The nutrient profile of the beverage market: associations with national-level sugar-sweetened beverage taxes and nutrition labelling policies

by

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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.

I understand that my thesis may be made electronically available to the public.

STATEMENT OF CONTRIBUTIONS

Karen Hock was the sole author for Chapters 1, 2, and 6 which were written under the supervision of Dr. David Hammond and were not written for publication.

This thesis consists in part of three manuscripts written for publication. Exceptions to sole authorship of material apply to research presented in Chapters 3, 4, and 5 and are as follows:

Dr. David Hammond was the Principal Investigator on the Canadian Institutes of Health Research (CIHR) grant which supported this work. Drs. Sharon Kirkpatrick, Gary Sacks, and Lana Vanderlee were co-investigators on the grant and are co-authors of publications relating to this work.

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The research was conducted at the University of Waterloo by Karen Hock under the supervision of Dr. David Hammond. Karen Hock designed the three thesis studies with consultation from Drs. David Hammond, Sharon Kirkpatrick, Gary Sacks, and Lana Vanderlee. Karen Hock conducted data analysis with consultation from Dr. David Hammond, Dr. Maryam Iraniparast, and Ms. Vicki Rynard. Karen Hock drafted all manuscripts, which all co-authors contributed intellectual input on.

As lead author of the three studies, Karen Hock was responsible for conceptualizing study design, conducting data analysis, and drafting and submitting manuscripts. Co-authors provided guidance and feedback on draft manuscripts. Dr. David Hammond provided significant direction and editorial assistance throughout.

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ABSTRACT

Background

A healthy diet across the lifespan is critical to help prevent malnutrition and non-communicable diseases. However, global dietary patterns have shifted in recent decades toward increased intake of less healthful foods and beverages, which are often energy-dense and nutrient-poor. An increasing number of countries have implemented nutrition policies aimed at improving the consumer nutrition environment, such as sugar-sweetened beverage (SSB) taxes, front-of-package nutrition labels (FOPLs), and serving size regulations. While these policies may be associated with reduced sugar consumption, product (re)formulation and/or consumer understanding of nutritional information, several evidence gaps remain on their real-world impact. First, most research on SSB taxes and FOPLs has focused on within-country changes in sales or nutrient content, with less cross-country evidence examining how different policy designs are associated with beverage composition. Second, existing literature on (re)formulation has focused on sugar reduction, with fewer studies examining the presence of low/no-calorie sweeteners (LNCS), which may influence beverage composition without reducing the level of processing. Third, there is limited cross-country evidence comparing serving size formats and amounts.

Research Objectives

The overall objective of this thesis was to examine how nutritional composition, sweetener use, and serving sizes of non-alcoholic pre-packaged beverages vary across countries with different sugar-related policies (i.e., SSB taxes, FOPLs, and serving size regulations). Study 1 examined differences in sugar concentrations across countries and beverage categories. Study 2 examined the proportion of beverages containing sweeteners across countries and beverage categories. Study 3 examined differences in serving size formats ('per 100mL', 'per serving', or both) and voluntary serving sizes on labels selected by brands across countries and beverage categories, when applicable.

Methods

Data for the three studies were based on a market scan of non-alcoholic, pre-packaged beverages across six countries: Australia, Canada, Chile, Mexico, the United Kingdom (UK), and the United States (US). Data were collected by web scraping websites of grocery stores, food delivery platforms, and brands between October 2023 and February 2025. Data collection involved two approaches: manual web scraping (i.e., copying data from brand websites) and automatic web scraping (i.e., applying Python 3.13 scripts to grocery store and food delivery websites). Study 1 included 15,640 beverages from Australia (n=1,728), Canada (n=2,643), Chile (n=1,242), Mexico (n=1,588), the UK (n=2,598), and the US (n=5,841). Linear regression examined cross-country differences in sugar concentrations, adjusting for beverage category and retail source. Proportions of beverages within 1.0g/100mL below (or at) versus above country-specific sugar concentration thresholds from SSB tax or sugar FOPL policies were also examined. Study 2 included 15,994 beverages from Australia (n=2,105), Canada (n=2,672), Chile (n=1,229), Mexico (n=1,564), the UK (n=2,587), and the US (n=5,837). Binary regression models examined differences in sweetener presence between countries and beverage categories, adjusting for beverage category and retail source. Study 3 included 26,552 beverages from Australia (n=4,589), Canada (n=4,907), Chile (n=1,816), Mexico (n=3,430), the UK (n=3,554), and the US (n=8,256). Linear regression examined cross-country differences in serving sizes, adjusting for beverage category and retail source. Proportions examined cross-country differences in serving size formats and containers with multiple servings.

Results

Study 1: Sugar concentrations differed across countries and by policy design. Adjusted mean sugar concentrations were lowest in countries with SSB tax or sugar FOPL policies triggered by sugar-concentration thresholds (the UK: 4.3g/100mL; Chile: 4.3g/100mL) versus other countries (the US: 5.2g/100mL; Mexico: 5.5g/100mL; Australia: 5.5g/100mL; Canada: 6.0g/100mL; all pairwise contrasts $p<0.05$, except Chile versus the UK). The proportion of beverages with sugar concentrations that were 1.0g below (or at) the 5.0g/100mL threshold used by the UK tax and Chile FOPL (versus above) was greatest in the UK (21.6-23.7%) and Chile (23.8-31.7%) versus other

countries (≤12.0-15.2%). Sugar concentrations were lower in countries with threshold-based sugar-related taxes and FOPLs, with greater proportions just below (or at) thresholds.

Study 2: The percentage of beverages with LNCS was highest in countries with mandatory SSB taxes and/or sugar FOPLs (Chile: 64.7%; UK: 48.8%; Mexico: 45.3%) versus countries without mandatory policies (US: 36.1%; Australia: 24.4%; Canada: 17.5%; p<0.001). Similar patterns were observed for combined presence of LNCS and added sugars (Chile: 31.7%; UK: 27.1%; Mexico: 26.5% vs US: 17.4%; Australia: 8.4%; Canada: 7.5%; p<0.001). Patterns were less consistent for added sugars without LNCS (Chile: 45.2%; UK: 59.2%; Mexico: 58.9% vs US: 56.3%; Australia: 46.8%; Canada: 56.4%; p=0.002). Across all countries, LNCS presence was highest in energy drinks (75.2% vs ≤49.5% in other categories) and added sugars presence was lowest in water drinks (36.7% vs ≥52.9% in other categories).

Study 3: **Results:** Over 60% of beverages in Australia, Chile, and the UK used both 'per 100mL' and 'per serving' sizes, while nearly half in Mexico used 'per 100mL' only, and virtually all in Canada and the US used 'per serving' only. Adjusted mean serving sizes were highest in Canada (327.4mL) and the US (340.1mL) versus other countries (≤304.3mL; all contrasts p<0.001). The proportion of small containers (<355mL) with multiple servings was highest in the UK (7.9%) and Mexico (16.1%) versus other countries (≤5.6%), while proportions among moderate containers >355-600mL were highest in the UK (40.1%), Chile (67.5%), and Mexico (79.8%) versus other countries (≤20.1%).

Contribution/Significance

The findings of this thesis add to the growing body of evidence on the complexity of the consumer nutrition environment. Specifically, this thesis highlighted that nutrition policies can shape how beverages are formulated across countries: mandatory policies involving sugar thresholds may incentivize (re)formulation to lower-sugar options and greater LNCS use, suggesting that these approaches do not necessarily improve overall product healthfulness. While these observed patterns are consistent with policy-related differences in product composition, the cross-sectional

design does not allow causal conclusions to be drawn, and other factors may have contributed to differences across countries. Additionally, the findings suggest opportunities to standardize the use of 'per 100mL' and 'per serving' formats, as well as serving size labelling requirements for smaller and larger beverage containers, which may improve the comparability and interpretability of nutrition information across beverages. The branded beverage composition database developed as part of this thesis provides a baseline for ongoing monitoring of beverages across countries, supporting the examination of sugar-related policies aimed at promoting healthier intakes and reducing the burden of diet-related disease worldwide.

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Returning to graduate school after five years in the workforce was one of the hardest decisions I have ever made, and ultimately one of the best. I came back hoping to develop as a researcher, and in doing so I learned that mentorship, collaboration, and community are at the heart of that process. This thesis took many years of work, and it reflects the encouragement and support of the many people who have shaped me, both as a researcher and as a person.

