumers' purchases of product categories that received conflicting ratings across FOP systems.

Design: This study used data from an experimental marketplace. Participants were randomly assigned to complete a series of purchases in which products displayed one of five FOP conditions: No label, High in nutrient label, multiple traffic light (MTL), health star rating (HSR), or Nutrition grade. This analysis compared the impact of each label condition on purchases of 100% fruit juice, white milk, chocolate milk, cheese snacks, and diet beverages.

Setting: Shopping centres in three Canadian cities (Toronto, Kitchener, Waterloo).

Participants: Canadians aged 13 years and older (n=1,990) who reported noticing the FOP labels following the purchasing task.

Results: Participants who saw the HSR were more likely to purchase 100% fruit juice (compared to MTL) and cheese snacks (compared to No label and High in). The High in label led to fewer purchases of white milk and chocolate milk compared to No label. Diet beverage purchases were higher in all FOP conditions relative to No label.

Conclusions: Despite some similarities, existing FOP systems differ in the extent to which they promote or dissuade five common product categories. While the HSR may encourage products with certain positive nutritional attributes, High in and MTL systems may more effectively discourage purchases of products contributing negative nutrients.

Keywords: nutrition labels; front-of-package labels; nutrition policy; food policy; experimental marketplace

5.2 Introduction

An increasing number of jurisdictions are implementing front-of-package (FOP) nutrition labelling systems, which provide simple nutrition information—often in the form of symbols or ratings—on pre-packaged foods and beverages.[1,2] A growing body of evidence suggests FOP labelling strategies, as part of a comprehensive approach, may improve dietary intake; however, research investigating nuances among different FOP labelling systems is nascent.[2–4]

Examples of FOP labelling systems implemented to date include nutrient-specific systems, such as the multiple traffic light (MTL) system used in the UK or Chile's mandatory *alto en* ('high in') warning symbols, as well as summary indicator systems such as the Australasian Health Star Rating (HSR) and France's Nutri-Score letter grading system.[2] Similar systems have been proposed in other countries, including a mandatory 'high in' nutrient label for sugars, sodium and saturated fats in Canada.[5] Given the variety of FOP labelling systems, questions remain as to how they may uniquely influence consumer behaviour. For example, 100% fruit juice products and higher fat or sugary dairy products receive high healthfulness ratings from the HSR system due to their fruit and vegetable or dairy content, but the same products would have a 'high in' warning or red traffic light in the systems that emphasize sugar, saturated fat, and sodium content. Similarly, diet beverages are assigned relatively poor ratings under the HSR scheme, but receive either no 'high in' symbols or three green traffic lights under the nutrient-specific systems. Research comparing FOP labels suggests that different systems often elicit different behaviours and that some may be better suited for certain policy objectives than others;[1,2,6] however, it remains unclear how consumers' purchases of the products noted above might vary across FOP systems.

The current analysis leveraged data from a large experimental marketplace conducted with Canadian youth and adults. Previously published findings indicated that a 'high in' FOP symbol led to purchases of beverages with lower levels of sugars, saturated fats and calories, and snack foods with less sodium and calories compared to no FOP[7], without compromising the levels of positive nutrients (protein, calcium, fibre) purchased.[8] Here, we examined differences between the FOP systems for the subset of products that receive 'positive' ratings under one FOP system, but 'negative' ratings under another. These included 100% fruit juice, milk, cheese and diet beverages.

5.3 Methods

5.3.1 Study design

Data were drawn from an experimental marketplace study conducted in March to May 2018.[7] Participants aged 13 years and older were recruited using convenience sampling from three shopping centres in Ontario, Canada. Participants completed eight consecutive tasks in which they were provided with $5 to make a purchase from a selection of 20 beverages or 20 snack food products, which were presented on large print-outs resembling a grocery or convenience store shelf. Participants were randomly assigned to one of five FOP conditions: *No label* (control); a *High in* warning system labelling foods high in sugars, sodium or saturated fats; a multiple traffic light (*MTL*) system for sugars, sodium and saturated fats; a health star rating (*HSR*) label; or a five-colour *Nutrition grade* label. Labels corresponding to each of the products are presented in [Appendix C, Table C1]. The randomly assigned labelling system was displayed accordingly on the beverage and snack food images throughout all eight tasks, without additional educational materials or explanation. Following the purchasing tasks and using an iPad, participants completed a series of survey questions about their sociodemographic characteristics and health behaviours. Participants then received the selected beverage or snack food product from one of the eight purchasing tasks and their change from the $5. Participants did not know which purchase they would receive until the end of the experiment and were instructed to treat all eight tasks as actual purchases.

The current analysis was restricted to participants who reported noticing the FOP nutrition labels in their assigned condition (for those assigned to *High in*, *MTL*, *HSR*, or *Nutrition grade*) or not noticing a FOP nutrition label (for those assigned to *No label*) following the purchasing task. This analytic decision was made to increase the likelihood that observed responses were a result of the FOP labels. As reported previously, 51.5% (1,473) of the 2,858 participants assigned to view products with a FOP label reported noticing the labels, and 71.2% (517) of the 726 participants assigned to *No label* responded that they did not notice any nutrition symbols or labels on the packages.[7] These participants (n=1,990) thus made up the sample for the analysis described here. Participants in these two subsamples differed significantly by age and frequency

of sugary beverage consumption. Therefore, all models included variables for 'age' and 'sugary beverage frequency' to control for differences between the subsamples.

Results from analyses on the full sample are available in [Appendix E, Figure E1]. Compared to all participants, the subset who noticed the FOP labels had a slightly higher proportion of 19 to 35-year-olds and fewer older participants, and they reported consuming slightly more sugary drinks in the past week (Table 1).

5.3.2 Outcome variables

A series of binary outcomes (1=purchased, 0=not purchased) were defined to assess the probability of participants purchasing a beverage or snack food from five product categories: '100% fruit juice', 'white milk', 'chocolate milk', 'cheese snacks', and 'diet beverages'. These categories, detailed in Table 2, were targeted because the 'healthfulness' messages communicated were contradictory across the four FOP label conditions tested. In particular, the 100% fruit juice beverages, white milk, chocolate milk, and cheese snacks received high healthfulness ratings from *HSR* (4-5 stars) and *Nutrition grade* ('A' or 'B'), whereas the same products were characterized by at least one 'high' or 'red' nutrient of concern under the *High in* and *MTL* conditions. Similarly, diet beverages were assigned poor ratings by *HSR* (2 stars) and *Nutrition grade* ('D'), whereas under the *High in* and *MTL* conditions, the same products were assigned no *High in* label or three green *MTL* lights. Overall, the summary indicator FOP labels (*HSR, Nutrition grade*) were hypothesized to elicit more purchases of fruit juice, milk beverages, and cheese snacks, and fewer purchases of diet beverages compared to the nutrient-specific FOP labels (*High in, MTL*).

5.3.3 Analyses

Separate generalized linear mixed models (GLMMs) were used to estimate the influence of *label condition* on each of the binary outcomes outlined above.

5.4 Results

Table 1 presents characteristics of the total sample, as well as the subsample of participants who reported noticing the FOP labels.

5.4.1 Effect of FOP labels on purchasing of product categories

Results from the GLMMs revealed some differences in purchasing of the key product categories of interest across the labeling conditions (Figure 1). Among participants who noticed the FOP labels, those assigned to view *MTL* labels were 4.5 (95% CI –7.2, –1.8; $p = .001$), 3.6 (95% CI –6.3, –1.0; $p = .007$), and 2.5 (95% CI –4.8, –0.2; $p = .032$) percentage points (pp) less likely to purchase a 100% fruit juice product compared to participants who viewed the *HSR*, *Nutrition grade*, and *No label*, respectively. Participants who viewed products with *No label* were 5.0 pp more likely to purchase chocolate milk (95% CI 1.6, 8.5; $p = .004$) than participants who saw products with the *High in* label. Participants who saw products with the *HSR* labels, which labelled cheese snacks with 5 stars, were 3.9 (95% CI 0.9, 7.0; $p = .012$) and 3.4 (95% CI 0.2, 6.7; $p = .039$) pp more likely to purchase these snacks than the *No label* and *High in* conditions, respectively. Lastly, those assigned to the *No label* condition were 7.5 (95% CI –11.8, –3.2; $p = .001$), 7.2 (95% CI –11.9, –2.6; $p = .002$), and 5.4 (95% CI –9.7, –1.1; $p = .015$) pp less likely to purchase a diet beverage compared to those who saw the products labelled with the *High in*, *MTL*, or *HSR* symbols, respectively.

5.5 Discussion

Overall, differences in purchases between the nutrient-specific and summary indicator FOP conditions were inconsistent; however, some patterns emerged. Presumably due to the high star ratings displayed on these products, exposure to the *HSR* condition led to more purchases of 100% fruit juice (compared to the *MTL*) and cheese snacks (compared to *No label* and *High in*). The high star ratings assigned to 100% fruit juice products in particular have been raised as a key criticism of Australia's FOP system due to the high sugar content found in these products,[9,10] and in the system's five-year review this was cited as a recommended area for improvement to more clearly distinguish water and other low-calorie beverages from high calorie drinks.[11]
Interestingly, the *HSR* condition did not have the same effect on 4.5-star rated 2% white milk products. It is possible that the 4.5-star rating, while seemingly high on its own, was a deterrent to participants when observed in the context of other 5-star rated beverages such as water or fruit juice.

Results for the *High in* labels provide some insight into the potential effects of similar FOP labels proposed in Canada. Those exposed to *High in* labels were less likely to purchase 1% MF chocolate milk (compared to *No label*), and cheese snacks (compared to *HSR*); both of these products displayed at least one 'high' nutrient of concern. Raw purchase data for all 20 beverages and 20 snack food products [Appendix E, Table E1] suggest that participants in the *High in* condition purchased fewer products contributing 'high' nutrients of concern overall compared to those in the *No label* condition, and to a lesser extent compared to *HSR*. These results are consistent with evidence from several recent studies, which suggest that nutrient warning labels discourage product selection.[12–20]

Some of the most substantial differences were seen in the diet beverage category; however, only with respect to the *No label* control. Diet beverages—which were rated relatively poorly by the *HSR* and *Nutrition grade*, but displayed no *High in* labels and three green traffic lights under the *MTL* condition—were purchased more frequently in all of the FOP label conditions relative to *No label*. It is likely that the higher levels of diet beverage purchases compared to the control condition were driven by participants shifting away from the other high-sugar beverages that displayed the poorest ratings, as reflected in the raw purchase data presented in [Appendix E, Table E1]. Given current disagreement and limited evidence on the recommended intake of artificially sweetened beverages,[21,22] the potential for consumers to substitute this product category for others should be a key consideration for policymakers implementing a FOP system.

Collectively, the results reinforce previous research suggesting that different FOP labelling systems may be better for certain policy goals than others.[1,2,6] As expected, our analyses suggest that 'high in' nutrient labels may be better at discouraging consumption of products containing high levels of nutrients of concern, such as fruit juice or sugary milk beverages, two of the most frequently consumed beverages and top contributors to sugar and calorie consumption in Canada.[23] In contrast, a summary indicator system such as Australia's HSR may be less likely to deter purchases of such products, particularly if fruit or dairy content are valued highly in their rating algorithms. Results from previous analyses of this experimental marketplace also suggest that the summary indicator systems were no better at encouraging purchases of protein, calcium or fibre from snack foods compared to the nutrient-specific labels.[8]

Strengths of the current study include the between-subject experimental design and the use of real products and actual monetary exchange in the purchase tasks. Limitations include the use of a convenience sample, which limits the sample's representativeness of the larger Canadian population; however, the sample provided good variability across sociodemographic characteristics and health behaviours. The product categories assessed are important given their conflicting ratings across FOP systems, but they represent only a small portion of the broader food supply. In particular, the current study did not include a low-fat, unsweetened milk beverage option, and therefore omitted a key beverage alternative that would have displayed no 'high in' symbols or red traffic lights. Additionally, it is likely that some participants may have reported noticing the FOP labels when they didn't, and vice versa.

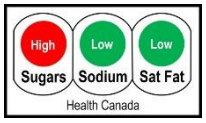
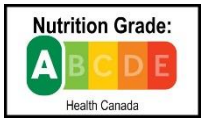
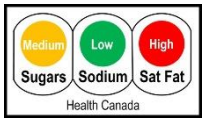
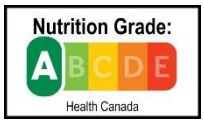
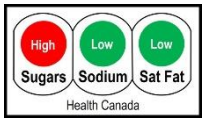
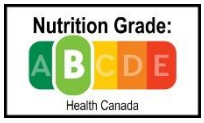
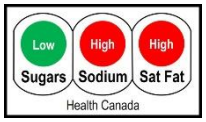
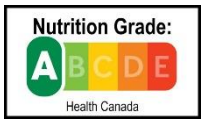
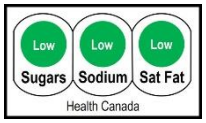
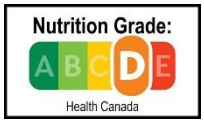
Overall, this brief analysis suggests that despite some similarities, existing FOP systems differ in the extent to which they promote or dissuade key food categories, such as 100% fruit juice or dairy products. While a star rating system may encourage purchases of products with certain positive nutritional attributes, a 'high in' or MTL system may be more effective at discouraging purchases of products containing excess negative nutrients.

Table 1. Sociodemographic characteristics of total sample and participants who reported noticing FOP nutrition labels, with test results for differences between the samples

Characteristic	Total sample (n=3548) %	Participants who noticed FOP labels* (n=1990) %	Test for differences χ^2
Age (years)			
13-18	15.3	15.6	
19-25	31.0	32.6	
26-35	20.6	22.6	35.5
36-45	11.9	10.8	(*p*<.0001)
>45	21.3	18.4	
Sex			
Male	44.0	44.2	0.1
Female	56.0	55.8	(*p*=.792)
Weekly sugary beverage frequency (past week)			
0	22.3	20.0	
1-3	39.4	41.8	
4-7	24.9	24.6	16.2
8-14	9.6	9.7	(*p*=.003)
>14	3.8	3.9	
Ethnicity			
White	44.9	44.7	
Other, mixed, not stated	51.8	52.2	0.4
Indigenous	3.3	3.1	(*p*=.810)
Education			
High school or less	26.6	26.7	
CEGEP/Trade School/College (partial or complete)	11.7	12.0	0.5
University (partial or complete)	61.7	61.3	(*p*=.796)
Income adequacy			
'Very difficult' or 'Difficult'	19.5	19.6	
'Neither easy nor difficult'	41.4	41.8	0.3
'Easy' or 'Very easy'	39.1	38.6	(*p*=.850)
BMI classification			
Underweight	3.3	3.2	
Normal weight	46.0	46.4	
Overweight	22.8	22.8	3.7
Obesity	12.1	12.6	(*p*=.444)
Not reported	15.8	14.9	

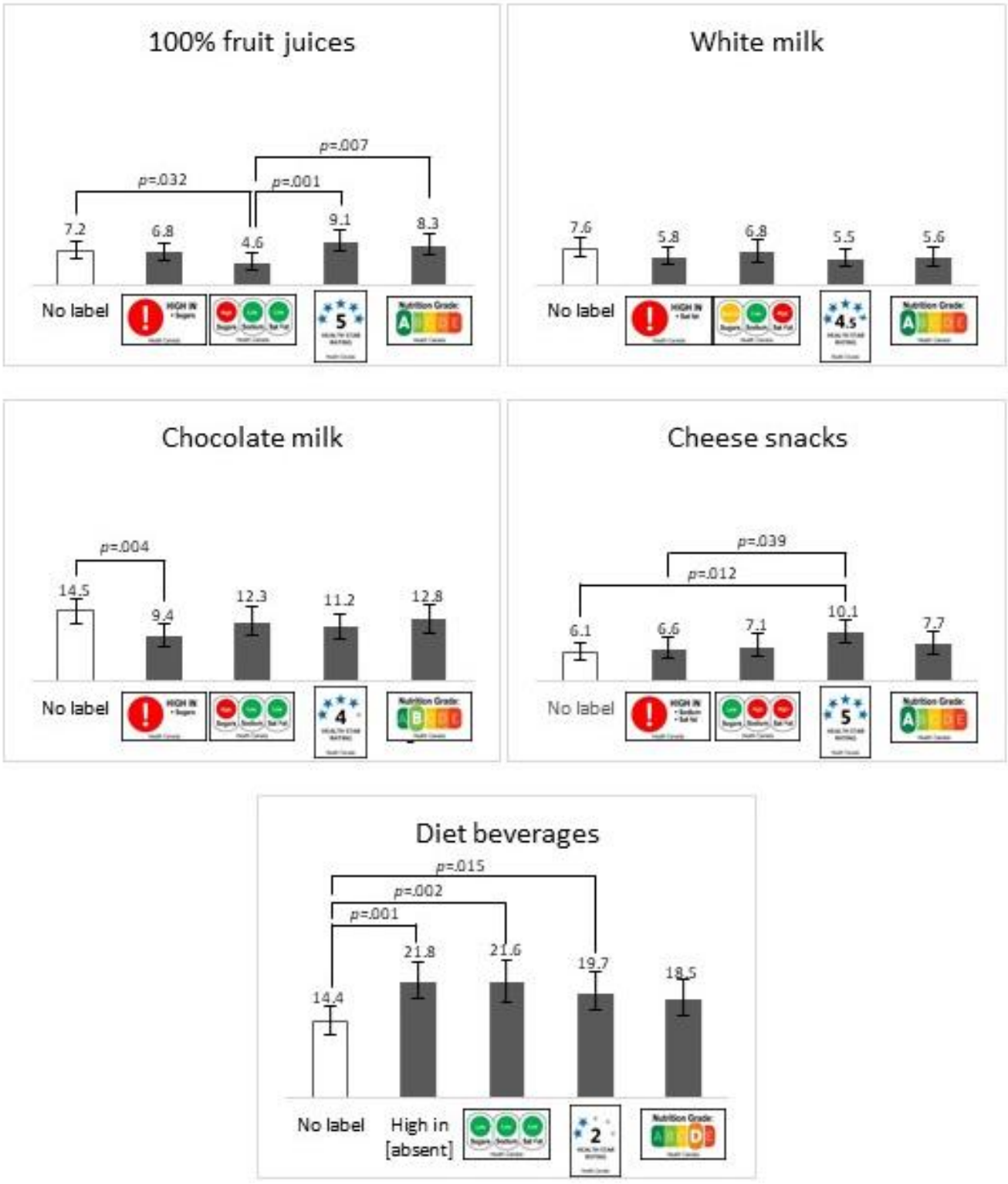
FOP, front-of-package; CEGEP, collège d'enseignement général et professionnel (general and vocational college); BMI, body mass index.
*Analyses in the current manuscript draw upon this subsample.

Table 2. FOP labels and ratings assigned to five food and beverage categories receiving conflicting ratings across label conditions, and associated hypotheses

Product category	Nutrient-specific labels		Summary indicator labels		Hypotheses
	'High in'	MTL	HSR	Nutrition grade	
100% fruit juice[a]					The summary indicator FOP labels will elicit more purchases compared to the nutrient-specific FOP labels.
White milk[b]					
Chocolate milk[c]					
Cheese snacks[d]					
Diet beverages[e]	[N/A]				The summary indicator FOP labels will elicit fewer purchases compared to the nutrient-specific FOP labels.

MTL, multiple traffic light; HSR, health star rating; FOP, front-of-package.
[a] '100% fruit juice' includes 100% orange juice and 100% apple juice beverages.
[b] 'White milk' includes a 2% MF white (unsweetened) milk beverage.
[c] 'Chocolate milk' includes the 1% MF chocolate (sweetened) milk beverage.
[d] 'Cheese snacks' include Cheestring and Mini Babybel Light products.
[e] 'Diet beverages' include Diet Coke, Diet Pepsi, Diet 7-Up, G2 Low-Cal Gatorade, and VitaminWater Zero products.

Figure 1. Estimated means for the percentage of participants who purchased a 100% fruit juice, 2% MF white milk, 1% MF chocolate milk, cheese snack, or diet beverage product in an experimental marketplace, by FOP labelling condition. Sample is limited to participants (n=1,990) who noticed a front-of-package nutrition label. Significant differences are indicated with brackets. Error bars represent 95% confidence intervals.



Chapter 6: How do consumer purchases of 100% fruit juice and moderately sugary beverages vary across different sugar tax structures?

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Authors: Rachel B Acton BSc[1], Sharon I Kirkpatrick PhD[1], David Hammond PhD[1]

[1] School of Public Health & Health Systems, University of Waterloo, 200 University Ave. W., Waterloo, ON Canada N2L 3G1

6.1 Overview

Objective: Sugar-sweetened beverage (SSB) taxes are increasingly being used to discourage sugar intake, however the impact on consumer preferences for particular products is largely unknown. This study explored the impact of two tax variants (tiered vs. non-tiered and inclusive vs. exclusive of 100% fruit juice) on participants' purchases of moderately sugary beverages and 100% fruit juice.

Methods: A sample of 3,584 Canadians aged 13 years and older completed a series of beverage purchasing tasks, each corresponding to a different tax condition, within an experimental marketplace. Tax conditions included a no-tax control, plus 4 taxes varying by structure (tiered vs. non-tiered) and whether or not they included 100% fruit juice.

Results: The odds of purchasing a moderately sugary beverage were higher under tiered versus non-tiered taxes. Purchases of higher-sugar beverages differed little across tiered versus non-tiered structures. Odds of purchasing 100% fruit juice were lower when these products were taxed versus when they were not.

Conclusions: Results suggest that two key tax formats are likely to function as expected: taxes that include 100% fruit juice products may lead to fewer purchases of fruit juice, and taxes that incorporate multiple tiers may encourage purchases of moderately sugary products more than non-tiered formats.

Keywords: taxes; sugar tax; sugar-sweetened beverages; nutrition policy; health policy

6.2 Introduction

Excessive intake of sugary beverages is associated with an increased risk of obesity and other non-communicable diseases.[1–4] A number of countries and cities have implemented sugar-sweetened beverage (SSB) taxes to reduce consumption,[5,6] and the real-world evidence on their impacts thus far is promising.[7–10]

SSB taxes are often discussed as a uniform intervention; however, taxes vary substantially in their format and delivery.[11] Two key variations of SSB taxes that are of interest to industry and policymakers are (1) tiered versus non-tiered structures, and (2) inclusion or exclusion of 100% fruit juices in the scope of taxed products.

SSB taxes have most commonly been implemented in non-tiered formats, by applying a single tax rate to an entire group of beverages. In contrast, several countries have begun to explore 'tiered' tax structures. An example is the UK's two-tiered soft drinks industry levy, which applies price increases of £0.18/L for beverages containing 5 to 8 g sugar/100 ml (i.e., moderately sugary beverages), or £0.24/L for beverages containing > 8 g/100 ml.[12] By offering an attainable lower tax tier, the UK levy aims to encourage product reformulation by soft drink companies. Preliminary observational evidence suggests many manufacturers reduced the sugar content of their soft drink offerings in response to this levy.[13] In Portugal and Catalonia, Spain, evidence suggests sales or reported intake of SSBs were reduced following implementation of similar two-tiered taxes.[14,15] In terms of experimental evidence, two previous studies by the current authors have examined the impact of tiered tax structures on the sugar and energy content of consumers' purchases in experimental marketplace settings, finding that tiered taxes perform similarly to non-tiered formats.[16,17] However, to the authors' knowledge, no studies to date have specifically examined how tiered taxes influence consumers' preferences for 'moderately' sugary beverages (i.e., those falling under the lower tax tier) versus beverages with higher levels of sugars. A tiered tax may allow consumers to switch more easily from a higher- to a lower-sugar option. On the other hand, a lower tax on moderately sugary beverages may draw in more consumers who would have otherwise stopped drinking these products under a non-tiered tax, and therefore make less of an impact on sugar consumption overall.

Similarly, few studies have compared consumers' responses to taxes that include 100% fruit juice versus those that do not. The same experimental marketplace assessed in this brief report

found taxes that were inclusive of 100% fruit juice elicited purchasing of beverages with lower sugars and caloric content than taxes that did not[17]; however, it has not been explored whether these differences were due to lower likelihood of purchasing 100% fruit juice. Although the majority of SSB taxes do not include 100% fruit juice, there is increasing evidence and pressure from health organizations for these products to be treated similarly to conventional SSBs.[18,19] This area, however, is controversial, with some research finding no direct relationship between 100% fruit juice and weight.[20]

This brief report examines purchasing data from an experimental marketplace to explore two key SSB tax variations: tiered versus non-tiered, and inclusion versus exclusion of 100% fruit juice products. The current analysis aims to expand on previous work[17,21] by exploring whether these tax structures influence participants' purchases of moderately sugary beverages and 100% fruit juice.

6.3 Methods

6.3.1 Study design

Data were drawn from an experimental marketplace conducted in March to May 2018, the full methodology and primary results of which are published elsewhere.[17] Briefly, research assistants stationed in shopping centres in three cities in Ontario, Canada recruited participants aged 13 years and older using convenience sampling. Participants completed five consecutive experimental purchasing tasks, with each corresponding to a different tax condition (Table 1). Participants were provided with $5 in each task to make a purchase from a selection of 20 beverages. Beverages were categorized as 'SSBs' if they contained added sugars[*], or as 'sugary drinks' if they contained free sugars[†]. 'Sugary drinks' include 100% fruit juice, while 'SSBs' do not. Moderately sugary beverage products were defined as those containing 5 to 8 g added or free sugars. The beverages were presented on a large print-out resembling a grocery or convenience store shelf, with price tags corresponding to the associated tax condition for each task. Price information is presented in [Appendix C, Table C2].

[*] Defined as sugars, syrups or caloric sweeteners added to foods during processing, manufacturing or preparation.
[†] Defined by WHO as all added sugars plus sugars that are naturally present in honey, syrups and fruit juices.[22]

Following the purchasing tasks, participants completed a series of items on an iPad querying various sociodemographic characteristics and health behaviours. At the end of the experiment, the participant received the actual product and their change from the $5 for one of the purchasing tasks. Participants did not know which purchase they would receive until the end of the experiment.

6.3.2 Analyses

Two generalized linear mixed models (GLMMs) were run to assess the influence of tax condition on participants' odds of purchasing moderately sugary beverages (1=yes, 0=no) and 100% fruit juice (1=yes, 0=no). Each model included variables for tax condition and label condition, plus individual-level variables (sex, age, and reported level of thirst). 95% confidence intervals (95% CI) were reported for all adjusted odds ratios (AORs) and probability estimates. Additional descriptive analyses examined the distribution of participants' purchases across all 20 beverage products.

6.4 Results

Sample characteristics are presented in Table 2.

6.4.1 Moderately sugary beverages

Table 3 presents AORs for pairwise comparisons between tax conditions. Figure 1 shows predicted probabilities of participants purchasing moderately sugary beverages and 100% fruit juice by tax condition. GLMM results indicated that the overall effect of tax condition on moderately sugary beverage purchases was significant (F [4, 17897] = 29.3, $p < .0001$). The odds of purchasing a moderately sugary beverage were lower under the *20% SSB* and *20% SD* tax structures compared to the *Tiered SSB* and *Tiered SD* taxes. Compared to no tax, the odds of purchasing a moderately sugary beverage were lower under each of the *20% SSB*, *20% SD*, *Tiered SSB* and *Tiered SD* tax conditions.

In contrast, descriptive analyses of participants' purchasing patterns across other beverage categories [Appendix F, Table F1] suggest that purchases of high sugary products (i.e., those containing > 8 g sugar and taxed 20%) differed very little across tiered and non-tiered taxes.

6.4.2 100% fruit juice

The overall effect of tax condition on 100% fruit juice purchases was significant (F [4, 17897] = 46.4, $p < .0001$). The odds of purchasing a 100% fruit juice product were lower under the *20% SD* and *Tiered SD* tax conditions compared to *20% SSB* and *Tiered SSB*. Compared to no tax, the odds of purchasing 100% fruit juice were higher under *20% SSB* and *Tiered SSB*, and lower under *20% SD* and *Tiered SD*.

6.5 Discussion

The findings demonstrate that two key SSB tax structures functioned as expected. First, participants were more likely to purchase moderately sugary products falling in the lower (10%) tax tier under the influence of a tiered tax structure compared to a non-tiered tax in which all sugary beverages were taxed at a rate of 20%. However, results from previous analyses of these data found no differences in sugars or energy content of participants' purchases across tiered and non-tiered tax structures, suggesting that although these tax structures may influence purchases of moderately sugary products, they may be unlikely to have an effect on overall sugars or energy intake.[17] To the authors' knowledge, no other experimental studies have evaluated consumers' purchases across different tax tiers. Future research should continue to monitor consumer responses to tiered excise taxes in the real world, where industry reformulation efforts are likely to play a key role.[6,13]

Second, participants were less likely to purchase 100% fruit juice when these products were included in a tax versus not. In addition, participants were more likely to purchase 100% fruit juice under a traditional SSB tax compared to the no tax control, indicating that an SSB tax may push consumers towards fruit juices, which contain similar—or higher—amounts of sugars than the taxed beverages they are shifting away from. These results build on previous analyses by the authors, which found that taxes that included 100% fruit juice elicited greater reductions in sugars and calories compared to taxes that did not.[17] The current results suggest these differences were driven by shifts away from 100% fruit juice options. As highlighted above, the majority of SSB taxes implemented thus far do not include 100% fruit juice; however, it is increasingly

recognized that these beverages contribute similar levels of sugar to our diets as conventional SSBs, and are consumed at particularly high levels among children and youth.[18,23]

The results of this paper should be interpreted with caution when extrapolating to other populations given the convenience sampling method and Ontario-specific sample. Additionally, the experimental purchasing tasks may not accurately reflect consumers' behaviours in real-world settings. Participants did not have the option to decline a purchase, and were not informed that the price increases were due to taxes; in the real world, consumer responses to SSB taxes are often partially driven by heightened awareness of the taxed products as a result of media and education campaigns.[6,15] Further, this study did not capture impacts of product reformulation, which is likely to be a key outcome of tiered taxes.[13]

6.5.1 Conclusion

Tiered taxes may have distinct effects with respect to consumer demand for moderately sugary products, which will also be influenced by industry reformulation in real world scenarios. Although there remains considerable debate as to whether 100% fruit juice products should be subject to sugar taxes, doing so is likely to enhance the impact of SSB taxation.