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Over the past few years, I have learned that our greatest accomplishments are never achieved alone. As I look toward the next chapter, I hope to offer others the same encouragement, generosity, and kindness that have made this experience so meaningful.

DEDICATION

For my parents, who built a ladder to the stars and encouraged me to climb on every rung.

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LIST OF ABBREVIATIONS

AOR	Adjusted Odds Ratio
CI	Confidence Interval
FOPL	Front-of-Package Nutrition Label
GDA	Guideline Daily Amounts
HSR	Health Star Rating
LNCS	Low/No-Calorie Sweetener
MTL	Multiple Traffic Light
NSS	Non-Sugar Sweetener
OR	Odds Ratio
SD	Standard Deviation
SE	Standard Error
SSB	Sugar-Sweetened Beverage
UK	United Kingdom
US	United States

LIST OF SYMBOLS

β	Estimated regression coefficient

Chapter 1: INTRODUCTION

1.1 Diet and health

A healthy diet across the lifespan is critical to help prevent malnutrition and non-communicable diseases, such as heart disease, diabetes, and stroke.[1] However, global dietary patterns have shifted in recent decades towards increased intake of energy-dense, nutrient-poor foods and beverages at the expense of fruits, vegetables, and dietary fibre.[2,3] A major driver of this transition is the rising consumption of products typically made from refined ingredients and additives, rather than whole foods, which are often high in calories, added sugars, fats, and sodium.[3]

Increased intake of less healthful foods and beverages, including sugar-sweetened beverages (SSBs; Section 1.2), has been associated with a higher prevalence of obesity worldwide.[2,3] According to the Global Burden of Disease Study, approximately half of adults over 25 years old (2.11 billion) had overweight or obesity in 2021, with prevalence expected to rise to two-thirds (3.80 billion) by 2050.[5] Similar patterns in obesity prevalence have been observed among children and adolescents.[5] While industrial food processing has historically played an important role in improving the safety and availability of the food supply, the current scale of less healthful food and beverage consumption raises concerns for population health[4] and underscores the need for evidence-driven policy interventions to reverse current trends.[3]

1.1.1 Sweeteners and health

Sweeteners play a key role in shaping the nutritional profile of food and beverages. Sweeteners can be classified in different ways, including by caloric value (nutritive versus low/no-calorie sweeteners, LNCS).[6,7] Nutritive sweeteners include regular sugars (e.g., sucrose, high-fructose corn syrup, and honey) and rare sugars (e.g., allulose, tagatose, and xylose), which provide less sweetness and fewer calories than sucrose.[7] In contrast, LNCS include non-sugar sweeteners (NSS; e.g., aspartame, sucralose, and stevia), which are often intensely sweeter than sucrose[8] and provide little or no calories, as well as sugar alcohols (also called 'polyols'; e.g., xylitol, sorbitol, and erythritol) that provide less or the same

sweetness and fewer calories than sucrose.[7,9] While the health impacts of sugar consumption are well-characterized,[10] the effects of LNCS consumption are debated.[11]

1.1.1.1 Sugar and health

Sugar is the most commonly used sweetener in food and beverages worldwide[12] and is often added to improve flavour, colour, texture, and shelf-life.[6,13] Sugar can be classified in different ways: intrinsic sugars are naturally present in whole fruits and vegetables (e.g., fructose), while milk-derived sugars are naturally present in dairy products (e.g., lactose and galactose). Added sugars are monosaccharides and disaccharides added to food and beverages during manufacturing (e.g., sucrose); free sugars include added sugars and sugars naturally found in honey, syrups, and fruit juices, and total sugars include intrinsic, milk-derived, and free sugars.[10]

High intake of free sugars is a major public health concern, with evidence linking consumption to adverse outcomes, including obesity, type 2 diabetes, and cardiovascular disease.[10] Accordingly, the World Health Organization recommends that children and adults consume less than 5%-10% of their total energy from free sugars, or about 25-50g daily for a 2,000-calorie diet.[10] However, a global review of dietary surveys concluded that mean free sugars intake across ages exceeds these recommended guidelines, ranging from 8% in adults aged 65 years and over to 14% in children aged 13-18 years, with similar patterns for added sugars intake.[14] Increasing awareness of the health risks of sugar intake has led to consumer and government demand for lower-sugar options in the food and beverage supply.[15] In response, brands have reduced container sizes and (re)formulated products to contain less sugar, including by substituting with LNCS.[7]

1.1.1.2 Low/no-calorie sweeteners and health

The use of LNCS in the global food and beverage supply has increased in recent decades, driven in part by efforts to reduce the intake of sugar (Sections 1.4 and 1.5) and calories, while maintaining sweetness.[16] While safety assessments of LNCS are conducted by regulatory organizations prior to use, their health effects remain uncertain.[11] Mechanisms underlying outcomes such as weight management,

appetite regulation, sweetness preferences, and the gut microbiota have been identified in cell and animal studies, yet they are not consistently supported in human research.[17]

A major class of LNCS is NSS, which often provide intense sweetness without increasing energy levels.[18] For example, of the eight NSS approved for use by the US Food and Drug Administration, only two are known to contribute calories: aspartame provides 4kcal/g (but is used in such low amounts that the added calories are negligible) and Advantame provides 3.85kcal/g[18] (versus sucrose, which provides 4kcal/g).[19] As a result, NSS are often promoted by the food and beverage industry as a way to help control weight.[20] However, evidence on health effects is mixed, which may reflect generalizing results across a diverse group of compounds and differences in study design.[17] A systematic review and meta-analysis found consumption of NSS led to weight loss in short-term randomized controlled trials (mainly due to decreased energy levels compared with the intake of other sugars),[21] yet NSS were associated with cardiometabolic conditions (e.g., obesity, diabetes, and cardiovascular disease) in long-term prospective cohort studies with follow-ups of two to over 30 years.[21] Consequently, organizations such as the World Health Organization do not recommend their use in promoting healthy weight balance or decreasing the risk of non-communicable diseases.[20] Furthermore, a policy statement from the American Academy of Pediatrics in 2019 concluded that limited research suggests benefits of replacing sugars with NSS among those with conditions including diabetes; that the evidence on the impact of NSS and appetite or sweetness preferences in children is inconsistent; and that long-term safety of NSS use in childhood is unknown.[18] Nevertheless, LNCS are often recommended in clinical guidelines worldwide as an option to help reduce carbohydrate and energy intake, particularly for those with diabetes.[7]

Sugar alcohols are another class of LNCS used in the food industry as low-calorie sweeteners.[22] The eight sugar alcohols approved by the US Food and Drug Administration provide 0 to 2.4kcal/g.[22] As they are poorly broken down and absorbed by the body, sugar alcohols promote a lower glycemic index and insulinemic response than sugars, which may benefit those with type 2 diabetes.[22] However, undigested sugar alcohols can be fermented by gut bacteria, leading to gastrointestinal symptoms such as bloating and gas, which may worsen symptoms among those with irritable bowel syndrome.[22] Consequently, the European Union requires products containing more than 10% sugar alcohol levels to include the warning "excessive consumption may produce laxative effects."[22] In contrast, as research has demonstrated that

plaque-producing oral bacteria cannot break down sugar alcohols, the US Food and Drug Administration and European Food Safety Authority have approved non-cariogenic health claims on certain sugar alcohol-containing products, most notably sugar-free chewing gums.[22] Given their increasing use and potential health implications, ongoing monitoring of LNCS presence in the food and beverage supply is important for characterizing population-level dietary exposure.