Table 1. Tax conditions tested in an experimental marketplace

Tax condition	Tax amount and products targeted
No tax	-
20% SSB	+20% on all beverages containing > 5 g added sugars
20% SD*	+20% on beverages containing > 5 g free sugars
Tiered SSB	+10% on beverages containing 5 to 8 g added sugars (i.e., moderately sugary beverages); +20% on beverages containing > 8 g added sugars
Tiered SD*	+10% on beverages containing 5 to 8 g free sugars (i.e., moderately sugary beverages); +20% on beverages containing > 8 g free sugars

SSB, sugar-sweetened beverage; SD, sugary drink
*SD taxes included 100% fruit juice; SSB taxes did not.

Table 2. Sociodemographic characteristics of participants (N=3,584) in an experimental marketplace

Characteristic	%
City	
Kitchener	17.5
Toronto	41.2
Waterloo	41.4
Age (years)	
13-18	15.3
19-25	31.0
26-35	20.6
36-45	11.9
>45	21.3
Gender	
Male	44.0
Female	56.0
Weekly beverage frequency	
Number of sugary drinks (*mean*)	4.0
Ethnicity	
White	44.9
Other/mixed	50.3
Indigenous	3.3
Not stated	1.6
Education	
High school or less	26.6
CEGEP/Trade School/College (partial or complete)	11.7
University (partial or complete)	61.7
Income adequacy	
'Very difficult' or 'Difficult'	19.5
'Neither easy nor difficult'	41.4
'Easy' or 'Very easy'	39.1
BMI classification	
Underweight	3.3
Normal weight	46.0
Overweight	22.8
Obesity	12.1
Not reported	15.8

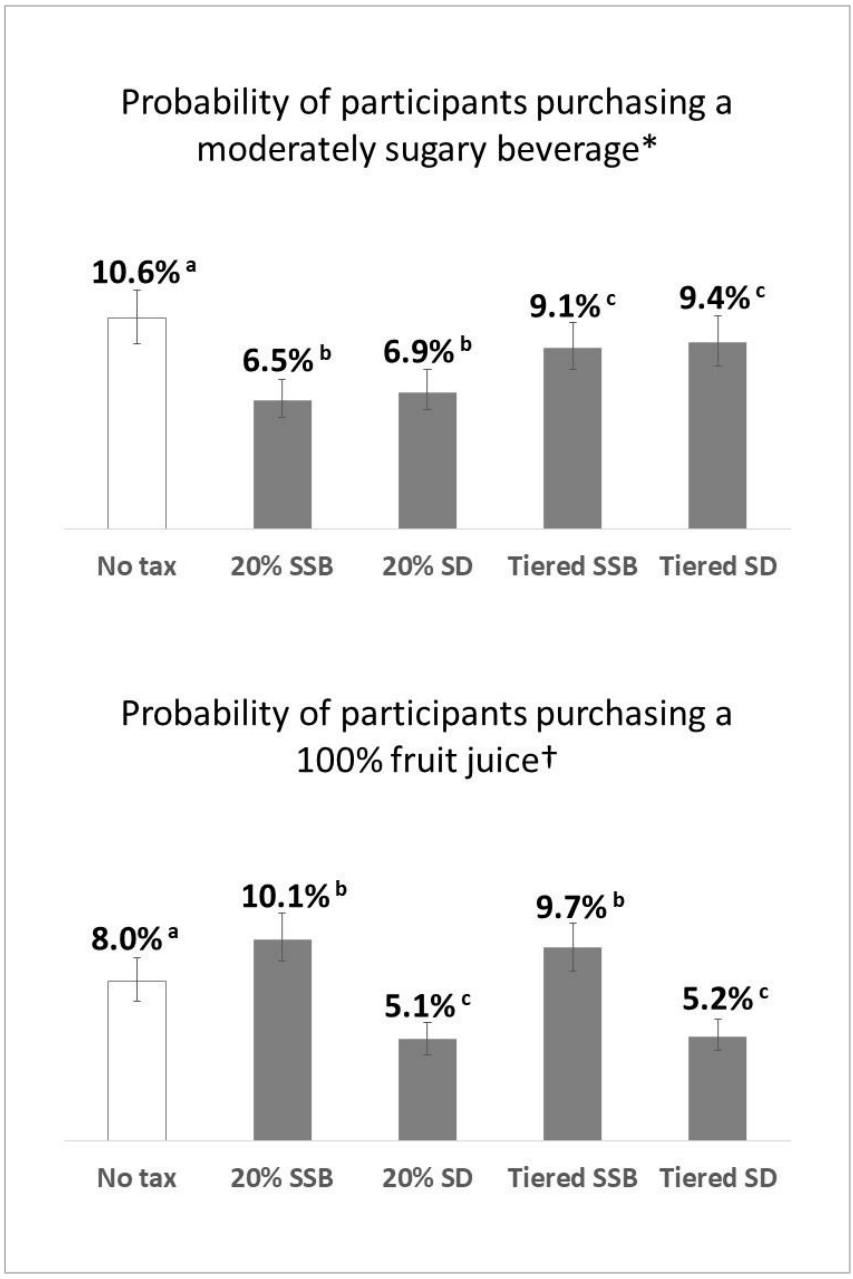
CEGEP, Collège d'enseignement général et professionnel (general and vocational college); BMI, body mass index

Table 3. Adjusted odds ratios for pairwise contrasts comparing the effects of tax format on participants' purchases of (A) moderately sugary beverages and (B) 100% fruit juice in an experimental marketplace (N=3,584)

	AOR	95% CI	*p* value
(A) Odds of purchasing a moderately sugary beverage by tax condition			
No tax - 20% SSB tax*	1.71	(1.53, 4.60)	<.0001
No tax - 20% SD tax	1.60	(1.42, 4.16)	<.0001
No tax - Tiered SSB tax	1.18	(1.06, 2.89)	0.002
No tax - Tiered SD tax	1.14	(1.03, 2.80)	0.013
20% SSB tax - 20% SD tax	0.93	(0.82, 2.28)	0.272
20% SSB tax - Tiered SSB tax	0.69	(0.61, 1.84)	<.0001
20% SSB tax - Tiered SD tax	0.67	(0.59, 1.81)	<.0001
20% SD tax - Tiered SSB tax	0.74	(0.66, 1.93)	<.0001
20% SD tax - Tiered SD tax	0.72	(0.64, 1.89)	<.0001
Tiered SSB tax - Tiered SD tax	0.97	(0.87, 2.39)	0.576
(B) Odds of purchasing 100% fruit juice by tax condition			
No tax - 20% SSB tax	0.78	(0.69, 0.88)	<.0001
No tax - 20% SD tax	1.64	(1.42, 1.90)	<.0001
No tax - Tiered SSB tax	0.82	(0.72, 0.92)	0.001
No tax - Tiered SD tax	1.59	(1.37, 1.83)	<.0001
20% SSB tax - 20% SD tax	2.11	(1.83, 2.44)	<.0001
20% SSB tax - Tiered SSB tax	1.05	(0.94, 1.18)	0.399
20% SSB tax - Tiered SD tax	2.04	(1.77, 2.35)	<.0001
20% SD tax - Tiered SSB tax	0.50	(0.43, 0.57)	<.0001
20% SD tax - Tiered SD tax	0.97	(0.82, 1.13)	0.669
Tiered SSB tax - Tiered SD tax	1.94	(1.69, 2.24)	<.0001

*For each pairwise contrast, the second component is the reference category.
95% CI, 95% confidence interval; AOR, adjusted odds ratio; SD, sugary drink; SSB, sugar-sweetened beverage.

Figure 1. Predicted probabilities of participants purchasing moderately sugary beverages and 100% fruit juice in an experimental marketplace, by tax condition



*Moderately sugary beverages were defined as those that contained 5 to 8 g added or free sugars, and included 2 sports drinks and 2 vitamin waters.

†100% fruit juices included an orange juice and apple juice product. *20% SD* and *Tiered SD* conditions taxed 100% fruit juice products; *20% SSB* and *Tiered SSB* conditions did not.

[a,b,c] Different letters indicate significant differences.

Error bars represent 95% confidence intervals.

Chapter 7: General Discussion

7.1 Overview

This dissertation used an experimental marketplace design to explore the impacts of two prominent food policies on the dietary patterns of Canadian consumers. The following research questions were examined: (1) Do different FOP labels and sugar taxes influence consumer purchases of sugars, sodium, saturated fats or energy?; (2) Do different sociodemographic or individual characteristics moderate the effects of FOP labels and sugar taxes on participants' purchasing of sugars, sodium, saturated fats or energy?; (3) How do consumers' purchases of specific product categories vary across different FOP labelling systems?; and (4) How do consumers' purchases of specific product categories vary across different sugar taxation formats? Overall, the papers presented in this dissertation provide insights into the potential effects of sugar taxes and FOP nutrition labelling policies. Several cross-cutting themes are discussed below.

7.2 Key themes – sugar taxes

Several key themes around sugar taxation policies emerged throughout this dissertation. First, the structure by which a tax is delivered is an important consideration and significantly influences how a population will respond to a tax. This dissertation tested two tax structures: a tiered tax applying either 10% or 20% price increases depending on sugar content, and a flat (non-tiered) tax rate of 20% to all sugary products. One of the primary goals of tiered taxes is to provide a 'middle ground', particularly to make it easier for industry to reformulate and avoid a high tax rate;[1] however, consumers' responses to these taxes are also of interest. Overall, there was little difference in the sugars, sodium, saturated fats or calorie content of participants' purchases between tiered and non-tiered tax structures in this study. However, Chapter 6 showed that participants were more likely to purchase moderately sugary beverages falling in the 10% tier under the tiered tax compared to the non-tiered tax. Participants' incremental responses to price in this study reflect basic economic theory, and parallel the vast majority of evidence to-date on consumer responses to varying levels of sugar taxes.[2,3] These patterns suggest that when tiered taxes are implemented in the real world, a significant proportion of consumers will be likely to

shift their purchases from products in the highest taxed category towards moderately sugary beverages in the lower tax category. Although this study showed that these shifts did not result in significant differences in sugars or calories purchased compared to a 'flat' non-tiered tax, as manufacturers continue to reformulate and introduce new products falling into the lower tax category (as has been seen in the UK[4]), overall sugar consumption may eventually decrease with the shifts in the food supply.

Second, the range of products to which a tax applies is an important consideration. This dissertation provides evidence on two under-studied areas in this regard: taxes on sugary snack foods, and taxes on all sugary drinks (i.e., including 100% fruit juice). Since this study was conducted, interest in taxes on sugary or calorie-dense snack foods has begun to grow,[5] pointing to a need for additional evidence to support jurisdictions considering a tax on sugary foods. Although the selection of snack foods presented in this study was limited, results suggest that taxing sugary snack foods could produce similar effects to that of a sugary beverage tax in terms of reducing consumers' purchases of sugars and calories, and therefore has the potential to make a valuable addition to the tax landscape of jurisdictions wishing to improve the dietary intake of their population. These results mirror real-world evidence from Mexico, where evidence suggests that the country's tax on non-essential energy-dense foods has been effective in reducing purchases of the taxed foods.[6–8]

Further, this study demonstrated that taxes that include 100% fruit juice led to fewer purchases of fruit juice, and purchases with fewer sugars and calories overall compared to taxes that do not include fruit juice. There continues to be little research in this area, with only a handful of studies evaluating taxes that include 100% fruit juice, and the majority of them being simulation studies.[9–13] Of particular importance, this study identified a potential compensation effect with fruit juice: in the presence of a traditional SSB tax (i.e., when 100% fruit juice is not taxed), it appears that some consumers may shift away from SSBs and instead towards fruit juice products, which is not helpful—and potentially detrimental—from a sugar intake perspective. Fruit juice products often contain similar or greater amounts of sugars compared to other SSBs.[14] Extending the scope of a tax beyond SSBs, however, raises challenges: while traditional SSBs provide no nutritional value beyond their sugar content, 100% fruit juice (as well as sugary snack foods) often contain other nutritional components, such as protein, fibre, vitamins and minerals. In

particular, those who support 100% fruit juice as a healthy beverage argue that it provides many of the nutrients of whole fruit in a more economical form, including calcium and vitamin D in fortified juices, and that 100% juice represents a large proportion of children's already low fruit intake.[15–17] The argument to tax these products, therefore, is likely to be met with more contention than SSBs. Interestingly, results from a separate analysis of the current study suggest that as participants moved away from sugars, sodium and saturated fats in response to the sugary food taxes, their purchases of protein, calcium and fibre were not impacted; in fact, the sugary food taxes led to purchases of snack foods with higher fibre density compared to when no tax was present.[18] Therefore, though sugar taxes outwardly target sugars, their potential benefits may be more broad.

Lastly, the potential equity of a sugar tax is a key concern for policymakers, and is a point of frequent debate surrounding these policies.[19,20] As explored in Chapter 4, it is important to estimate whether and how a tax may differentially impact subpopulations prior to implementation. In particular, differential effects across income levels are a key consideration when designing and implementing a tax. As discussed in the Introduction to this dissertation, lessons from existing evidence tell us that SSB taxes may be financially regressive, in that the tax may take a larger percentage of income from low-income populations than from high-income earners.[21–24] However, the proportion of a household's income spent on a tax is projected to be very small.[21–24] Further, although SSB taxes have been shown to be financially regressive to some degree—primarily in high income countries where lower SES groups are the largest consumers of SSBs—they are projected to be progressive in terms of health outcomes. The combination of higher SSB intake, higher rates of NCDs, and higher responsiveness to a tax among low-income populations means that these groups are projected to receive the greatest health benefits from a tax at the population level.[21,22] It is also recommended that governments earmark the revenue generated from a tax towards initiatives and funding to reduce existing health inequities and further improve the equity of the tax, as has been done in Malaysia, Dominica, Philadelphia, and others.[22,25,26]

7.3 Key themes – FOP nutrition labels

The results of this dissertation also highlight several key themes around FOP nutrition labelling strategies. First, how do nutrient-specific and summary indicator FOP formats compare, and is one better at improving the healthfulness of consumers' purchases than the other? In the current dissertation, it was demonstrated that the nutrient-specific 'high in' symbols led to the most reductions across sugars, sodium, saturated fats and calorie content of participants' beverage and snack food purchases, while the MTL and HSR formats led to significant reductions in one to two cases. These results are reflective of the broader FOP literature, which has found that simple, nutrient-specific systems are often more effective at communicating nutrient level information to consumers and eliciting purchases with lower levels of the targeted nutrients.[27,28] However, the question of which FOP system is superior depends on the specific policy objectives that a country hopes to achieve, as emphasized in Chapter 5. In Canada, the Healthy Eating Strategy specifically identifies sugars, sodium and saturated fats as three critical nutrients of public health concern, therefore rationalizing the 'high in' nutrient approach taken by Health Canada, and the main outcomes selected for this dissertation. These nutrients, however, do not encompass Canadians' entire diets, and if a country is instead motivated to provide ratings of overall healthfulness rather than specific nutrients to avoid, then a summary indicator system such as the Health Star Rating or Nutri-Score may be more suitable. As discussed above, a separate analysis explored participants' purchases of positive nutrients in this study to test whether policies focused on negative nutrients negatively impacted the protein, calcium or fibre content of participants' purchases.[18] This analysis found no differences in protein or calcium across FOP label conditions, and in fact, the MTL and HSR labels led participants to purchase snack foods with higher fibre density relative to no FOP label. Thus, summary indicator FOP systems—which directly consider positive nutrients in their ratings—performed no better at encouraging purchases of nutrient-dense products than the systems solely targeting sugars, sodium and saturated fats. Although 'high in' and MTL FOP systems may be inherently nutrient-specific, the potential positive impacts of these labels may be broader.

It is also important to remember that summary indicator systems are only as good as the algorithms used to calculate their ratings, and consumers' responses to the labels will reflect any unintended flaws in that algorithm. This was seen in Chapter 5, in which products such as 100%

fruit juice and cheese snacks received high Health Star Ratings despite their high content of nutrients of concern. In Australia, ongoing revisions of the Health Star Rating reflect this issue: a five-year review of the voluntary labelling system identified several recommendations to ensure that the ratings better reflect national dietary guidelines, including penalizing total sugars to a greater extent.[29]

Lastly, a notable finding throughout this dissertation is that the FOP nutrition labels demonstrated lower effects than the taxes. As discussed previously, this is likely in part a result of the study design and reduced power due to the between-subject design for FOP conditions. However, based on similarly modest effect sizes of FOP labels observed in other studies[30,31] and the substantial projected impact of price,[32] it is reasonable to presume that the differences observed in this study are to some extent reflective of actual differences in effects between FOP labels and taxes. These results are also generally consistent with other domains, such as tobacco control, which demonstrate that price measures have the greatest impact among policy tools.[33] Though FOP nutrition labels may have smaller effects on consumers' purchases compared to price changes, these smaller effects remain meaningful, and can be maximized if labels are designed in a way that are salient, simple, and interpretive. For example, simulation modelling work has estimated that a 17 kcal average reduction in per capita daily energy intake may translate to the prevention of over 12,000 cancer cases, 36,000 cases of ischemic heart disease, 4,800 strokes, and 138,000 cases of type 2 diabetes over 25 years in Canada.[34] The 12% (12.6 kcal) reduction in the energy content of participants' beverage purchases observed under the 'high in' FOP label in this study, if extrapolated to daily reductions, would be likely to demonstrate proportionally large impacts. Further, the tax and labelling effects reported in this study were detected in the context of each other, meaning that labels produced an effect above and beyond those of the taxes, and vice versa. These two policies demonstrate promising cumulative effects; however, additional measures—such as advertisement and marketing restrictions, school food programs, or income supports—will be needed to fully address the problems of poor dietary intake and related health outcomes.[35,36]

7.4 Limitations

The research presented in this dissertation should be interpreted in the context of the following limitations. The study used a convenience sampling method, which limits its generalizability to the greater Canadian population, and should be interpreted with caution when applying to populations outside of Canada. The experimental purchasing tasks employed in this study used real money and real products to replicate authentic consumer behaviour as closely as possible; however, they may not represent how consumers interact with prices and labels in real world settings. In particular, participants were not made aware that the price differences represented sugar taxes, or that the FOP labels were present. This was intentionally incorporated into the study design to test the policies' standalone effects, but real-world sugar taxes and FOP nutrition labels are rarely implemented without parallel media attention and/or educational campaigns. Indeed, this is a key component in labelling campaigns. In this study, only 52% of participants assigned to see a FOP label on products reported noticing any nutrition labels or symbols following the purchasing tasks. Therefore, it is expected that the current study may have underestimated participant's responses to the policies, compared to a real-world scenario. The study also does not reflect any effects of social norms that may develop from taxes or labels over time, which may enhance their impact. On the same note, this study did not consider the policies' influences on other broader outcomes or unintended consequences, such as the potential to promote unhealthy relationships with foods.

The selection of 20 beverages and 20 snack foods in this study do not capture the wider variety of products available to consumers in the real world, but is more comprehensive than that of many studies in the literature to date. The selection of 20 beverages covered a majority of the most common non-alcoholic beverage categories consumed in the Canadian marketplace, excluding some more novel products such as kombucha or drinkable yogurt. The selection of foods in this study was particularly limited, in that it was restricted to 'snack'-type foods, and provided fewer options within product categories. Although several healthier snack options were available in this study, consumers would have a much wider selection of products containing no 'high' nutrients in the real world, meaning that consumers would have greater opportunity to react to the policies by shifting away from products contributing nutrients of concern.

Participants did not make purchases using their own money, and therefore may have been more carefree in their purchase selections and spending. However, the significant effects detected across tax conditions indicate that participants did respond to the price manipulations and monetary component of the purchasing tasks, despite not using their own money. In the context of real shopping scenarios and economic pressures, consumers' responses to the price increases may be stronger.

Lastly, sociodemographic and health behaviour variables were self-reported by participants in this study and some items may therefore may be subject to social desirability biases or recall error. In particular, BMI and dietary intake have been shown to be underreported in self-report measures.[37,38] The current study included BMI non-reporters as a distinct category in all analyses in order to address some of the effects of misreporting. Further, the self-reported intake of sugary drinks in this study are still valuable for exploring patterns across the sample and relationships with other variables of interest. Strengths of this study include the use of a randomized between-within experimental design, and behavioural outcomes with real monetary consequences.

7.5 Future directions

Moving forward, this dissertation highlights several areas for future research. First, the potential influence of sugar tax and FOP labelling policies on product reformulation was not captured in this study, but represents a critical component of both strategies. Tax policies—particularly those that are assigned based on sugar content and applied at the level of the manufacturer—have often been implemented with the explicit intention of encouraging product reformulation as much as they are intended to improve consumers' dietary patterns. In fact, the UK's Soft Drinks Industry Levy, among others, represents a tax policy that was implemented with the primary intention of encouraging product reformulation by the industry and improving the food supply for consumers, rather than influencing consumers' purchases.[1] Evidence to date largely suggests that both sugar taxes and FOP labelling systems are powerful motivators for manufacturers to reduce the content of key nutrients of concern in their product offerings.[4,39–41] Future research should continue to monitor the potential impacts of these policies on reformulation.

Future research should also continue to explore and identify any potential unintended consequences resulting from sugar taxes and FOP labelling measures. Evaluations of food

supplies should investigate whether less healthful ingredients are being introduced in place of sugars, sodium, or saturated fat following policy implementation. For example, companies may reformulate products by replacing added sugars with artificial sweeteners, for which evidence on health outcomes is still emerging.[42–44] Further, as noted in the limitations of this dissertation, the potential impacts of nutrition policies may extend beyond consumers' purchasing, consumption, and disease outcomes. Policies that flag particular food and beverage products as less desirable, whether through pricing or labelling, may lead consumers to inappropriately stigmatize those foods. It will be particularly important to understand whether such policies improve or exacerbate existing weight stigma and biases. To assist policymakers in assessing and correcting for weight bias and stigma in policies and programs, Obesity Canada's *Weight Bias Analysis Tool for Public Health Policies* could be used to evaluate tax and labelling strategies.[45,46] Further, researchers have raised concerns that obesity-related policies may increase risk factors for disordered eating.[47] Some evidence is available on the impacts of menu calorie labelling on the behaviours and symptoms of individuals with eating disorders;[48,49] however, further research is warranted to investigate the same questions in the context of sugar taxes and FOP nutrition labelling.

In addition, as some research groups have already begun to do,[11,50] future research should look more closely at the potential effects of messaging or education implemented alongside nutrition policies, and the extent of their role in impacting consumer behaviour. In this dissertation, the research protocol intentionally did not inform participants of the presence of the taxes or FOP nutrition labels, with the aim of measuring the effects of these strategies apart from associated messaging or media attention. Evidence to date suggests that the increased attention raised leading up to and following implementation of these policies (whether through news media or formal educational campaigns) is likely to play a significant role in influencing consumers' responses to the policy, beyond that of the tax or FOP labels themselves.[11,50–52]

Similarly, as more jurisdictions implement sugar taxes and FOP nutrition labels, researchers should continue to monitor and collect evidence on their effects in the real world. Evaluation of taxes and labels across key sociodemographic strata, such as income, education and literacy, will be critical in informing the equitable application of these policies in the future. In addition,

monitoring of novel tax and labelling systems—such as taxes that stray from the usual 'SSB' definition, or novel FOP labelling formats—should be prioritized.

Lastly, reported experiences from the implementation of real-world sugar taxes and FOP labelling systems has taught us that there are significant political barriers in implementing such policies.[53–57] These barriers can range from limitations in a country's existing legislative structure, to the powerful political opposition of industry stakeholders and the threat of legal challenges. As jurisdictions continue to face these challenges, several organizations have published guidelines to help direct countries in how to best prepare for and mitigate potential obstacles to implementation. For example, the World Cancer Research Fund (WCRF) identifies seven distinct challenges that are often raised by those in opposition to SSB taxes, including arguments that the tax impinges on trade and commerce or rights of the consumer, that the tax is discriminatory (i.e., only applies to certain products and not others), or that the tax will impact local economy through job losses or negative impacts on small business owners.[25] WCRF has also outlined a list of common tactics used by industry to challenge FOP labelling, categorized into four main strategies: 'delay' (pushing for longer consultation periods or for more research to be collected), 'divide' (developing and promoting their own industry-developed FOP systems, which are usually insufficiently stringent and less interpretive), 'deflect' (claiming, for example, that warnings will scare or mislead consumers, or reframing the issue to be about business, economy, or "nanny state" concerns), and 'deny' (casting doubt on the effectiveness of the FOP labels or the sufficiency of evidence).[58] These lessons learned may now allow jurisdictions in the future to be better prepared with evidence, carefully consider the local context, develop a broad base of support, and be prepared for push back when advocating for and introducing a sugar tax or FOP labelling policy.[25,58]

7.6 Conclusions

Following the 2019 Canadian federal election, the Prime Minister requested in his mandate letter to Patty Hajdu, Minister of Health, to continue to promote healthy eating through the establishment of new FOP labelling.[59] Additionally, although a sugary drink tax is not currently under consideration by the federal government, countries around the world continue to introduce SSB tax measures,[26] making it increasingly likely that the Canadian government may table it as a

priority in the future. This study presents some of the first Canadian evidence on the effects of sugar taxes and FOP nutrition labels—including novel formats such as tiered taxes, 'high in' nutrient symbols, and the Nutri-Score label—and suggests that both strategies have the potential to improve dietary patterns and associated diet-related health outcomes. These results have informed the development of FOP labelling systems in Canada and elsewhere, and will contribute to future discussions of sugar taxation measures globally.

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Chapters 1-2

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Appendix A: Study forms and documents

Participant feedback letter

UNIVERSITY OF WATERLOO
FACULTY OF APPLIED HEALTH SCIENCES
School of Public Health and Health Systems

FEEDBACK LETTER

Title of Project: **Food & Beverage Experimental Marketplace**

Principal Investigator: Dr. David Hammond PhD, School of Public Health & Health Systems
University of Waterloo, Canada
1-519-888-4567, ext. 36462 dhammond@uwaterloo.ca

We appreciate your participation in our study, and thank you for spending the time helping us with our research!

In this study, you performed a series of purchasing tasks, and answered some basic questions about your health behaviours and background. The primary purpose of this study was to investigate whether consumers' food and beverage purchase choices change in response to price increases or nutrition labelling. In the purchasing tasks, each participant viewed sets of snacks and beverages that were displayed with either no additional labels, a "high in" labelling system, a star rating system, a traffic light system, or a 5-colour nutrition rating system. This will allow us to assess whether the participants who saw the labels purchased healthier items. In addition, we varied the prices of the sugary foods and beverages in each purchasing task. This will allow us to assess whether participants chose items with less sugar when the high-sugar items cost more. Your sociodemographic information will help us to know whether the labels or taxes work differently for people of different genders, ages, or sociodemographic backgrounds.

The results of this study will provide information on the effects of taxes and nutrition labelling on food and beverage purchases, and may help to inform future nutrition policy decisions in Canada.

As a reminder, this study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE #22494). If you have questions for the Committee contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca. The dataset without identifiers may be shared publicly, but your identity will be confidential. Electronic copies of the data will be stored for at least 7 years on a password-protected computer at the University of Waterloo. If you would like any further information about the study, including a copy of our findings when they become available, please contact Professor David Hammond at 1-519-888-4567 ext. 36462 or dhammond@uwaterloo.ca. We really appreciate your participation, and hope that this has been an interesting experience for you.

Thank you again for your help.

Sincerely,

David Hammond.

David Hammond, PhD
School of Public Health and Health Systems
University of Waterloo

Research assistant scripts

RA SCRIPTS

INFORMATION & CONSENT SCRIPT

After a participant has been confirmed eligible, move to the next screen and invite the participant to view the iPad with you. Read the following script as they follow along the information letter with you:

This screen gives some details about the study. I'll go over the key points with you.

- The purpose of this study is to better understand consumers' food and beverage choices.
- [You / Your child] will complete a 10-minute survey on an iPad. The survey will ask [you / your child] to complete a series of "purchasing tasks". In each of these purchasing tasks, [you / they] will have a budget of $5.00 to purchase one item from a range of products that we have here. I'll go through a practice with [you / them] first before the real ones. [You / They] will then complete some general questions on the iPad about [your / their] background and health behaviours.
- In appreciation of [your / your child's] time, we will give you the food or beverage that [you /they] purchased in one of those purchasing tasks, and [your / their] change from the $5.00.
- Your identity in this study and all of the information that you provide will be kept strictly confidential, and only the investigators directly associated with the study will have access to this information.
- You're free to choose whether or not to participate in this study, and you can choose to stop at any time. You can also decline to answer any question that you wish throughout the survey.
- This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee. If you have any questions, you can contact the Chief Ethics Officer in the Office of Research Ethics. I'll give you a letter at the end that will include their contact information.
- If you have any questions or require additional information about the study you can also contact the researcher mentioned in that Letter.

Do you have any questions? *[Pause and answer any questions.]*

[When they are ready, click NEXT to go to the Consent screen(s)]

As part of the ethics process, we'd like you to read over this consent page. I'll give you some time to read it over.

[If <16, repeat for Child Consent page.]

FOOD & BEVERAGE PURCHASING TASKS SCRIPT

RA holds iPad until the purchasing tasks are complete.

- After the practice tasks are complete, read the instructions on the iPad to the participant.
- On the next screen, show the iPad to the participant, and allow them to read the info and click okay to proceed.
- After this, follow the short scripts below for each purchasing task:
  (i.e., read this after you give them the appropriate printed shelf image.)

PURCHASE 1

This is your first purchasing task. Please look carefully at all of the products. **The labels may be different from what you've seen in the past.**

You have a budget of $5.00 to purchase one item.

Remember, you may receive this item and the change from your $5.00 budget.

Once you have made your decision, let me know and you can select it on the iPad.

PURCHASE 2

This is your second purchasing task. Please look carefully at all of the products.

Again, you have a budget of $5.00 to purchase one item, but notice that the prices may have changed from your last purchase. We'd like you to make another selection based on the new set of prices. You can choose the same product as last time, or a different one.

Remember, you may receive this item and the change from your $5.00 budget.

Once you have made your decision, let me know and you can select it on the iPad.

PURCHASES 3 - 8

This is your ____ purchasing task. Please look carefully at all of the products.

Again, you have a budget of $5.00 to purchase one item, but again notice that the prices may have changed.

Remember, you may receive this item and the change from your $5.00 budget.

Once you have made your decision, let me know and you can select it on the iPad.

Once the purchasing tasks are complete, hand the iPad to the participant to complete the rest of the questions on their own.

REMIND THE PARTICIPANT TO **NOT PRESS THE BACK BUTTON ON THE BROWSER!**

Note: Yellow highlighting indicates text that was added March 26, 2018.

Refusal tracking sheet

REFUSAL TRACKING SHEET

Research Assistant name:_____

Date:_____

Start time:_____ **End time:** _____

Refusals include non-response or refusal from any respondent who is approached.
Ineligible respondents should not be recorded.