1.2 Sugar-sweetened beverages

SSBs are drinks made with added sugars, including carbonated, sports, fruit, and energy drinks, as well as sweetened coffee and tea.[2,23] While 100% fruit juice is not considered an SSB due to the lack of added sugars, it is classified as a 'sugary drink,' a broader category of beverages based on free sugars content.[24,25] Although different forms of sugars may contribute to diet-related chronic diseases,[24] most research in this field has focused on the role of SSBs as a significant source of added sugars worldwide.[26]

1.2.1 Sales and consumption patterns of sugar-sweetened beverages

SSB consumption worldwide increased between 1990 and 2018,[27] with the global non-alcoholic beverage market expected to grow from over USD$1.2 trillion in 2025 to over USD$1.6 trillion by 2030.[28] However, differences in SSB sales vary across countries. For instance, SSBs sales over the past decade have been relatively stable in high income countries, and remain significantly higher than in lower income countries, yet the beverage market is rapidly expanding in lower- and upper-middle income countries.[26,29] In one analysis of Euromonitor data from 2014, the three countries with the highest daily calories sold per capita from SSBs included Chile, Mexico, and the US, with other high-income countries like Canada and Australia among the top 15.[29]

Patterns of SSB sales also vary by beverage category. For example, carbonated beverage sales are increasing in many regions, and already represent the major SSBs sold in Africa, the Middle East, and parts of Asia and Europe.[26] In regions where carbonated beverage sales are stable or decreasing, growth has been offset by increases in other categories, such as energy and sports drinks (in Australasia, North America, and Western Europe), pre-packaged coffee and tea (in Asia), and juice drinks and nectars (in Latin America and the Caribbean).[26]

Similar patterns in SSB consumption have been observed in population-level dietary intake data. For example, a global study of dietary intake data in 2010 (derived from dietary surveys and the United Nations Food and Agriculture Organization's food balances) from nearly 200 countries found that SSB intake was particularly high in the Caribbean and parts of Latin and North America (reaching nearly one to two 8oz servings per day).[30] A more recent cross-sectional study found that SSB consumption in the past seven days varied from a low of 47% in the UK to a high of 81% in Mexico, with rates around 55% for Australia, Canada, and the US.[31] Nationally-representative surveys have found similarly high levels of sugary drink consumption among adults in countries across Latin America, North America, and Europe.[32–35] SSB intake also varies by age, with high consumption often observed among those under 40 years old.[36] For example, an analysis of the 2015 Canadian Community Health Survey found that daily SSB intake per capita was highest among those aged 9-30 years, while consumption of diet or light beverages was highest among adults over 31 years.[37]

Beyond consumption patterns, a small number of studies have used sales data to examine changes in SSB characteristics, including SSB container sizes, in recent decades. One evaluation of carbonated beverage sales data between 2005 and 2019 across Australia, Canada, the UK, and the US found that the most popular container volume was 300-399mL.[38] Additionally, all four countries showed increased growth in containers less than 300mL and decreased sales of those above 2,000mL during the same timeframe.[38] According to industry reports, these trends resulted from greater health consciousness among consumers, convenience, and portion control.[38] Nevertheless, larger container sizes continued to be marketed to provide better monetary value, expand product lines, and meet consumer demand.[38]

Evidence also suggests that LNCS are increasingly used to sweeten SSBs worldwide. For instance, the per capita amount of LNCS sold in SSBs increased between 2007 and 2019 in most regions of the world, particularly in carbonated beverages and bottled water in North America.[39] This increase occurred alongside a global decrease in the per capita sales of added sugars, especially in juice and carbonated beverages in North America.[39] In turn, this pattern indicates that manufacturers may substitute added sugars with LNCS.[39] Collectively, evidence highlights global shifts in SSB sales and composition, including beverage categories, container volumes, and sweeteners used, in recent decades.[26,29,38,39]

1.2.2 Health implications of sugar-sweetened beverages

Although some beverages provide beneficial nutrients, such as vitamin C and calcium, SSBs are a primary source of sugar and calories.[40] For example, a survey of soft drinks worldwide found that the free sugars content of 88% of products with available nutrition data exceeded the World Health Organization's lower recommendation for intake (less than 5% of energy or approximately 25g for adults consuming 2,000 calories each day).[41,42] Specifically, a 330mL can of 7UP, Coca Cola, or Pepsi in any country tested contained at least 32g of sugar.[41] While differences in sugar levels existed across countries (e.g., Schweppes Tonic water varied by 29g/300mL between the US and Argentina), four of seven North American products contained higher levels of free sugars per 330mL than those in Europe (e.g., 14g/330mL difference between Dr Pepper in the US versus Germany).[41]

Consumption of sugars, especially from SSBs, can increase the risk of diet-related chronic diseases through the contribution to excess energy intake.[24] As a result, SSBs have been associated with conditions including obesity, diabetes, and cardiovascular disease.[43] In addition, the high sugar and acid levels in SSBs can lead to dental caries and impaired oral health.[23] According to the 2021 Global Nutrition Report, high SSB consumption was linked with nearly 300,000 avoidable deaths in 2018, with higher percentages of premature deaths in regions such as North America, Latin America, and Africa.[44] Individuals with minority ethnic identities and lower socioeconomic status are often disproportionately affected by obesity and other diet-related disorders, and often have higher SSB intake.[45,46] As a result of their widespread consumption, poor nutrient profiles, and associations with chronic disease, limited SSB intake is recommended by leading international health organizations, such as the World Health Organization, and national dietary guidelines (e.g., Canada's food guide and Dietary Guidelines for Americans).[24,47–49]

1.3 The food environment

Dietary intake is largely influenced by the food environment, which includes the availability, convenience, cost, marketing, quality, and sustainability of food and drinks in both natural and built locations.[50] The food environment comprises four broad domains: community nutrition environment

(the type, location, and accessibility of food outlets), organizational nutrition environment (food availability in settings such as homes, schools, and workplaces), information environment (media and advertising that can shape consumer perceptions), and consumer nutrition environment (product availability, pricing, and nutrition information).[50] Food environments are shaped by the broader social and political environment (e.g., culture, media, and policies) and interact with individual factors (e.g., nutrition knowledge, income, and time constraints) to influence dietary patterns.[50] Globally, the current food environment promotes diets high in less healthful foods and beverages, largely driven by their wide availability, low cost, and extensive marketing.[2]

Traditionally, the consumer nutrition environment has been examined in physical retail settings; however, it increasingly extends to digital platforms, including online grocery stores and brand websites.[51] The use of these platforms has increased since the COVID-19 pandemic, largely due to the convenience of online shopping, wide product availability, contactless and express delivery options, and competitive prices or promotions.[52] The global online grocery market is projected to increase from nearly USD$402 billion in 2025 to USD$3.9 trillion by 2035.[53] Online platforms can provide detailed information, such as flavours, varieties, container sizes, nutrition facts tables, and ingredient lists, for individual food and beverages, although this information is not consistently provided across retailers. Nevertheless, online retail environments can represent an important and evolving context for understanding beverage availability and nutritional composition, including sweetener exposure. Moreover, these platforms offer new opportunities to systematically monitor food environments across countries, particularly where in-store data collection may be resource-intensive (Section 1.6).

1.4 Policies to reduce sugar-sweetened beverage consumption

Food environments are key targets for interventions that aim to support healthier dietary patterns, as they shape eating decisions through product availability, affordability, and composition.[50] In recent decades, governments worldwide have increasingly implemented policies to reduce the availability and consumption of SSBs.[26] This thesis will focus on two national-level policies: SSB taxes and nutrition labelling (specifically front-of-package nutrition labels (FOPLs) and serving sizes). Other policies that may be associated with SSBs, including restrictions on school sales, marketing and price, and government procurement policies, were considered outside the scope of this analysis.