Circle or cross out number for each refusal

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110
111	112	113	114	115	116	117	118	119	120
121	122	123	124	125	126	127	128	129	130
131	132	133	134	135	136	137	138	139	140
141	142	143	144	145	146	147	148	149	150
151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170
171	172	173	174	175	176	177	178	179	180
181	182	183	184	185	186	187	188	189	190
191	192	193	194	195	196	197	198	199	200
201	202	203	204	205	206	207	208	209	210
211	212	213	214	215	216	217	218	219	220
221	222	223	224	225	226	227	228	229	230
231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250

Survey tracking sheet

Survey Tracking Sheet

Date: _____

RA Name: _____

Respondent ID #	Final Status (Complete/Partial/ Ineligible)	End Time	$ Given	Product Given	Notes* (If necessary)
TOTALS:					

^(Total *Completes*)

ENTER TOTALS INTO GOOGLE SPREADSHEET AT END OF EVERY SHIFT

*Please be as specific as possible. Note whether you have 'some concerns' or 'serious concerns' about the data quality, if applicable.

Appendix B: Survey document

DOMAIN/SOURCE	QUESTION
RECRUITMENT & ELIGIBILITY CHECK	
Recruit_intro	[RA Script:] "Hi, are you interested in completing a survey? It takes about 10 minutes, and we will give you $5.00 to spend on a food or beverage from a large selection that we have here. Are you interested?" [If YES → "Great, thanks. I have a couple quick questions for you."] [If NO → "Okay – have a nice day."]
Gender	[Do not ask out loud] 1. Male 2. Female
Age	"Can you please tell me your age?" _____ years [IF UNDER 13 → "Sorry, you are not eligible to participate, but thank you for your time."] [IF REFUSE → "Sorry, you must provide your age in order to participate in our study. Thank you for your time."]
Parent/Guardian	[Programming note: Show if participant age < 16] "Do you have a parent or guardian present?" 1. Yes 2. No [IF NO → "Sorry, you must have a parent or guardian present in order to participate. Thank you for your time."]
Repeat	"Have you already participated in this study?" 1. Yes 2. No [IF YES → "Sorry, you can only participate once."]
Recruit_exit	"Great. Next I'll go over some more information about the study with you. If you're still interested in participating, I'll ask you to provide your consent and then you can get started."
Study Information page_16+	[Programming note: Show if participant age ≥ 16] STUDY INFORMATION Title of Project: *Food and Beverage Experimental Marketplace Study* Principal Investigator: Dr. David Hammond, PhD School of Public Health & Health Systems

	University of Waterloo, Canada 1-519-888-4567, ext. 36462 dhammond@uwaterloo.ca • You are being asked to participate in a research study examining food and beverage choices. Approximately 3,000 people will take part in the 10-minute survey. • If you choose to participate in this study, you will complete a survey on an iPad. The survey will ask you to complete a series of purchasing tasks. For each purchasing task you will have $5.00 to make one purchase from a range of products. We will then ask some general demographic and lifestyle questions. • In appreciation of your time, you will be provided with your selected food or beverage from one of the purchasing tasks. The task for which you receive the food or beverage will be randomly selected. You will also receive the remainder of the unspent $5.00 (your "change") from that purchasing task. • By participating in this study, you will help us to understand factors that influence food and beverage purchases. • There are no known risks or discomforts in relation to this study. Of course, you are free to decline any questions that you wish. You can withdraw from participation in the survey at any time by advising the interviewer and your responses given to that point will not be included in the study. If you choose to withdraw from the study before completion, you will still receive remuneration of $5.00. • All of your responses will be kept confidential. Electronic copies of your survey data will not contain any personal identifiers and will be stored for at least 7 years on a password protected computer at the University of Waterloo. The results of the study may be published for scientific purposes but will only be presented in aggregate. • This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE #22494). If you have questions for the Committee contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca. If you have any questions after you leave today, require additional information about the study, or you are interested in receiving a copy of study findings, please feel free to contact the researcher listed at the beginning of this information letter. Please click NEXT when you are finished reading.
Consent page_16+	[Programming note: Show if participant age ≥ 16] CONSENT I have read the information presented in the information letter about the study being conducted by Dr. Hammond, PhD in the School of Public Health and Health Systems and I have had the opportunity to ask the research assistant any questions related to this study, to receive satisfactory answers to my questions, and to request any additional details I wanted. I am aware that I may withdraw from the study at any time by advising the research assistant of this decision. In appreciation of my time, I am aware that I will be provided

	with $5.00 today, minus the cost of a snack or beverage that I select and will be provided with. This study has been reviewed by and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE #22494). I understand that if I have questions for the Committee I may contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca. I also understand that if I require additional information about the study, I may contact David Hammond at 1-519-888-4567 ext. 36462 or dhammond@uwaterloo.ca. With full knowledge of all foregoing, I agree, of my own free will, to participate in this study. 1. Yes 2. No [If no, terminate survey]
Study information page_parent	[Programming note: Show if participant age < 16] INFORMATION FOR PARENT OR GUARDIAN **Title of Project:** *Food and Beverage Experimental Marketplace Study* **Principal Investigator:** Dr. David Hammond, PhD School of Public Health & Health Systems University of Waterloo, Canada 1-519-888-4567, ext. 36462 dhammond@uwaterloo.ca • Your child is being asked to participate in a research study examining food and beverage choices. Approximately 3,000 people will take part in the 10-minute survey. • If your child participates in this study, they will complete a survey on an iPad. The survey will ask your child to complete a series of purchasing tasks. For each purchasing task they will have $5.00 to make one purchase from a range of products. We will then ask some general demographic and lifestyle questions. • In appreciation of your child's time, they will be provided with their selected food or beverage from one of the purchasing tasks. The task for which they receive the food or beverage will be randomly selected. They will also receive the remainder of the unspent $5.00 (their "change") from that purchasing task. • By participating in this study, your child will help us to understand factors that influence food and beverage purchases. • There are no known risks or discomforts in relation to this study. Of course, your child is free to decline responding to any questions that they wish. Your child can withdraw from participation in the survey at any time by advising the interviewer and their responses given to that point will not be included in the study. If your child chooses to withdraw from the study before completion, they will still receive remuneration of $5.00.

	• All of your child's responses will be kept confidential. Electronic copies of the survey data will not contain any personal identifiers and will be stored for at least 7 years on a password protected computer at the University of Waterloo. The results of the study may be published for scientific purposes but will only be presented in aggregate. • This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE #22494). If you have questions for the Committee contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca. If you have any questions after you leave today, require additional information about the study, or you are interested in receiving a copy of study findings, please feel free to contact the researcher listed at the beginning of this information letter. Please click NEXT when you are finished reading.
Consent page_parent	[Programming note: Show if participant age < 16] PARENTAL CONSENT I have read the information presented in the information letter about the study being conducted by Dr. Hammond, PhD in the School of Public Health and Health Systems and I have had the opportunity to ask the research assistant any questions related to this study, to receive satisfactory answers to my questions, and to request any additional details I wanted. I am aware that my child may withdraw from the study at any time by advising the research assistant of this decision. In appreciation of my child's time, I am aware that they will be provided with $5.00 today, minus the cost of a food or beverage that they select and will be provided with. This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE #22494). I understand that if I have questions for the Committee I may contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca. I also understand that if I require additional information about the study, I may contact David Hammond at 1-519-888-4567 ext. 36462 or dhammond@uwaterloo.ca. With full knowledge of all foregoing, I, of my own free will, give permission for my child to participate in this study. 1. Yes – I would like my child to participate in this study. 2. No – I would not like my child to participate in this study. [If no, terminate survey]
Consent page_child	[Programming note: Show if participant age < 16] CHILD CONSENT This survey looks at your food and beverage choices, and those of other children and adults in Ontario. We want to know how different factors might affect the types of food and beverages you buy.

	We will give you money to make some "purchases" in the survey, and at the end you will get one of the snacks or beverages you purchased. The survey will also ask you some questions about your background and health behaviours. The survey is completely private. No one, except researchers, will see your finished survey. If there is a question that you do not know how to answer, or do not want to answer, that's okay, just go on to the next one. Do you agree to participate in this survey? 1. Yes 2. No [If no, terminate survey]
Intro text	[Only display if 'Yes' selected on all relevant consent pages] Thank you for agreeing to participate! First, please answer two short questions about how you are feeling right now, and then we will begin.
HUNGER & THIRST	
Hunger scale (Epstein, 2015)	Please think about how **HUNGRY** you are **right now**. Select the choice below that best represents how **HUNGRY** you are right now: [displayed horizontally] 1. Not at all hungry 2. Slightly hungry 3. Moderately hungry 4. Very hungry 5. Extremely hungry 77. Don't know 88. Refuse to answer
Thirst scale	Please think about how **THIRSTY** you are **right now**. Select the choice below that best represents how **THIRSTY** you are right now: [displayed horizontally] 1. Not at all thirsty 2. Slightly thirsty 3. Moderately thirsty 4. Very thirsty 5. Extremely thirsty 77. Don't know 88. Refuse to answer
Hunger & Thirst exit text	Thanks! In a minute, we'll ask you to complete the purchase tasks. First, we'll start with a practice to make sure you understand how this works.
PRACTICE PURCHASING TASKS	
PRACTICE Purchasing Tasks	

Prior to the actual purchasing tasks, the participant will complete 2 hypothetical purchasing tasks as a practice. The procedures will be identical to the actual purchasing tasks described below, but the participants will be clearly informed that the tasks are for practice purposes only. They will not actually receive the hypothetical "purchased" items.	
Practice - RA Script	[RA reads:] **"Great. Before we start the real purchasing tasks, I'm going to go through a practice purchasing task with you so that you know what to expect in the real one.** • **In this practice example, you will make two different purchases. You will have a budget of $5.00 for each purchase. You won't know which one would be the real purchase until the end.** • **Remember, this is just a practice, so you will not actually receive the product from one of the purchases. In the real task that you complete later, you WILL receive one of your purchases and any money remaining from the $5.00 that you did not spend.** **If you're ready, I will walk through this practice with you."**
Practice - Intro	THIS IS A PRACTICE PURCHASE. You will complete <u>two</u> purchasing tasks. You can purchase <u>one</u> item in each task, with a budget of $5.00. PLEASE HAND THE IPAD BACK TO THE RESEARCH ASSISTANT.
Viewing of practice board – 1	[RA displays first practice "product shelf" print-out to participant, and reads:] **"This is the first of two practice purchase tasks. You have a budget of $5.00 to purchase one item.** **<u>Remember that you would receive your change from the $5.00!</u> In other words, if you choose a product that is <u>cheaper</u>, you will get <u>more</u> change back from the $5.00. If you choose a product that <u>costs more</u>, you will get <u>less</u> change back.** **Once you have made your decision, let me know and you can select it on the iPad."** [RA hands iPad back to participant when they are ready]
Practice Purchase 1	You have a budget of <u>$5.00</u> to purchase one item. Please click on the picture of the item you would like to purchase and then click NEXT.  [separate radio buttons for each item] [allow selection of only <u>one</u>]

Practice – purchase 2 intro	[RA reads:] **"Great! Next you'll do the second practice purchasing task.** **It will be similar to the first: you will choose from the same set of products, but the prices will be different.** **We'd like you to make another selection based on the new set of prices."** [RA hands 'Practice 2' shelf print-out to participant, and reads:] **"Remember, you would hypothetically get any leftover money from the $5.00. You can choose the same product again, or choose a different one.** **Once you have made your decision, let me know and you can select it on the iPad."** [RA hands iPad back to participant when they are ready]
Practice Purchase 2	You have a budget of $5.00 to purchase one item. Please click on the picture of the item you would like to purchase and then click NEXT.  [separate radio buttons for each item] [allow selection of only one]
Practice – display random selection	[Programming note: randomly select on of the two practice purchases & display corresponding text] Thanks. In the real study, the computer will randomly choose one of the purchase tasks. You will then purchase the product you chose in that task. For example, for the practice tasks you just completed, the computer randomly chose the [*first* / *second*] task: You would have purchased the [*display random selection*] and received [$____] in change. If these were the actual purchase tasks, at the end of the survey you would take a real item home and the change from $5.00, just as if you were buying it from a store.
Practice End / Real tasks intro	[RA reads:] **"NOW YOU WILL COMPLETE THE REAL PURCHASING TASKS.** **In that practice, you completed two purchases of different toys. In the real purchasing tasks that you will do shortly, you will be making five purchases of beverages, and then three purchases of foods. At the end, the computer will randomly choose one of these**

	purchasing tasks. You will then take that real beverage and your change from the $5.00 *[take out $5 bill]*, just as if you were buying it from a store. Remember, these are REAL purchasing tasks. You MUST purchase one of the products in each of the tasks with your $5.00 *[gesture to $5 bill]*. So be sure it is one that you want to take home. You will not know which one will be the real purchase until the end of the survey. Do you have any questions about how the purchases will work?" [RA answers any questions.] "Okay. We can start the purchasing tasks now. After we're done these, you will just need to answer a few more questions on the iPad, and then we will see which purchase you made and I will give you your food or beverage and your change. Let me know if you have any questions at any time." [RA leaves $5 bill on table next to participant.]

PURCHASING TASKS

ACTUAL Purchasing Tasks

Each respondent will be randomized to one of 5 labelling conditions:

1. No labels
2. "High in" symbol
3. Multiple traffic light
4. Health star rating
5. 5-colour nutrition grade

Sample images of labelling conditions:

1. No labels:

2. High-in Symbol:

3. Multiple Traffic Light:

4. Health Star Rating:

5. Nutrition grade: 

Based on this randomization, the images of the beverages and snacks that the participant sees will incorporate *no health labels*, the *high-in symbol*, the *multiple traffic light*, the *health star rating*, or the *nutrition grade*.

Each participant will complete the five beverage purchases first, followed by the three food purchases. The order of the five beverage purchases and the three food purchases will be randomized for each participant.

Purchases - Intro	REMEMBER, THESE ARE NOW REAL PURCHASING TASKS. YOU WILL RECEIVE THE FOOD OR BEVERAGE THAT YOU PURCHASED AND YOUR CHANGE FROM ONE OF THESE PURCHASES. The research assistant will show you the foods and beverages available to purchase. Please take your time to consider all of the options. You MUST purchase one of the items on each of the screens. Make sure it is one that you want to take home. 1. Okay [RA takes iPad from participant.]
BEVERAGE PURCHASING TASKS	
Label Condition Randomization	[At this point, the survey program has randomly assigned the participant to one labelling condition. Alphanumeric codes on the following screens tell the RAs which shelf print-outs to show to the participants.]
Viewing of beverage shelf – 1	[RA displays appropriate product shelf print-out to participant, and reads:] **"This is your first purchasing task. Please look carefully at all of the products. The labels may be different from what you've seen in the past.** **You have a budget of $5.00 to purchase one item.** **Remember, you may receive this item and the change from your $5.00 budget.** **Once you have made your decision, let me know and you can select it on the iPad."** [RA turns iPad towards participant when they are ready]
Beverage selection 1	You have a budget of $5.00 to purchase one item. Please click on the picture of the item you would like to purchase and then click NEXT.