1.4.1 Sugar-sweetened beverage taxes

Taxation has emerged as a notable strategy to reduce SSB intakes,[26,54] as cost is a primary driver of purchasing decisions.[55] Economic theory suggests that increasing the price of SSBs leads to fewer purchases,[56] a pattern observed with other health-related taxes on products, such as tobacco, alcohol, and calorie-dense foods.[57–60] Reflecting this evidence, the World Health Organization launched the '3 by 35' initiative in 2025 to motivate countries worldwide to increase taxes on tobacco, alcohol, and sugary drinks by ≥50% by 2035 to reduce consumption, future health expenses, and avoidable deaths, while raising revenue for health programs.[61]

To date, SSB taxes have been implemented in more than 50 countries around the world.[62] While cross-country differences in designs exist, these taxes usually target SSBs in various forms (e.g., bottles, powders, and concentrates), yet exclude 100% juices and milk-based drinks.[63] Additionally, most policies have been implemented as excise taxes levied on distributors and manufacturers, who often pass on the cost to consumers.[43] Excise taxes can be implemented as *specific* (e.g., based on sugar levels or drink volume) or *ad valorem* (based on a percentage of price).[64] According to the World Health Organization, specific taxes may provide the greatest impact, particularly when adjusted to inflation, because they tax all eligible products at the same rate, generate consistent revenue, and may be easier to implement than other tax designs.[54,64]

Most specific excise taxes have been designed using flat rates, which similarly affect eligible products, regardless of their sugar level.[65] Table A-1 in Appendix A displays selected SSB taxes currently implemented worldwide. For example, Mexico applies a flat rate of MX$1/L on SSBs, while several US cities with SSB taxes (e.g., Berkeley, Seattle, and Boulder) commonly use rates of USD$0.01/oz.[65] Other countries have instituted taxes based on sugar thresholds to further motivate consumers to decrease sugar intake and stimulate brands to reduce sugar content in beverages.[66] For example, the UK's thresholds are set at 5-8g and >8g of sugar/100mL (at rates of £0.18 and £0.24/L, respectively), while Chile's threshold is set below and above 6.25g of sugar/100mL (at rates of 10% and 18%, respectively).[65] In countries without national SSB taxes, including Canada and Australia, advocates have called for government action to introduce relevant policies.[67,68] Some recent government responses in Canada

include removing the provincial sales tax exemption for sodas (at a rate of 7%) in British Columbia and an SSB tax implemented in September 2022 (at a rate of CAD$0.20/L) in Newfoundland and Labrador, which was subsequently eliminated in 2025.[69–71]

1.4.1.1 Impact of SSB taxes on SSB consumers

Studies evaluating the 'real-world' impact of SSB taxes have found these policies are associated with reduced SSB intake.[43] In a meta-analysis of 17 studies across six jurisdictions, standardizing effects to represent a 10% tax was associated with a 10% decrease in the purchase and consumption of taxed beverage.[72] Similarly, a more recent meta-analysis of 62 studies reported that SSB taxes were associated with increased prices by 8% and decreased SSB sales by 15%.[73]

SSB taxes may particularly reduce SSB intake among low SES populations.[74–76] For example, one study showed that SSB purchases decreased by an average of nearly 8% in the first two years of Mexico's SSB tax compared to expected levels, ranging from a low of 5% to a high of 12% among the highest and lowest SES participants, respectively.[75] These decreases in SSB sales occurred alongside increased purchases of untaxed beverages, especially water.[74,75]

Simulation models have been developed to estimate the potential effects of SSB taxes on health outcomes.[46] To date, modelling studies suggest that SSB taxes not only reduce the risk of developing diet-related conditions, but also decrease the financial burden of these conditions on the healthcare system.[68,77–79] For example, a modelling study estimated the SSB tax in Mexico would reduce type 2 diabetes and obesity by 61,000 and 240,000 cases over 10 years, respectively.[80] Another modelling study found that implementing the Berkeley, California SSB tax on a national level would save approximately USD$24 billion in healthcare spending over 10 years, largely resulting from decreases in body mass index.[78] Additionally, a small number of studies have evaluated health and economic impacts of taxing 100% fruit juices and milk-based products, as they are often excluded in SSB regulations.[81] One modelling study in Canada found that while both SSBs and sugary drinks will lead to a considerable health and economic burden over 25 years, healthcare savings and revenue generation would be nearly CAD$18 billion greater with a 20% sugary drink tax compared to a 20% SSB tax (which would exclude fruit juices and milk-based products) during the same timeframe.[82]

Overall, proponents of SSB taxes claim these policies are health progressive.[43,46] Specifically, they are associated with improved health outcomes and revenue that can be used to fund equity-promoting programs, which may further support low SES populations.[43,46] For instance, revenue from SSB taxes in the US have been used to fund programs that support public health in low income areas, including nutrition education and improvements to parks and schools.[46] However, as individuals of low SES experience the greatest price burden associated with SSB taxes, critics claim these policies are financially regressive.[43] Nevertheless, a systematic review of SSB taxes in high-income countries found that the difference in yearly spending on SSBs between those of low and high SES following taxation may be relatively low (under US$5), suggesting that concerns over the regressivity of SSB taxes in these countries may be limited.[45]

1.4.2 Nutrition labelling policies

Nutrition labelling is a central component of the consumer nutrition environment.[83] As the primary means of communicating information about ingredients and nutrient levels to consumers, these labels can support healthier purchasing decisions.[84] Nutrition labelling may therefore be particularly relevant for pre-packaged beverages, given their typically high sugar and calorie content.[10,84]

Nutrition labels are often found on the back or side of pre-packaged products and may be referred to as nutrition facts labels or tables or nutrition information panels.[85] Systematic reviews have concluded that regular use of back-of-package nutrition labels among adults can support healthier dietary patterns by helping consumers identify and limit nutrients of concern, such as sugar, fat, and sodium.[86,87] However, label effectiveness depends on consumer use and understanding, with greater self-reported use when prompted by researchers and lower use observed in real-world settings.[88] For instance, an online cross-country study found that nearly one-third to one-half of adults across Australia, Canada, Mexico, the UK, and US self-reported using nutrition labels ‘often’ or ‘all the time’,[89] while a cross-country study of European shoppers found that less than one-fifth of participants used nutrition labels when shopping in-store.[90] Additionally, use of nutrition labels varies across populations, with higher use among women, health-conscious individuals, and those of higher income and education levels.[86,87] As

back-of-package nutrition labels often present numerical information that can be difficult to interpret, their use is particularly low among those with limited numeracy skills.[91,92]

1.4.2.1 Front-of-package nutrition labels

FOPLs have been proposed as a way to provide key information on the front of food and beverages to make healthier choices at the point of purchase.[92–94] Unlike nutrition facts tables, FOPLs are designed to be quickly noticed and easily interpreted by consumers.[92–94] A variety of FOPL systems have been implemented in different countries, eight of which are displayed in Table A-2 in Appendix A. These systems can be divided into two main categories: nutrient-specific or summary labels.[95] Nutrient-specific labels highlight information on single nutrients, including sugars.[95] For example, the Guideline Daily Amounts label (GDA, similar to the Facts Up Front or Reference Intake labels) lists nutrient and energy contents per serving and as a percentage of daily value, and is voluntarily used in the US.[95] Multiple Traffic Light (MTL) labels, which are voluntary in countries like the UK, use a similar design, but include traffic light colours to indicate if a product contains high, medium, or low levels of nutrients (displayed as red, orange, or green, respectively).[95,96] 'High in' warning labels, which are mandatory in countries including Chile and Mexico, provide a short statement about the high content of calories or nutrients of concern (e.g., "high in sugar").[94,95] Mexico also includes a FOPL that warns of products containing LNCS,[97] which is listed above text saying "avoid in children".[98] Based on the success of existing systems, such as Chile's, Canada introduced a black-and-white FOPL for food and beverages high in sugar, salt, and/or fat.[99] This FOPL depicts a magnifying glass, with the words "High in" at the top and "Health Canada / Santé Canada" at the bottom.[99,100]

In contrast to nutrient-specific labels, summary labels provide an indication of the overall healthfulness of a product.[96] For example, the Health Star Rating (HSR) system, which is voluntary in countries including Australia, uses ratings that range from half to five stars (indicating least to most healthy).[95] Similarly, Nutri-Score, which was developed in France and later implemented in countries across Europe, denotes product healthfulness (from most to least) using a five-level colour-coded letter scale, ranging from A (dark green) to E (red).[95]

Other FOPL designs have been experimentally tested, but not yet implemented. For instance, pictorial warning labels combine images with statements of harmful health effects.[101] These labels were originally used on cigarette packages to reduce smoking, and have since been investigated as a potential policy option to reduce SSB intake.[101] A pictorial warning label on SSBs could include an image of a gangrenous foot with a warning that excess intake of beverages containing added sugar may lead to type 2 diabetes.[101] Such labels involving graphics, such as icons or symbols, may be particularly important for equity considerations, as they can account for limited proficiency of dominant language(s) or unfamiliarity of sweetener names in ingredient lists.[102,103] However, these labels may also raise concerns over stigma if they disproportionately appear on products that are more commonly consumed by certain population groups. Additional experimentally tested labels have included a "High Added Sugars" warning alone or in combination with a display of added sugars content in teaspoons.[104]

1.4.2.1.1 Impact of front-of-package nutrition labels on consumers

Evidence suggests that FOPLs can help consumers make informed decisions about the products they purchase.[94] Compared to traditional nutrition facts tables, FOPLs are more effective in attracting attention to a product's nutritional information and increase understanding of product healthfulness;[107,108] however, these effects may vary by label design. For example, GDA labels, which were developed by the food industry, are recognized as one of the least effective designs for attracting consumer attention and promoting understanding of nutritional information because they feature the same quantitative nutrient amounts as nutrition facts tables, which have demonstrated limited understanding among consumers.[94,98,108–112] In contrast, 'high in' warning labels are more intuitive and have been shown to help consumers determine the healthfulness of products compared to GDA and MTL labels.[111,113–116]

There is evidence that FOPLs can influence consumer purchases. In a systematic review and meta-analysis, exposure to FOPLs resulted in the purchase of products lower in sugar and sodium when compared to no FOPLs;[117] however, impacts on purchases may differ by label system. In a study of purchase intentions among low- and middle-income Mexicans, the 'high in' warning and MTL labels increased the nutritional quality of products selected when compared to GDA labels.[118] In contrast, experiments in Australia and Brazil have found limited effects of MTL labels on product purchases when

tested alone or compared to 'high in' warning labels.[115,119] Additionally, warning labels, both in the form of text and graphics, have been shown to reduce preferences for and intended purchases of SSBs.[120–123]

The impact of FOPLs may also depend on whether these policies are voluntary or mandatory. Many countries with FOPLs have voluntary policies, which may limit their effectiveness in the real world.[94,95] For example, uptake of HSR labels in Australia and New Zealand has been low, with only about 40% of products displaying labels after 8 years,[124] and some brands have chosen to use labels only on healthier products.[94,125] In turn, limited and selective uptake may lead to low awareness and use of HSR labels among consumers, as observed in a 2020 cross-country study of FOPLs, which reported rates less than 50% awareness and 30% use, respectively, among participants.[89] In contrast, Chile's mandatory FOPL was displayed on 93% of required products after implementation, demonstrating improved compliance,[126] which may enhance consumer awareness and use through increased label exposure. Consequently, mandatory labelling policies may result in greater health benefits.[125,127]

While it will still take years to accurately establish the health outcomes of mandatory warning FOPLs, simulation models suggest they may significantly improve public health and reduce healthcare costs.[77,128] For example, a modelling study estimated that implementation of Mexico's 'high in' warning labels on beverages and snacks would reduce caloric intake and body mass index over five years, ultimately decreasing the prevalence of obesity by at least 1.3 million cases (including over 750,000 cases through changes in beverage consumption alone), as well as obesity-related costs by US$1.8 billion.[77] Similarly, a modelling study found that implementing a 'high in' FOPL in Canada may reduce sugar and calorie intake from beverages, along with other nutrients of concern, resulting in the prevention or avoidance of nearly 2,000-9,000 diet-related deaths, largely from those associated with cardiovascular disease.[129]

1.4.2.2 Serving size policies

Across most countries, back-of-pack nutrition labels are required to display nutrient levels according to a serving size.[130] However, there is no international consensus on best practices for displaying or determining serving sizes. Countries have adopted different serving size labelling requirements across

beverage container sizes and categories. Some jurisdictions, such as Chile, Mexico and the UK, mandate a standard serving size of 100mL across all beverage container sizes and categories to facilitate product comparisons.[130] Mexico and the UK also permit manufacturers to display nutrients in a serving size of their choice, while Chile permits serving sizes by product category (e.g., 200mL for non-alcoholic pre-packaged beverages).[131–133] Other countries, including Canada and the US, mandate 'per serving' labels, with serving size ranges based on reference amounts that reflect typical consumption patterns, often informed by dietary intake data for beverage categories (e.g., 250mL for juices and 375mL for carbonated beverages).[134–136] In Australia, both 'per 100mL' and 'per serving' labels are mandatory, and serving sizes are based on voluntary industry standards (e.g., 250mL for containers >600mL). Overall, there are notable differences in serving size labelling practices across countries.

1.4.2.2.1 Impact of serving size policies on consumers

Differences in serving size formats may impact consumer understanding of beverage content. For instance, using 'per 100mL' labelling facilitates product comparisons; however, presenting these labels alone may be misleading if amounts do not reflect typical consumption.[137] Additionally, calculating nutrient intake from 'per 100mL' labels may be challenging, especially among those with poor numeracy skills.[137,138] In contrast, 'per serving' formats support understanding of nutrient content for products with serving sizes above or below 100mL, and may better inform consumers with dietary considerations, such as diabetes, of nutrient intakes.[137] However, 'per serving' formats alone may limit product comparability when serving sizes vary across similar products and may be less informative when serving sizes do not reflect typical consumption.[137] For example, a cross-sectional, multi-country study reported large variations in serving sizes for single serving beverages, ranging from 100-568mL in the Netherlands and 118-750mL in Canada,[139] which may complicate consumer comparisons and interpretations of beverage contents.[138] Consequently, using both 'per 100mL' and 'per serving' formats may better facilitate product comparisons and support consumer understanding of nutrient intakes than either format alone.[137 140,141] For instance, qualitative research among healthcare professionals in Australia and New Zealand found that nutrition facts tables were used to educate clients on dietary intake, with 'per 100mL' formats preferred for comparing products and 'per serving' formats considered useful when providing a realistic representation of typical consumption.[137] Complementary strategies, such as dual-column labelling ('per serving' and 'per container'), may also improve consumer understanding of the

nutrient content of larger container sizes;[142,143] however, evidence from real-world settings remains scarce.

Interpretation of nutrition information may be affected by the alignment between serving and container size. For larger beverage containers, the serving size is often smaller than the container volume, resulting in multiple servings per container. For example, a 1L beverage may display nutrient levels for a 250mL serving. In contrast, for containers with single servings, the serving size is equivalent to the container volume, and the nutrient levels correspond to amounts consumers will ingest by drinking the entire beverage. Misalignment between serving and container sizes (e.g., small containers appearing as multiple servings or large containers appearing as a single serving) may contribute to underestimation of nutrient intake and overconsumption.[138,144] However, limited research has examined alignment between serving and container sizes of SSBs across countries.

Serving sizes may also influence consumption, although findings are inconsistent and evidence specific to SSBs is limited. One experimental study among US adults reported that larger serving sizes of discretionary foods led to reduced consumption, likely by decreasing perceived healthfulness and increasing calorie estimates and anticipated guilt of consumption.[145] In contrast, another experiment among US adults showed that smaller serving sizes led to increased purchase intentions of discretionary foods among those with dietary concerns, likely by raising perceived healthfulness and reducing anticipated guilt of calorie intake.[146] Consequently, standardizing 'per serving' formats may limit brands from selecting smaller serving sizes to make beverages appear healthier and appeal to 'health conscious' consumers (i.e., by reducing sugar/calorie amounts on labels).[130,146] Collectively, evidence suggests that serving size policies remain an underexplored component of the consumer nutrition environment, despite potential influences on consumer understanding of nutrient contents and consumption.

1.5 Nutrition policies and product (re)formulation

Product availability within the consumer nutrition environment is closely connected to the nutritional composition of the food and beverage supply. Differences in the beverages sold and their formulations may vary across brands and countries due to factors such as consumer taste preferences, regulatory

requirements, or technical capacity of manufacturers,[147] which shape consumer exposure to nutrients of concern, including sweeteners.[148] Consequently, examining cross-country differences in product composition can improve understanding of how policy environments and market conditions influence dietary risks; benchmark product composition across countries; and identify feasible levels of product (re)formulation.