	Remember, you may receive this item and the change from your $5.00 budget. [prices = **current market prices** (no tax)]  [separate radio buttons for each beverage] [allow selection of only <u>one</u>]
Viewing of beverage shelf – 2	[RA displays appropriate product shelf print-out to participant, and reads:] **"This is your second purchasing task. <u>Please look carefully at all of the products.</u>** **Again, you have a budget of <u>$5.00</u> to purchase <u>one</u> item, but <u>notice that the prices may have changed from your last purchase</u>. <u>We'd like you to make another selection based on the new set of prices</u>. You can choose the same product as last time, or a different one.** **Remember, you may receive this item and the change from your $5.00 budget.** **Once you have made your decision, let me know and you can select it on the iPad."** [RA turns iPad towards participant when they are ready]
Beverage selection 2	You have a budget of <u>$5.00</u> to purchase one item. Please click on the picture of the item you would like to purchase and then click NEXT. *Remember, you may receive this item and the change from your $5.00 budget.* [same beverage selection as above] [prices = **+20%** on SSBs]

	[separate radio buttons for each beverage] [allow selection of only one]
Viewing of beverage shelf – 3	[RA displays appropriate product shelf print-out to participant, and reads:] **"This is your third purchasing task. Please look carefully at all of the products.** **Again, you have a budget of $5.00 to purchase one item, but again notice that the prices may have changed.** **Remember, you may receive this item and the change from your $5.00 budget.** **Once you have made your decision, let me know and you can select it on the iPad."** [RA turns iPad towards participant when they are ready]
Beverage selection 3	You have a budget of $5.00 to purchase one item. Please click on the picture of the item you would like to purchase and then click NEXT. *Remember, you may receive this item and the change from your $5.00 budget.* [same beverage selection as above] [prices = **tiered tax** on SSBs] [separate radio buttons for each beverage] [allow selection of only one]
Viewing of beverage shelf - 4	[RA displays appropriate product shelf print-out to participant, and reads:] **"This is your fourth purchasing task. Please look carefully at all of the products.** **Again, you have a budget of $5.00 to purchase one item, but again notice that the prices may have changed.** **Remember, you may receive this item and the change from your $5.00 budget.** **Once you have made your decision, let me know and you can select it on the iPad."** [RA turns iPad towards participant when they are ready]
Beverage selection 4	You have a budget of $5.00 to purchase one item. Please click on the picture of the item you would like to purchase and then click NEXT. *Remember, you may receive this beverage and the change from your $5.00 budget.* [same beverage selection as above] [prices = **+20%** on sugary drinks] [separate radio buttons for each beverage] [allow selection of only one]

Viewing of beverage shelf – 5	[RA displays appropriate product shelf print-out to participant, and reads:] **"This is your fifth purchasing task. Please look carefully at all of the products.** **Again, you have a budget of $5.00 to purchase one item, but again notice that the prices may have changed.** **Remember, you may receive this item and the change from your $5.00 budget.** **Once you have made your decision, let me know and you can select it on the iPad."** [RA turns iPad towards participant when they are ready]
Beverage selection 5	You have a budget of $5.00 to purchase one item. Please click on the picture of the item you would like to purchase and then click NEXT. *Remember, you may receive this beverage and the change from your $5.00 budget.* [same beverage selection as above] [prices = **tiered tax** on sugary drinks] [separate radio buttons for each beverage] [allow selection of only one]
FOOD PURCHASING TASKS	
Viewing of food shelf – 1	[RA displays appropriate product shelf print-out to participant, and reads:] **"This is your sixth purchasing task. Please look carefully at all of the products.** **Again, you have a budget of $5.00 to purchase one item, but again notice that the prices may have changed.** **Remember, you may receive this item and the change from your $5.00 budget.** **Once you have made your decision, let me know and you can select it on the iPad."** [RA turns iPad towards participant when they are ready]
Food selection 1	You have a budget of $5.00 to purchase one item. Please click on the picture of the item you would like to purchase and then click NEXT. *Remember, you may receive this item and the change from your $5.00 budget.* [prices = **current market prices** (no tax)]

	 [separate radio buttons for each item] [allow selection of only one]
Viewing of food shelf – 2	[RA displays appropriate product shelf print-out to participant, and reads:] **"This is your seventh purchasing task. Please look carefully at all of the products.** **Again, you have a budget of $5.00 to purchase one item, but again notice that the prices may have changed.** **Remember, you may receive this item and the change from your $5.00 budget.** **Once you have made your decision, let me know and you can select it on the iPad."** [RA turns iPad towards participant when they are ready]
Food selection 2	You have a budget of $5.00 to purchase one item. Please click on the picture of the item you would like to purchase and then click NEXT. *Remember, you may receive this item and the change from your $5.00 budget.* [same food selection as above] [prices = **+20%** on high-sugar foods] [separate radio buttons for each item] [allow selection of only one]
Viewing of food shelf – 3	[RA displays appropriate product shelf print-out to participant, and reads:]

	"This is your last purchasing task. Please look carefully at all of the products. Again, you have a budget of $5.00 to purchase one item, but again notice that the prices may have changed. Remember, you may receive this item and the change from your $5.00 budget. Once you have made your decision, let me know and you can select it on the iPad." [RA turns iPad towards participant when they are ready]
Food selection 3	You have a budget of $5.00 to purchase one item. Please click on the picture of the item you would like to purchase and then click NEXT. *Remember, you may receive this item and the change from your $5.00 budget.* [same food selection as above] [prices = **tiered/sugar-specific** on high-sugar foods] [separate radio buttons for each item] [allow selection of only one]
Purchases End text	Great, you have completed the purchasing tasks! After you complete a few more questions, you will receive the food or beverage and your change from one of the purchasing tasks. Please click OKAY and NEXT to continue the survey. 1. Okay
Label Noticing	[Ask all] In all of the previous purchasing tasks, did you notice any nutrition labels or symbols on the front of the food and beverage packages? 1. Yes 2. No 77. Don't know 88. Refuse to answer
HEALTH BEHAVIOURS	
Health Behaviours_intro	We would now like to ask you a few questions about your diet and health behaviours. Please click NEXT.
BFQ	During the PAST 7 DAYS, how many sugary drinks did you have? (This includes pop, fruit drinks, fruit juice, sports drinks, vitamin waters, energy drinks, chocolate milk, tea/coffee with more than 5 teaspoons of sugar, and specialty coffees.) Do NOT count diet or sugar-free drinks. Do NOT include today. # OF DRINKS

_____ [numeric]

77. Don't know
88. Refuse to answer

Eating efforts
TNT

Have you made an effort to consume more or less of the following in the past year?

	Consume LESS	Consume MORE	No effort made	Don't Know	Refuse to answer
Calories					
Saturated fat					
Sugar/added sugar					
Salt/sodium					

Health Literacy
(Newest Vital Sign)

This information is on the back of a container of a pint of ice cream:

Nutrition Facts

Serving Size	½ cup
Servings per container	4
Amount per serving	
Calories 250	Fat Cal 120
	%DV
Total Fat 13g	20%
Sat Fat 9g	40%
Cholesterol 28mg	12%
Sodium 55mg	2%
Total Carbohydrate 30g	12%
Dietary Fiber 2g	
Sugars 23g	
Protein 4g	8%

*Percentage Daily Values (DV) are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.

Ingredients: Cream, Skim Milk, Liquid Sugar, Water, Egg Yolks, Brown Sugar, Milkfat, Peanut Oil, Sugar, Butter, Salt, Carrageenan, Vanilla Extract.

If you eat the entire container, how many calories will you eat?
Enter number of calories: _____ [numeric]
[correct answer = 1,000]

If you are allowed to eat 60 grams of carbohydrates as a snack, how much ice cream could you have?
Enter number of cup(s): _____ [numeric]

[correct answer = 1 cup (or any amount up to 1 cup)]

	Your doctor advises you to reduce the amount of saturated fat in your diet. You usually have 42 g of saturated fat each day, which includes one serving of ice cream. If you stop eating ice cream, how many grams of saturated fat would you be consuming each day? *Enter number of grams:* _____ [numeric] [correct answer = 33] If you usually eat 2,500 calories in a day, what percentage of your daily value of calories will you be eating if you eat one serving? *Enter percentage*: _____ [numeric] [correct answer = 10] Pretend that you are allergic to the following substances: penicillin, peanuts, latex gloves, and bee stings. Is it safe for you to eat this ice cream? 1. Yes 2. No 77. Don't know 88. Refuse to answer [correct answer = No] [Programming note: Ask only participants who answered "No" in previous question] Why not? *Enter reason:* _____ [numeric] [correct answer: (approximately) because it has peanut oil]
SOCIODEMOGRAPHICS	
Sociodemographics intro	The final set of questions will ask about your background, for statistical purposes only. Click NEXT to continue.
Aboriginal status (CCHS)	Are you an Aboriginal person, that is, First Nations (North American Indian), Métis or Inuit (Inuk)? 1. Yes 2. No 77. Don't know 88. Refuse to answer
Ethnicity (CCHS)	[Programming note: Do not ask for respondents who answered "Yes" in previous question.] People living in Canada come from many different cultural and racial backgrounds. Are you… (Select all that apply) 1. White 2. Chinese 3. South Asian (e.g., East Indian, Pakistani, Sri Lankan) 4. Black 5. Filipino 6. Latin American 7. Southeast Asian (e.g., Cambodian, Indonesian, Laotian, Vietnamese) 8. Arab 9. West Asian (e.g., Afghan, Iranian) 10. Japanese 11. Korean 12. Other → Please specify: _____ [open text]

	77. Don't know 88. Refuse to answer
Education (17+) (Adapted from CCHS & NHANES)	[Programming note: Ask only if age≥17] What is the highest level of formal education that you have completed? 1. Grade 10 2. Grade 11 3. Grade 12 (completed high school) 4. Technical / trade school or college 5. Some university, no degree 6. Completed university degree 7. Post-graduate degree (e.g., Master's or PhD, professional programs) 77. Don't know 88. Refuse to answer
Education (<17) (Adapted from CCHS & NHANES)	[Programming note: Ask only if age<17] What is the highest level of formal education that you have completed? 1. Grade 5 or lower 2. Grade 6 3. Grade 7 4. Grade 8 5. Grade 9 6. Grade 10 7. Grade 11 8. Grade 12 / high school diploma or equivalent
Income adequacy (from CFS)	Thinking about your total monthly income, how difficult or easy is it for you to make ends meet? 1. Very difficult 2. Difficult 3. Neither easy nor difficult 4. Easy 5. Very easy 77. Don't know 88. Refuse to answer
Self-reported height	It is helpful to know the height and weight of survey participants. How tall are you without shoes? Report height in… 1. Feet and inches 2. Centimeters [Programming note: display if selected 'feed and inches' above.] *Enter numbers*: _____ feet [numeric, allow 0-12] _____ inches [numeric, allow 0-12] [Programming note: display if selected 'centimeters' above.] *Enter number*: _____ cm [numeric, allow 100-250]

	77. Don't know 88. Refuse to answer
Self-reported weight	How much do you weigh without clothes or shoes? Report weight in… 1. Pounds 2. Kilograms [Programming note: display if selected 'pounds' above.] *Enter number*: _____ pounds [numeric, allow 60-999] [Programming note: display if selected 'kilograms' above.] *Enter number*: _____ kg [numeric, allow 30-500] 77. Don't know 88. Refuse to answer
END & REMUNERATION	
End transition text	Thank you! You are almost done the survey. Please click NEXT to see which purchase you made.
Beverage & Change	[Programming note: survey to randomly select one of the five purchases & display corresponding text] Congratulations! You will receive the [*display snack or beverage and change from one randomly selected purchase task*] that you purchased. PLEASE SHOW THIS SCREEN TO THE RESEARCH ASSISTANT. 1. Okay [RA to give participant their food or beverage and change that was randomly selected] [RA reads:] "We just have one more question for you to complete."
Plan for consumption	Do you plan to… 1. Eat (or drink) your purchased item now 2. Save it for later 77. Don't know 88. Refuse to answer
Remuneration Confirmation	[Programming note: only display for participants who have completed all purchasing tasks] I confirm that I have received a food or beverage item and my change from a $5.00 budget in return for completing the Food & Beverage Experimental Marketplace Study. I further acknowledge that: • this amount received from the University of Waterloo is taxable;

	• that it is my responsibility to report the amount received for income tax purposes; and • the University of Waterloo will not issue a tax receipt for the amount received. I have received the promised remuneration, and acknowledge that this amount received is taxable: 1. Confirm
Withdrawal Remuneration	[Programming note: direct participants here if they withdraw from the study prior to completing all purchasing tasks.] I confirm that I have received $5.00 in return for participating in the Food & Beverage Experimental Marketplace Study, and/or a food or beverage product of my selection. I further acknowledge that: • this amount received from the University Waterloo is taxable; • that it is my responsibility to report the amount received for income tax purposes; and • the University of Waterloo will not issue a tax receipt for the amount received. I have received the promised remuneration, and acknowledge that this amount received is taxable: 1. Confirm
Thank you text	Thank you for completing our survey! Your responses are very important to us.

Appendix C: Beverage and snack food product details

Table C1. Ratings/labels corresponding to label conditions for all beverage and snack food products included in the purchasing tasks

		High in			MTL			Health star rating	Nutrition grade
		Sugar	*Sodium*	*Sat fat*	*Sugar*	*Sodium*	*Sat fat*		
Beverages									
Product	*Flavour/variety*								
Coca Cola		●			High	Low	Low	★	E
Diet Coke					Low	Low	Low	★★	D
Pepsi		●			High	Low	Low	★	E
Diet Pepsi					Low	Low	Low	★★	D
7-Up		●			High	Low	Low	★	E
Diet 7-Up					Low	Low	Low	★★	D
Orange Crush		●			High	Low	Low	★	E
Gatorade Original	Lemon-Lime	●			High	Low	Low	★1/2	D
Gatorade Original	Fruit Punch	●			High	Low	Low	★1/2	D
Gatorade Low-Cal G2	Fruit Punch				Low	Low	Low	★★	D
VitaminWater	XXX (berry-pomegranate)	●			High	Low	Low	★1/2	D
VitaminWater	Energy (tropical citrus)	●			High	Low	Low	★1/2	D
VitaminWater ZERO	XOXOX (diet berry-pomegranate)				Low	Low	Low	★★	D
Nestea Lemon Iced Tea		●			High	Low	Low	★1/2	D
Minute Maid Lemonade		●			High	Low	Low	★1/2	D
Minute Maid Apple Juice		●			High	Low	Low	★★★★★	A
Minute Maid Orange Juice		●			High	Low	Low	★★★★★	A
Neilson 2% White Milk				●	Medium	Low	High	★★★★1/2	A
Neilson 1% Chocolate Milk		●			High	Low	Low	★★★★	B
Real Canadian Spring Water					Low	Low	Low	★★★★★	A
Snack foods									
Product	*Flavour/variety*								