Most of the research comparing product composition across countries has involved salt, with studies finding variations across product categories. For example, an analysis of instant noodles over 10 countries found the mean sodium levels in China were nearly 2.5 times greater than those in New Zealand.[149] Sodium levels of the same product available across countries have also been shown to vary. For instance, a survey of breakfast cereal in 29 countries found that Cornflakes from India had 46% greater sodium levels than those sold in Argentina or Brazil.[150]

Variation in sugar levels in both food and beverages has been observed across countries.[41,150–152] An analysis of breakfast cereals reported that Mexico's Honey Smacks had 25% more sugar than those sold in more than five other countries,[150] while another study found that beverages sold at Kentucky Fried Chicken™ in Germany had lower sugar levels than those in Australia.[151] Additional differences in sugar levels have been found across beverage categories: an evaluation of over 2,000 soft drinks in Romania, Austria, and France revealed that carbonated beverages sold in Romania had the highest sugar levels, while in France, sugar content in fruit drinks was highest among all countries.[152]

These product-level findings are consistent with broader market analyses. The Global Access to Nutrition Index 2024, which examined over 50,000 products from the world's 30 largest food and beverage manufacturers across 25 countries, found large differences in the nutrient profile of beverages across countries and categories.[153] Previous research has also found that multinational corporations may use different sugar concentrations in product formulations across countries, including within the same brands.[154,155] Despite growing evidence of cross-country differences in SSB composition, the drivers of these variations, including policy and market demands, remain unclear. Addressing these gaps is critical to informing strategies that improve the nutritional quality of the global beverage supply.

(Re)formulation is characterized by alterations in a product's nutrient composition.[156] Food and beverage brands regularly (re)formulate products to meet consumer demands, reduce expenses, remain competitive, and comply with regulatory requirements.[147,157] In recent decades, (re)formulation has been recognized as an important public health strategy to improve the healthfulness of food and beverages.[147,158,159] As it does not require changes in consumer behaviour, health-related (re)formulation is an unobtrusive and cost-effective approach to improve population-level dietary intakes.[160,161]

To date, much of the research on product (re)formulation has focused on reducing trans fats and salt/sodium in pre-packaged foods;[159–163] however, (re)formulation may also be key to decreasing sugar concentrations in food and beverages, particularly SSBs.[147,158,164] Brands may (re)formulate SSBs in a variety of ways, including reducing added sugars and/or substituting them with LNCS.[7] Overall, (re)formulation may be conducted subtly (e.g., not advertising reduced sugar concentrations) or overtly (e.g., marketed as lower-sugar options).[86]

Nutrition policies may play a key role in driving (re)formulation by incentivizing brands to improve product healthfulness. Mandatory SSB taxes and FOPLs may encourage (re)formulation to avoid punitive policies, such as financial penalties or negative product perceptions.[94,147,158,161,164] In contrast, voluntary approaches may result in limited changes, due to weaker (re)formulation incentives.[147,157,165] Beyond policy, (re)formulation may be driven by other factors, including consumer demand for healthier options, company size and resources, corporate reputation, and competitor behaviour.[166] Some large brands may undergo voluntary (re)formulation to pre-empt restrictive policies, such as setting voluntary agreements or creating partnerships with health organizations.[158] Brands may also change container and serving sizes, which can influence consumption without altering product composition.[161,164]

1.5.1 Product (re)formulation and sugar-sweetened beverage taxes

SSB taxes create financial incentives for manufacturers to reduce sugar concentrations to avoid taxation and maintain competitive prices.[167] A growing body of evidence across countries has demonstrated that SSB taxes can stimulate product (re)formulation.[164,168–170] However, the extent of (re)formulation may depend on policy design. For example, brands may be more incentivized to reduce sugar concentrations with mandatory policies versus voluntary industry commitments, or sugar

concentration thresholds (which apply higher tax rates to higher-sugar beverages) versus flat-rate volumetric taxes (which apply the same rate per unit volume, regardless of sugar concentration).[171–174]

Research in the UK has shown substantial product (re)formulation after implementation of the threshold-based SSB tax. For example, a repeated cross-sectional study found that average sugar concentrations in soft drinks decreased 34% between 2015 and 2018, with the largest changes occurring during the year of policy implementation.[168] Another study found few changes in taxable soft drinks 50 days after announcing the tax (March 16, 2016; -0.1% compared to counterfactual) and larger decreases 50 days before and after implementation (April 6, 2018; -20% and -30%, respectively), highlighting the policy's impact on (re)formulation.[164] Sustained decreases in sugar concentrations have also been observed, with a government analysis reporting a 47% mean decrease of sugar across taxable beverages between 2015 and 2024, and 'clustering' of sugar concentrations just below the 5g/100mL tax threshold.[175]

Similar (re)formulation patterns have been identified in other jurisdictions with threshold-based SSB taxes. In South Africa, a pre-post study reported that the proportion of taxable beverages (re)formulated to lower sugar concentrations increased from 5.2% to 17.1% between policy announcement and implementation.[169] Likewise, an evaluation in Poland found that the proportion of beverages exceeding sugar thresholds decreased from nearly 70% to 44% following tax implementation, while the availability of tax-exempt products nearly tripled compared to the months before implementation.[170] In contrast, minimal changes in (re)formulation have been observed in countries with a flat-rate tax (e.g., France) or voluntary industry sugar-reduction commitments (e.g., the Netherlands).[174] These findings highlight the role of policy design in shaping industry responses and suggest that mandatory, threshold-based SSB taxes may be most effective in promoting (re)formulation.

1.5.2 Product (re)formulation associated with front-of-package nutrition labelling

FOPLs may incentivize (re)formulation by altering product perception at the point of purchase. Many studies have observed an association between FOPLs and product (re)formulation in both food and beverages, particularly for sodium.[176–181] For example, an evaluation of Pick the Tick, a voluntary label system designed by the National Heart Foundation of New Zealand to demonstrate product

healthfulness, found that over 30t of salt were removed via (re)formulation in the program's first year.[176] Similarly, a study of the Heart & Stroke Foundation of Canada's Health Check program (a labelling system for foods meeting sodium thresholds) found that it promoted product (re)formulation and stimulated the development of new, program-eligible products, resulting in over 800t of sodium eliminated from the food supply over four years.[177] The Choices nutrition logo, which is displayed on products high in fibre and low in nutrients of concern in the Netherlands, was also associated with (re)formulation and the development of new, logo-eligible products, particularly those lower in sodium and higher in fibre.[178]

As with SSB taxes, the effectiveness of FOPLs on (re)formulation may vary by policy design.[182] For example, an evaluation of the Daily Intake Guide (an industry-supported label similar to the GDA) did not find evidence of (re)formulation in Australian breakfast cereals pre- and post-implementation.[182] As this label is not easily understood by consumers and may not influence purchase habits, manufacturers may not have been motivated to (re)formulate when compared to other label systems.[182] In contrast, evaluations of the summary HSR in Australia and New Zealand found that nearly 60-80% of products displaying the HSR underwent (re)formulation over the four years since label implementation, with significant decreases observed in levels of energy, saturated fat, and sodium.[179] Additionally, products with HSRs had lower energy densities and sodium levels compared to those without HSRs.[179] However, as this label is voluntary, differences between products with and without HSRs might have resulted from (re)formulation and/or the selective use of the label on healthier products.[125,179]

Mandatory labels may incentivize (re)formulation more than voluntary policies.[127] For instance, evaluations of Chile's mandatory FOPL have found evidence of (re)formulation after implementation.[180,183] Specifically, a pre-post evaluation found decreases in energy, sugar, and sodium across a variety of product categories, including reductions in sugar by 50-64% and energy by 17-52% among dairy drinks and SSBs, as well as fewer 'high in' sugar FOPLs among SSBs, from nearly 67% to 17%.[181] However, these effects likely reflected the influence of complementary policies, including FOPLs, an SSB tax, and marketing and sales restrictions, implemented in Chile.[181]

1.5.3 Product (re)formulation associated with low/no-calorie sweetener use

In addition to reducing nutrients of concern, manufacturers may (re)formulate by substituting ingredients with similar taste, texture, and other sensory attributes.[184,185] For example, margarine was used as a substitute for butter in the 1960s, leading to an increase in trans-fatty acid intake, while sugar was used as a substitute for fat in the 1980s and 1990s.[184] These examples suggest that (re)formulation strategies targeting single nutrients may alter product composition without necessarily reducing overall levels of food processing.