Potato chips	Lay's Salt & Vinegar		●		Low	High	Medium	★★1/2	C
Potato chips	Lay's Oven Baked Original				Medium	Medium	Medium	★★★★	B
Popcorn	Smartfood White Cheddar		●	●	Low	High	High	★★	D
Popcorn	Skinny Pop				Low	Medium	Medium	★★★★	B
Crackers/snack	Garden Veggie Straws		●		Low	High	Medium	★★1/2	C
Crackers/snack	Cheddar Goldfish		●		Low	High	Medium	★★	D
Candy gummies	Maynards Gummy Bears	●			High	Low	Low	★★	D
Chocolate bar	Snickers	●		●	High	Medium	High	★	E
Granola/cereal bar	Quaker Chewy Yogurt Bars	●		●	High	Medium	High	★1/2	D
Power/energy bar	Clif Energy Bar Chocolate Chip	●			High	Medium	Medium	★★1/2	C
Cookies	Mrs. Fields	●		●	High	Medium	High	★	E
Nuts	Planters Salted Peanuts			●	Low	Medium	High	★★★★	B
Nuts	Blue Diamond Salted Almonds				Low	Medium	Medium	★★★★★	A
Fresh fruit	Apple	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Fresh vegetable	Baby Carrots Snack Pack	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Yogurt	Beatrice Strawberry Fruit Bottom	●		●	High	Low	High	★★1/2	C
Yogurt	Iögo Fat Free Berry				Low	Low	Low	★★★★1/2	A
Cheese snack	Marbelicious Cheestrings		●	●	Low	High	High	★★★★★	A
Cheese snack	Mini-Babybel, Light		●	●	Low	High	High	★★★★★	A
Meat snack	Schneiders Hot Rods		●	●	Medium	High	High	1/2	E

Table C2. Prices corresponding to tax conditions for all beverage and snack food products included in the purchasing tasks

		Tax Conditions				
		No tax	**20% SSB** [a]	**20% SD** [b]	**Tiered SSB** [c]	**Tiered SD** [d]
Beverages						
Product	*Flavour/variety*					
Coca Cola		$ 2.49	$ 2.99 *	$ 2.99 *	$ 2.99 *	$ 2.99 *
Diet Coke		$ 2.49	$ 2.49	$ 2.49	$ 2.49	$ 2.49
Pepsi		$ 2.49	$ 2.99 *	$ 2.99 *	$ 2.99 *	$ 2.99 *
Diet Pepsi		$ 2.49	$ 2.49	$ 2.49	$ 2.49	$ 2.49
7-Up		$ 2.49	$ 2.99 *	$ 2.99 *	$ 2.99 *	$ 2.99 *
Diet 7-Up		$ 2.49	$ 2.49	$ 2.49	$ 2.49	$ 2.49
Orange Crush		$ 2.49	$ 2.99 *	$ 2.99 *	$ 2.99 *	$ 2.99 *
Gatorade Original	Lemon-Lime	$ 2.59	$ 3.11 *	$ 3.11 *	$ 2.85 *	$ 2.85 *
Gatorade Original	Fruit Punch	$ 2.59	$ 3.11 *	$ 3.11 *	$ 2.85 *	$ 2.85 *
Gatorade Low-Cal G2	Fruit Punch	$ 2.59	$ 2.59	$ 2.59	$ 2.59	$ 2.59
VitaminWater	XXX (berry-pomegranate)	$ 2.89	$ 3.47 *	$ 3.47 *	$ 3.18 *	$ 3.18 *
VitaminWater	Energy (tropical citrus)	$ 2.89	$ 3.47 *	$ 3.47 *	$ 3.18 *	$ 3.18 *
VitaminWater ZERO	XOXOX (diet berry-pomegranate)	$ 2.89	$ 2.89	$ 2.89	$ 2.89	$ 2.89
Nestea Lemon Iced Tea		$ 2.49	$ 2.99 *	$ 2.99 *	$ 2.99 *	$ 2.99 *
Minute Maid Lemonade		$ 2.79	$ 3.35 *	$ 3.35 *	$ 3.35 *	$ 3.35 *
Minute Maid Apple Juice		$ 2.79	$ 2.79	$ 3.35 *	$ 2.79	$ 3.35 *
Minute Maid Orange Juice		$ 2.79	$ 2.79	$ 3.35 *	$ 2.79	$ 3.35 *
Neilson 2% White Milk		$ 2.19	$ 2.19	$ 2.19	$ 2.19	$ 2.19
Neilson 1% Chocolate Milk		$ 2.19	$ 2.63 *	$ 2.63 *	$ 2.63 *	$ 2.63 *
Real Canadian Spring Water		$ 1.69	$ 1.69	$ 1.69	$ 1.69	$ 1.69
Snack foods						
Product	*Flavour/variety*	**No tax**	**20%**		**Tiered**	
Potato chips	Lay's Salt & Vinegar	$ 1.49	$ 1.49		$ 1.49	
Potato chips	Lay's Oven Baked Original	$ 1.49	$ 1.49		$ 1.49	

Popcorn	Smartfood White Cheddar	$ 1.49	$ 1.49	$ 1.49
Popcorn	Skinny Pop	$ 1.49	$ 1.49	$ 1.49
Crackers/snack	Garden Veggie Straws	$ 1.49	$ 1.49	$ 1.49
Crackers/snack	Cheddar Goldfish	$ 1.49	$ 1.49	$ 1.49
Candy gummies	Maynards Gummy Bears	$ 1.19	$ 1.43 *	$ 1.43 *
Chocolate bar	Snickers	$ 1.19	$ 1.43 *	$ 1.43 *
Granola/cereal bar	Quaker Chewy Yogurt Bars	$ 0.98	$ 1.18 *	$ 1.18 *
Power/energy bar	Clif Energy Bar Chocolate Chip	$ 1.89	$ 2.27 *	$ 2.27 *
Cookies	Mrs. Fields	$ 1.39	$ 1.67 *	$ 1.67 *
Nuts	Planters Salted Peanuts	$ 1.29	$ 1.29	$ 1.29
Nuts	Blue Diamond Salted Almonds	$ 1.29	$ 1.29	$ 1.29
Fresh fruit	Apple	$ 0.89	$ 0.89	$ 0.89
Fresh vegetable	Baby Carrots Snack Pack	$ 0.89	$ 0.89	$ 0.89
Yogurt	Beatrice Strawberry Fruit Bottom	$ 1.19	$ 1.43 *	$ 1.31 *
Yogurt	Iögo Fat Free Berry	$ 1.19	$ 1.19	$ 1.19
Cheese snack	Marbelicious Cheestrings	$ 0.98	$ 0.98	$ 0.98
Cheese snack	Mini-Babybel, Light	$ 0.98	$ 0.98	$ 0.98
Meat snack	Schneiders Hot Rods	$ 1.29	$ 1.29	$ 1.29

[a] Beverages containing > 5 g of *added sugar* per 100 ml were assigned a 20% tax.
[b] Beverages containing > 5 g of *free sugar* per 100 ml were assigned a 20% tax.
[c] Beverages containing 5-8 g *added sugar* per 100 ml were assigned a 10% tax; beverages containing > 8 g of *added sugar* per 100 ml were assigned a 20% tax.
[d] Beverages containing 5-8 g *free sugar* per 100 ml were assigned a 10% tax; beverages containing > 8 g of *free sugar* per 100 ml were assigned a 20% tax.
[e] Snack foods containing > 10 g total sugar per 100 g were assigned a 20% tax.
[f] Snack foods containing 10-20 g total sugar per 100 g were assigned a 10% tax; foods containing > 20 g total sugar per 100 g were assigned a 20% tax.
* Tax applies.

Table C3. Nutrition information of all beverage and snack food products included in the purchasing tasks

		Serving volume (mL)	**Calories** (kcal)	**Sugar** (g)	**Sodium** (mg)	**Saturated fat** (g)
Beverages						
Product	*Flavour/variety*					
Coca Cola		500	200	55	40	0
Diet Coke		500	0	0	55	0
Pepsi		591	260	69	20	0
Diet Pepsi		591	0	0	40	0
7-Up		591	260	70	100	0
Diet 7-Up		591	5	0	100	0
Orange Crush		591	270	71	120	0
Gatorade Original	Lemon-Lime	591	150	35	250	0
Gatorade Original	Fruit Punch	591	150	35	250	0
Gatorade Low-Cal G2	Fruit Punch	591	50	12	270	0
VitaminWater	XXX (berry-pomegranate)	591	130	32	0	0
VitaminWater	Energy (tropical citrus)	591	120	32	0	0
VitaminWater ZERO	XOXOX (diet berry-pomegranate)	591	0	1	0	0
Nestea Lemon Iced Tea		500	160	43	50	0
Minute Maid Lemonade		450	200	52	30	0
Minute Maid Apple Juice		450	210	48	40	0
Minute Maid Orange Juice		450	220	45	30	0
Neilson 2% White Milk		250	130	12	120	3
Neilson 1% Chocolate Milk		250	160	26	170	2
Real Canadian Spring Water		500	0	0	0	0
Snack foods						
Product	*Flavour/variety*	(g)				
Potato chips	Lay's Salt & Vinegar	60	320	1	530	2
Potato chips	Lay's Oven Baked Original	32	150	3	180	0.5
Popcorn	Smartfood White Cheddar	45	250	2	370	3
Popcorn	Skinny Pop	18	100	0	45	0.5

Crackers/snack	Garden Veggie Straws	28	130	1	210	1
Crackers/snack	Cheddar Goldfish	28	130	0	230	1
Candy gummies	Maynards Gummy Bears	60	200	32	35	0
Chocolate bar	Snickers	47	220	24	115	4
Granola/cereal bar	Quaker Chewy Yogurt Bars	35	150	11	115	2.5
Power/energy bar	Clif Energy Bar Chocolate Chip	68	250	21	150	1.5
Cookies	Mrs. Fields	60	270	24	230	5
Nuts	Planters Salted Peanuts	60	390	3	180	6
Nuts	Blue Diamond Salted Almonds	23	140	1	70	1
Fresh fruit	Apple	150	80	16	0	0
Fresh vegetable	Baby Carrots Snack Pack	65	25	4	30	0
Yogurt	Beatrice Strawberry Fruit Bottom	175	170	25	100	3
Yogurt	Iögo Fat Free Berry	100	35	3	45	0
Cheese snack	Marbelicious Cheestrings	21	60	0	150	2
Cheese snack	Mini-Babybel, Light	20	45	0	140	1.5
Meat snack	Schneiders Hot Rods	19	105	1	375	4

Appendix D: Chapter 4 supplementary information

Table D1. Interaction effects from linear mixed models modelling the effects of sugar taxes and FOP labels on (a) sugars purchased in beverages, (b) calories purchased in beverages, (c) sugars purchased in snack foods, and (d) calories purchased in snack foods in an experimental marketplace.

			95% CI		
Variable	**β**	**SE**	**low**	**high**	***p***
(a) Sugars (g) purchased in beverages					
Tax condition × Sex					
[**20% SSB**] (vs. no tax) × [**male**] (vs. female)	-0.42	0.67	-1.74	0.89	.530
[**20% SD**] (vs. no tax) × [**male**] (vs. female)	0.99	0.67	-0.32	2.31	.139
[**tiered SSB**] (vs. no tax) × [**male**] (vs. female)	-0.20	0.67	-1.52	1.12	.765
[**tiered SD**] (vs. no tax) × [**male**] (vs. female)	1.75	0.67	0.44	3.07	.009*
[**20% SD**] (vs. 20% SSB) × [**male**] (vs. female)	1.42	0.67	0.10	2.73	.035
[**tiered SSB**] (vs. 20% SSB) × [**male**] (vs. female)	0.22	0.67	-1.10	1.54	.742
[**tiered SD**] (vs. 20% SSB) × [**male**] (vs. female)	2.18	0.67	0.86	3.49	.001*
[**tiered SSB**] (vs. 20% SD) × [**male**] (vs. female)	-1.19	0.67	-2.51	0.12	.075
[**tiered SD**] (vs. 20% SD) × [**male**] (vs. female)	0.76	0.67	-0.56	2.08	.258
[**tiered SSB**] (vs. tiered SD) × [**male**] (vs. female)	-1.96	0.67	-3.27	-0.64	.004*
Tax condition × Age					
[**20% SSB**] (vs. no tax) × **Age**	0.07	0.02	0.03	0.11	<.001*
[**20% SD**] (vs. no tax) × **Age**	0.11	0.02	0.07	0.15	<.0001*
[**tiered SSB**] (vs. no tax) × **Age**	0.08	0.02	0.04	0.12	<.001*
[**tiered SD**] (vs. no tax) × **Age**	0.12	0.02	0.08	0.16	<.0001*
[**20% SD**] (vs. 20% SSB) × **Age**	0.03	0.02	-0.01	0.07	.093
[**tiered SSB**] (vs. 20% SSB) × **Age**	0.01	0.02	-0.03	0.05	.714
[**tiered SD**] (vs. 20% SSB) × **Age**	0.04	0.02	0.01	0.08	.035
[**tiered SSB**] (vs. 20% SD) × **Age**	-0.03	0.02	-0.07	0.01	.189
[**tiered SD**] (vs. 20% SD) × **Age**	0.01	0.02	-0.03	0.05	.665
[**tiered SSB**] (vs. tiered SD) × **Age**	-0.04	0.02	-0.08	0.01	.081
(b) Calories (kcal) purchased in beverages					
Tax condition × Sex					
[**20% SSB**] (vs. no tax) × [**male**] (vs. female)	-2.79	2.70	-8.08	2.51	.303
[**20% SD**] (vs. no tax) × [**male**] (vs. female)	3.29	2.70	-2.01	8.59	.224
[**tiered SSB**] (vs. no tax) × [**male**] (vs. female)	-1.56	2.70	-6.86	3.73	.563
[**tiered SD**] (vs. no tax) × [**male**] (vs. female)	5.80	2.70	0.51	11.10	.032
[**20% SD**] (vs. 20% SSB) × [**male**] (vs. female)	6.07	2.70	0.78	11.37	.025
[**tiered SSB**] (vs. 20% SSB) × [**male**] (vs. female)	1.22	2.70	-4.08	6.52	.651
[**tiered SD**] (vs. 20% SSB) × [**male**] (vs. female)	8.59	2.70	3.29	13.89	.001*
[**tiered SSB**] (vs. 20% SD) × [**male**] (vs. female)	-4.85	2.70	-10.15	0.44	.073
[**tiered SD**] (vs. 20% SD) × [**male**] (vs. female)	2.52	2.70	-2.78	7.81	.352
[**tiered SSB**] (vs. tiered SD) × [**male**] (vs. female)	-7.37	2.70	-12.67	-2.07	.006*
Tax condition × Age					
[**20% SSB**] (vs. no tax) × **Age**	0.24	0.08	0.08	0.41	.004*
[**20% SD**] (vs. no tax) × **Age**	0.41	0.08	0.24	0.57	<.0001*
[**tiered SSB**] (vs. no tax) × **Age**	0.28	0.08	0.11	0.44	.001*
[**tiered SD**] (vs. no tax) × **Age**	0.47	0.08	0.30	0.63	<.0001*
[**20% SD**] (vs. 20% SSB) × **Age**	0.17	0.08	0.01	0.33	.047
[**tiered SSB**] (vs. 20% SSB) × **Age**	0.03	0.08	-0.13	0.20	.689
[**tiered SD**] (vs. 20% SSB) × **Age**	0.23	0.08	0.06	0.39	.007*
[**tiered SSB**] (vs. 20% SD) × **Age**	-0.13	0.08	-0.30	0.03	.133

[**tiered SD**] (vs. 20% SD) × **Age**	0.06	0.08	-0.10	0.22	.465
[**tiered SSB**] (vs. tiered SD) × **Age**	-0.19	0.08	-0.36	-0.03	.021
Tax condition × Thirst					
[**20% SSB**] (vs. no tax) × [**slightly/moderately**] (vs. not at all)	-11.53	4.64	-20.63	-2.43	.013
[**20% SSB**] (vs. no tax) × [**very/extremely**] (vs. not at all)	-5.27	5.24	-15.54	5.00	.314
[**20% SSB**] (vs. no tax) × [**slightly/moderately**] (vs. very/extremely)	-6.26	3.30	-12.74	0.21	.058
[**20% SD**] (vs. no tax) × [**slightly/moderately**] (vs. not at all)	-8.96	4.64	-18.06	0.14	.054
[**20% SD**] (vs. no tax) × [**very/extremely**] (vs. not at all)	-6.69	5.24	-16.96	3.58	.202
[**20% SD**] (vs. no tax) × [**slightly/moderately**] (vs. very/extremely)	-2.26	3.30	-8.74	4.21	.493
[**tiered SSB**] (vs. no tax) × [**slightly/moderately**] (vs. not at all)	-14.04	4.64	-23.14	-4.95	.002*
[**tiered SSB**] (vs. no tax) × [**very/extremely**] (vs. not at all)	-13.07	5.24	-23.34	-2.80	.013
[**tiered SSB**] (vs. no tax) × [**slightly/moderately**] (vs. very/extremely)	-0.98	3.30	-7.45	5.50	.767
[**tiered SD**] (vs. no tax) × [**slightly/moderately**] (vs. not at all)	-9.36	4.64	-18.46	-0.26	.044
[**tiered SD**] (vs. no tax) × [**very/extremely**] (vs. not at all)	-2.01	5.24	-12.28	8.26	.701
[**tiered SD**] (vs. no tax) × [**slightly/moderately**] (vs. very/extremely)	-7.35	3.30	-13.82	-0.87	.026
[**20% SD**] (vs. 20% SSB) × [**slightly/moderately**] (vs. not at all)	2.58	4.64	-6.52	11.68	.579
[**20% SD**] (vs. 20% SSB) × [**very/extremely**] (vs. not at all)	-1.42	5.24	-11.69	8.85	.786
[**20% SD**] (vs. 20% SSB) × [**slightly/moderately**] (vs. very/extremely)	4.00	3.30	-2.48	10.47	.226
[**tiered SSB**] (vs. 20% SSB) × [**slightly/moderately**] (vs. not at all)	-2.51	4.64	-11.61	6.59	.588
[**tiered SSB**] (vs. 20% SSB) × [**very/extremely**] (vs. not at all)	-7.80	5.24	-18.07	2.47	.137
[**tiered SSB**] (vs. 20% SSB) × [**slightly/moderately**] (vs. very/extremely)	5.29	3.30	-1.19	11.76	.110
[**tiered SD**] (vs. 20% SSB) × [**slightly/moderately**] (vs. not at all)	2.18	4.64	-6.92	11.28	.639
[**tiered SD**] (vs. 20% SSB) × [**very/extremely**] (vs. not at all)	3.26	5.24	-7.01	13.53	.534
[**tiered SD**] (vs. 20% SSB) × [**slightly/moderately**] (vs. very/extremely)	-1.08	3.30	-7.56	5.39	.743
[**tiered SSB**] (vs. 20% SD) × [**slightly/moderately**] (vs. not at all)	-5.09	4.64	-14.19	4.01	.273
[**tiered SSB**] (vs. 20% SD) × [**very/extremely**] (vs. not at all)	-6.38	5.24	-16.65	3.90	.224
[**tiered SSB**] (vs. 20% SD) × [**slightly/moderately**] (vs. very/extremely)	1.29	3.30	-5.19	7.76	.697
[**tiered SD**] (vs. 20% SD) × [**slightly/moderately**] (vs. not at all)	-0.40	4.64	-9.50	8.70	.932
[**tiered SD**] (vs. 20% SD) × [**very/extremely**] (vs. not at all)	4.68	5.24	-5.59	14.95	.372
[**tiered SD**] (vs. 20% SD) × [**slightly/moderately**] (vs. very/extremely)	-5.08	3.30	-11.55	1.39	.124
[**tiered SSB**] (vs. tiered SD) × [**slightly/moderately**] (vs. not at all)	-4.69	4.64	-13.79	4.41	.313
[**tiered SSB**] (vs. tiered SD) × [**very/extremely**] (vs. not at all)	-11.06	5.24	-21.33	-0.79	.035
[**tiered SSB**] (vs. tiered SD) × [**slightly/moderately**] (vs. very/extremely)	6.37	3.30	-0.11	12.84	.054
(c) Sugars (g) purchased in snack foods					
Tax condition × Age					
[**20%**] (vs. no tax) × **Age**	0.04	0.01	0.02	0.06	<.001*
[**tiered**] (vs. no tax) × **Age**	0.03	0.01	0.01	0.05	.005*
[**tiered**] (vs. 20%) × **Age**	-0.01	0.01	-0.03	0.01	.510
(d) Calories (kcal) purchased in snack foods					
Tax condition × Education					
[**20%**] (vs. no tax) × [**trade school/college**] (vs. high school)	6.30	4.88	-3.27	15.88	.197
[**20%**] (vs. no tax) × [**university**] (vs. high school)	-0.34	3.26	-6.74	6.06	.918
[**20%**] (vs. no tax) × [**trade school/college**] (vs. university)	6.64	4.37	-1.92	15.20	.129
[**tiered**] (vs. no tax) × [**trade school/college**] (vs. high school)	7.05	4.88	-2.52	16.63	.149
[**tiered**] (vs. no tax) × [**university**] (vs. high school)	-6.10	3.26	-12.50	0.30	.062
[**tiered**] (vs. no tax) × [**trade school/college**] (vs. university)	13.15	4.37	4.59	21.72	.003*
[**tiered**] (vs. 20%) × [**trade school/college**] (vs. high school)	0.75	4.88	-8.82	10.33	.878
[**tiered**] (vs. 20%) × [**university**] (vs. high school)	-5.76	3.26	-12.16	0.64	.078

[**tiered**] (vs. 20%) × [**trade school/college**] (vs. university)	6.51	4.37	-2.05	15.08	.136

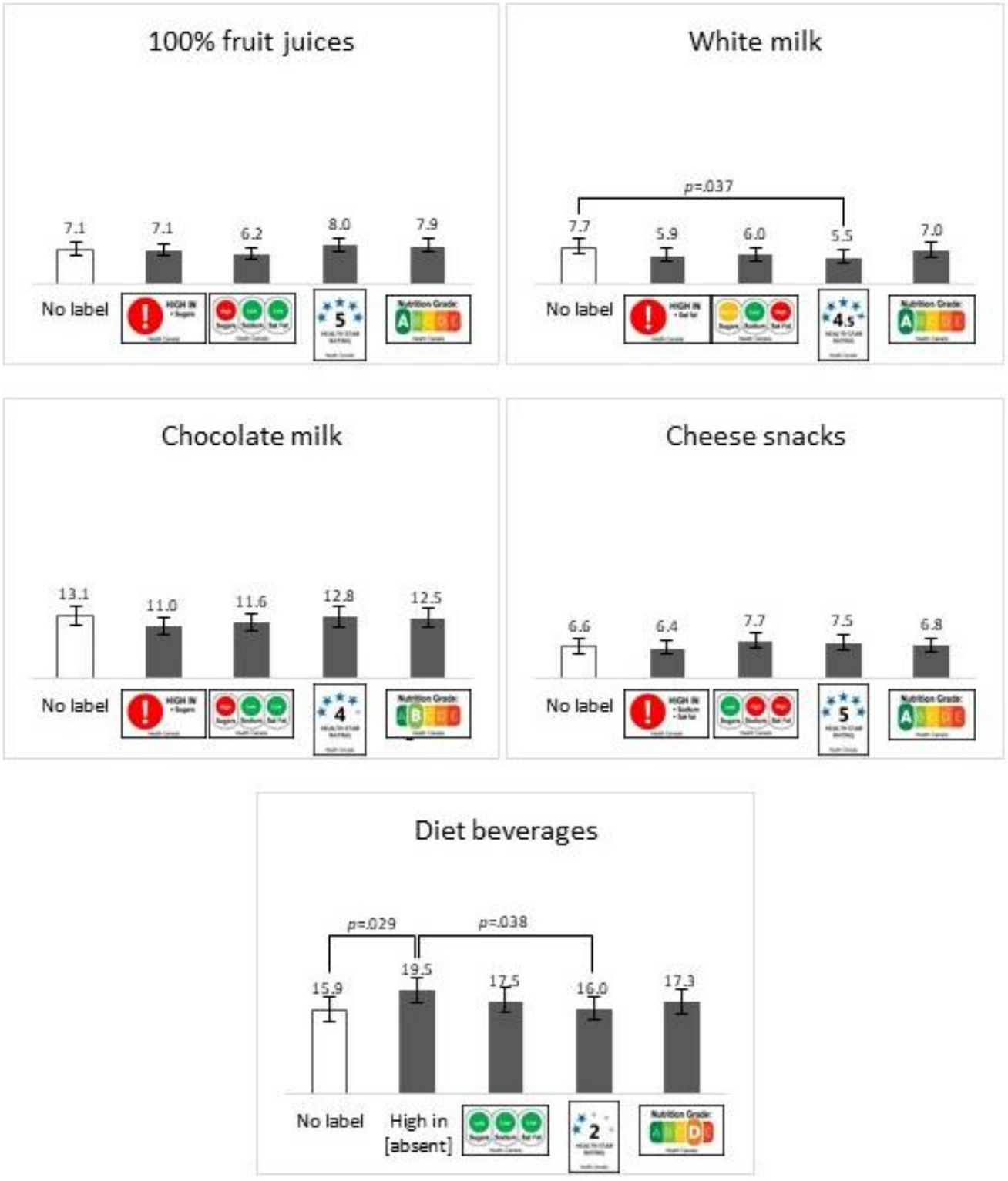
*Significant after Benjamini-Hochberg adjustment assuming a false discovery rate of 0.05.
95% CI, 95% confidence interval; SD, sugary drink; SE, standard error; SSB, sugar-sweetened beverage.

Appendix E: Chapter 5 supplementary information

Table E1. Mean % of sample who purchased each product across all tax conditions, among participants who noticed the labels (N=1,990)

		No label	High in	MTL	HSR	Nutrition grade
BEVERAGES						
1	Coke	4.6	3.1	3.0	3.7	4.1
2	Diet Coke	3.9	5.7	5.0	5.9	5.3
3	Pepsi	1.2	1.8	0.4	1.0	1.1
4	Diet Pepsi	2.2	0.7	2.6	1.8	2.7
5	7-Up	2.7	2.1	3.0	2.3	2.9
6	Diet 7-Up	1.0	1.8	1.9	1.0	1.4
7	Orange Crush	3.3	2.2	2.2	2.0	2.4
8	Gatorade - Lemon Lime	2.5	2.0	1.4	1.4	2.0
9	Gatorade - Fruit Punch	2.1	1.4	1.9	2.0	1.8
10	Gatorade (Low Cal) - Fruit Punch	3.3	5.0	4.9	3.4	3.8
11	Vitamin Water XXX	3.0	4.3	3.6	2.9	3.3
12	Vitamin Water Energy	2.7	1.5	2.3	2.0	1.4
13	Vitamin Water Zero XOXOX	3.9	9.0	6.8	6.9	4.5
14	Nestea	7.2	9.1	8.2	5.5	6.4
15	Lemonade	2.0	1.8	1.8	2.5	2.4
16	Apple Juice	3.5	2.8	2.3	4.3	3.7
17	Orange Juice	4.3	4.0	2.5	4.9	5.6
18	2% MF White Milk	8.2	5.6	6.8	5.8	5.5
19	1% MF Chocolate Milk	14.4	10.2	12.5	12.3	13.9
20	Water	24.3	25.9	26.9	28.5	25.8
SNACK FOODS						
1	Lays Salt & Vinegar Chips	6.9	4.6	5.7	4.5	6.6
2	Lays Oven Baked Chips	6.5	7.0	3.7	6.3	3.9
3	Smartfood Popcorn	10.6	7.2	7.8	6.7	7.9
4	Skinny Pop	4.4	7.1	6.5	5.5	5.7
5	Veggie Straws	5.4	6.1	7.1	6.8	6.3
6	Goldfish Crackers	2.2	2.3	2.5	2.0	2.0
7	Gummy Bears	5.0	5.5	5.4	3.5	4.6
8	Snickers Bar	7.2	8.0	5.0	7.2	6.4
9	Granola Bar	1.6	2.1	1.4	2.6	2.7
10	Clif Bar	7.3	3.2	7.1	6.1	6.6
11	Mrs Fields Cookie	4.4	3.3	4.4	3.4	3.7
12	Salted Peanuts	0.9	1.1	1.6	2.4	1.2
13	Almonds	8.5	9.4	6.2	6.5	10.0
14	Apple	10.6	12.9	14.9	11.5	13.2
15	Carrots	3.5	4.2	7.3	6.8	4.6
16	Strawberry Yogurt	1.9	1.3	1.6	1.9	1.0
17	Iogo 0% Yogurt	4.2	5.2	3.1	4.5	3.9
18	Cheestring	3.0	4.5	3.1	4.9	4.9
19	Light Babybel Cheese	3.4	1.9	4.2	4.6	2.4
20	Hot Rod	2.6	3.0	1.2	2.2	2.0

Figure E1. Estimated means for the percentage of participants across the full sample (N=3,584) who purchased a 100% fruit juice, 2% MF white milk, 1% MF chocolate milk, cheese snack, or diet beverage product in an experimental marketplace, by FOP labelling condition. Significant differences are indicated with brackets. Error bars represent 95% confidence intervals.



Appendix F: Chapter 6 supplementary information

Table F1. Mean % of sample who purchased each beverage product, by tax condition (N=3,584)

		No tax	20% SSB	20% SD	Tiered SSB	Tiered SD
BEVERAGES						
1	Coke	4.5	3.7	4.2	3.7	4.1
2	Diet Coke	4.0	4.9	5.0	4.9	4.9
3	Pepsi	1.6	1.3	1.2	1.3	1.3
4	Diet Pepsi	1.6	2.0	2.1	2.0	2.1
5	7-Up	2.5	2.3	2.6	2.1	2.6
6	Diet 7-Up	1.0	1.8	1.7	1.7	1.6
7	Orange Crush	3.0	2.2	2.5	2.0	2.2
8	Gatorade - Lemon Lime	2.5	1.5	1.7	2.7	3.1
9	Gatorade - Fruit Punch	2.2	1.2	1.3	1.9	2.2
10	Gatorade (Low Cal) - Fruit Punch	2.1	3.5	4.4	3.5	3.5
11	Vitamin Water XXX	4.4	3.0	2.9	3.5	3.2
12	Vitamin Water Energy	2.5	1.4	1.7	1.8	1.7
13	Vitamin Water Zero XOXOX	3.9	6.4	6.4	5.5	6.2
14	Nestea	8.3	6.9	7.9	6.8	7.5
15	Lemonade	3.3	2.3	1.9	2.2	2.0
16	Apple Juice	3.5	4.2	2.1	4.1	2.3
17	Orange Juice	4.4	5.8	2.9	5.5	2.9
18	2% MF White Milk	4.7	6.7	7.3	6.7	7.1
19	1% MF Chocolate Milk	15.7	11.2	11.8	10.8	11.9
20	Water	24.1	27.5	28.4	27.3	27.7
Moderately sugary beverages (5-8 g sugars) [8, 9, 11, 12]		**11.6**	**7.1**	**7.6**	**9.9**	**10.2**
High sugary beverages (>8 g sugars) [1, 3, 5, 7, 14, 15, 16, 17, 19]		**46.8**	**39.9**	**37.1**	**38.5**	**36.8**
100% fruit juice [16, 17]		**7.9**	**10.0**	**5.0**	**9.6**	**5.2**