A similar pattern of ingredient substitution has been observed more recently in beverages: LNCS have been used as a substitute for sugar in SSBs after implementation of SSB taxes and FOPLs in different countries worldwide.[186–188] In Portugal, a pre-post evaluation reported an increase in the proportion of beverages containing NSS following implementation of an SSB tax, alongside reductions in sugar content to concentrations just below policy thresholds.[186] Likewise, a pre-post study in Peru between 2019 and 2021 reported increased NSS use (from nearly 34-62%), alongside decreases in sugar concentrations in beverages and in the proportion of products eligible for a sugar-related FOPL (from 52-24%) after implementation of mandatory FOPLs.[188] However, these changes may have also reflected impacts of the SSB tax implemented in 2018.[188] A pre-post study in Poland reported a decrease in the proportion of beverages with sugar concentrations above the SSB tax threshold (70-44%), alongside a relatively small increase in NSS presence (15%), likely because LNCS were also targeted by the tax policy.[170] Limited cross-country comparisons also demonstrate changes in LNCS presence in response to policy implementation.[187,189] In a study of four supermarket chains in Chile, nearly 75% of non-alcoholic beverages contained at least one NSS post-implementation of the FOPL policy, compared to about 40% in Brazil and Mexico, 25% in the US, and less than 10% in Australia and New Zealand.[189]

Policy design may differentially influence the presence of sweeteners in beverages. For instance, brands may be more incentivized to replace sugar with LNCS in countries with mandatory policies versus voluntary industry commitments, sugar concentration thresholds versus flat-rate volumetric taxes, or policies that discourage LNCS use (e.g., sweetener FOPLs).[171–174] As sugar-related policies often target added sugars, rather than free or total sugars,[7,190,191] LNCS may also be more prevalent in beverage categories that traditionally contain added sugars, such as coffee, energy drinks, sports drinks, soft

drinks, or flavoured waters.[192] Sugar-reduction policies may therefore drive substitution of sugars with LNCS, consistent with reformulation patterns observed for other nutrients. However, the extent of this substitution remains uncertain and may be influenced by other factors, including consumer demand for low/no-sugar or -calorie options,[193] cultural differences in sweetness preferences, and LNCS perceptions.[192]

1.6 Summary: Thesis rationale & aims

Consistent and accurate monitoring systems are needed to examine how policies shape the nutritional quality of the food and beverage supply.[194] While sales data and dietary intake surveys provide insight into changes in consumer purchases and consumption, they offer limited ability to capture product-level changes in composition, such as sweetener presence and concentrations. As a result, food composition databases have emerged as a way of systematically aggregating label-based information on pre-packaged food and beverages available on the market.[195]

Traditionally, food composition databases have relied on data provided by manufacturers and retailers (often voluntarily with low uptake) or collected via photographs during in-store audits (which may be resource-intensive).[196] However, recent advances in technology have significantly improved the development and scalability of food composition databases.[197] Increasingly, automated data collection via web scraping from online retailer websites efficiently captures large amounts of product information,[198] such as ingredient lists, nutrition facts tables, and serving sizes, without the logistical challenges or intensive resources needed for in-store audits. In turn, web scraping is particularly valuable to compare product formulations across categories and countries, where differences in retailer infrastructure, languages, and resources may otherwise limit standardized data collection. Online databases may be particularly important for examining SSB formulations, as sugar concentrations and sweetener presence are listed on product labels.

A growing number of food composition databases have been developed by researchers, private companies, and other independent organizations to monitor the national food and beverage supply. Examples exist across countries, including in Australia,[199] Canada,[198] France,[200] Greece,[201] the

Netherlands,[202] Saudi Arabia,[203] Slovenia,[196] the UK,[204] and the US.[205] These databases have increasingly been used to examine changes in food and beverage composition before and after implementation of policies, such as SSB taxes and FOPLs in Chile and the UK.[206,207] However, cross-country examinations have been limited by differences in data collection, inconsistent beverage classification, lack of branded data, high cost of private databases, and incomplete or outdated records (particularly in open-access databases).[195,197,208] Additionally, few studies have used these databases to examine serving size formats or amounts in relation to serving size regulations within or across countries. As a result, systematic comparisons of sugar concentrations, sweetener presence, and serving sizes across policy environments remain limited. This gap has left important questions unanswered regarding how national-level policies may shape product composition and nutrition labelling across beverage markets.

1.6.1 Thesis rationale and aims

The consumer nutrition environment includes product availability, nutrition information, and other promotional factors that influence consumer decision-making at the point of purchase.[83] An increasing number of countries have implemented nutrition policies aimed at improving this environment, including SSB taxes, FOPLs, and serving size regulations.[130,209,210] Cross-country variation in policy design and implementation[130,209,210] enables comparisons of how different policy environments are associated with the food and beverage supply. Beverages are a particularly relevant category for examination, given their contribution to free sugars intake, the large market share of multinational brands, and their direct targeting by SSB taxes.

Despite increasing adoption of sugar-related policies, several gaps remain on their real-world impact. First, most research on SSB taxes and FOPLs has focused on within-country changes in sales or nutrient content, with less cross-country evidence examining how different policy designs are associated with beverage composition. Second, existing literature on (re)formulation associated with SSB taxes and FOPLs has focused on sugar reduction, with fewer studies examining the presence of LNCS, which may influence beverage composition without reducing the level of processing. Third, there is limited cross-country evidence comparing serving size formats and amounts, highlighting the need for further research to inform policy development. Overall, these gaps highlight the need for standardized research

examining complementary dimensions of the consumer nutrition environment across countries with different sugar-related policy environments.

Thus, the overall objective of this thesis is to examine how the nutritional composition and labelling practices of pre-packaged beverages vary across countries with different sugar-related policies (i.e., SSB taxes, sugar FOPLs, and serving size regulations). This thesis had three specific objectives:

1) Examine sugar concentrations, including means and differences relative to thresholds used in SSB taxes and sugar FOPLs (Study 1). It was hypothesized that countries with mandatory, threshold-based SSB taxes and/or sugar FOPLs would have lower mean sugar concentrations and a greater proportion of beverages with sugar concentrations below the relevant policy thresholds, and that mean sugar concentrations would differ across beverage categories, with water having the lowest and juice the highest mean sugar concentrations.

2) Assess sweetener presence in beverages, including added sugars and LNCS (Study 2). It was hypothesized that LNCS presence would be highest in Mexico, followed by Chile, the UK, Australia, Canada, and the US, reflecting differences in the presence and design of national SSB taxes and FOPLs, including mandatory versus voluntary policies and the inclusion of LNCS FOPLs.

3) Evaluate serving size labelling practices, including serving size formats ('per 100mL', 'per serving', or both) and voluntary serving sizes selected by brands (Study 3). It was hypothesized that mean serving sizes and the presence of multiple servings per container would be similar across countries.

Together, these studies provide a more comprehensive understanding of how sugar-related policies are associated with multiple dimensions of the consumer nutrition environment across countries, and may help inform policy development to support healthier dietary intakes.

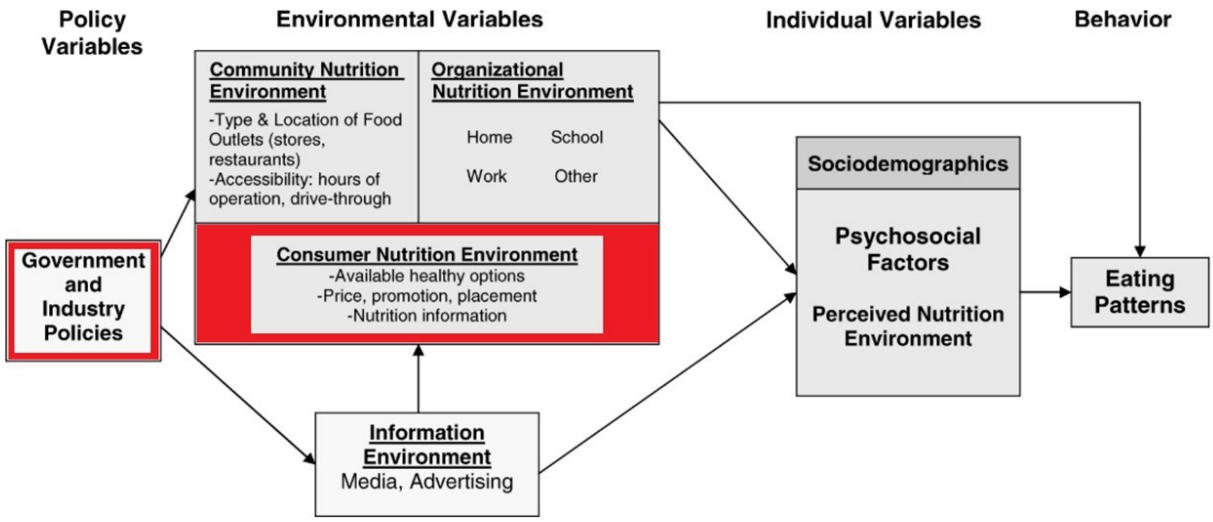
Chapter 2: METHODS

2.1 Conceptual framework

The theoretical framework of this thesis is broadly based on a conceptual model designed to study nutrition environments (Figure 2-1).[83] Originally developed using constructs from the ecological model of health behaviour,[211] the model demonstrates how the associations between food environments, government policies, and individual-level variables interact to influence eating patterns.[83] The framework includes four domains: community nutrition environment (the type, location, and accessibility of food outlets), organizational nutrition environment (food availability in settings such as homes, schools, and workplaces), information environment (media and advertising that can shape consumer perceptions), and consumer nutrition environment (product availability, pricing, and nutrition information).[83]

This thesis focuses on the consumer nutrition environment, including the composition and nutrition labelling of pre-packaged beverages. Government policies (e.g., SSB taxes, FOPLs, and serving size regulations) and industry responses represent key upstream factors that shape this environment. In turn, changes in product characteristics, such as sugar concentration (Study 1), sweetener use (Study 2), and serving sizes (Study 3), may influence downstream outcomes, including consumer purchasing decisions, dietary intake, and overall health. By examining product-level characteristics across six countries with different policy environments, this thesis provides evidence to inform the development of sugar-related nutrition policies to support population health.

Figure 2-1. Theoretical framework guiding the current thesis (adapted to highlight the most relevant variables, in red)[83]



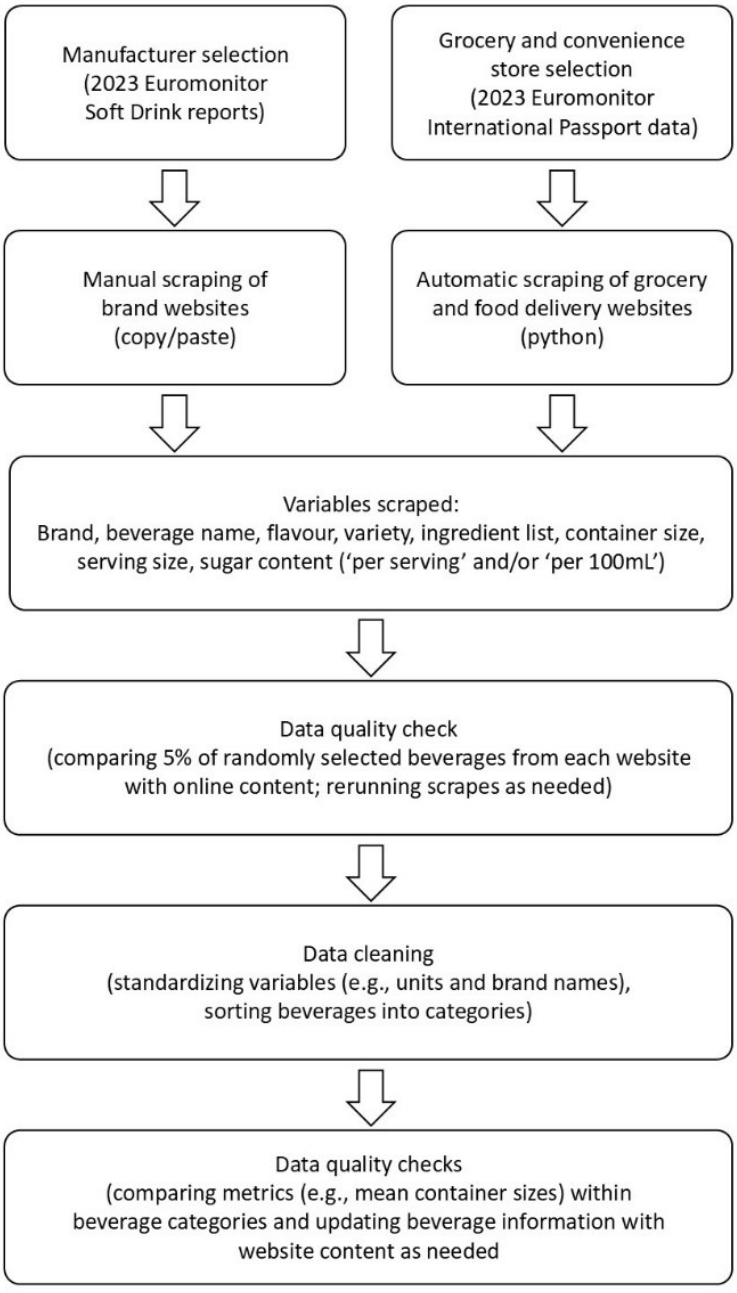
2.2 Overview of methods

This thesis is comprised of three studies that examine cross-country differences in composition and nutrition labelling of non-alcoholic, pre-packaged beverages. Data for the three studies were based on a market scan across six countries: Australia, Canada, Chile, Mexico, the UK, and the US. Data were collected by web scraping websites of grocery stores, food delivery platforms (to access convenience store product listings), and brands between October 2023 and February 2025. Study 1 examined differences in sugar concentrations of beverages across countries and beverage categories. Study 2 examined differences in the presence of sweeteners, such as added sugars and LNCS, across countries and beverage categories. Study 3 examined differences in serving sizes of beverages across countries and beverage categories.

Figure 2-2 shows a flowchart of the data collection methods. Data were collected using two approaches: manual web scraping (i.e., copying data from brand websites) and automatic web scraping (i.e., applying Python 3.13 scripts to grocery store and food delivery websites). Both manual and automated web scraping were used to maximize the capture of beverages across retailer and brand

websites, with automated methods for large-scale collection and manual methods for smaller-scale collection. Web scraping is an established method to obtain online information,[204,212,213] and has been previously used to collect data from online food retailers, including price, images, nutrition information, and product availability.[198,206,214,215] Grocery store and food delivery websites were scraped, as prior literature has found that product availability and the healthfulness of food and beverages may differ by store type across regions.[216–218] Although little research has examined differences in beverage composition within cities, multiple retail sources (i.e., grocery store, food delivery, and brand websites) were included to maximize product coverage.

Figure 2-2. Flowchart of study methods.



2.2.1 Country selection for web scraping

The six countries included in this thesis (Australia, Canada, Chile, Mexico, the UK, and the US) were selected to align with those involved in the International Food Policy Study, an annual repeat cross-

sectional study that evaluates the impact of national-level food policies on dietary qualities and perceptions.[219] The countries have diverse policy environments, including variations in SSB taxes and FOPLs (Table 2-1), as well as serving size labelling (Table B-1 in Appendix B). These cross-country differences allow examination of whether beverage characteristics vary across sugar-related policy environments, including sweetener presence, sweetener concentrations, and serving sizes, providing evidence to inform policy development.

Table 2-1. Summary of sugar-sweetened beverage tax and front-of-package nutrition label policies across the countries studied.

Country	Presence of national sugar-sweetened beverage tax			Presence of national front-of-package nutrition label		
	No	Yes – voluntary	Yes – Mandatory	No	Yes – voluntary	Yes – Mandatory
Australia	X				X	
Canada	X			X[1]		
Chile			X			X
Mexico			X			X
United Kingdom			X		X	
United States	X			X		

[1] The current thesis was conducted prior to full implementation of front-of-package nutrition labels in Canada.

2.2.2 Manufacturer selection for manual web scraping

Leading beverage manufacturers were identified using data from country-specific 2023 Euromonitor Soft Drink reports, which provide information on market sales and trends.[220–225] All manufacturers listed in each report were included, with the total number varying by country (from 20 to 30). Manufacturer websites in each country were searched to identify all brands. These manufacturers accounted for most

of the market share in 2022: 70.6% (UK), 75.4% (US), 80.3% (Canada), 80.9% (Australia), 82.7% (Chile), and 88.3% (Mexico); private/other brands accounted for the remainder.[220–225]

2.2.3 Grocery and convenience store selection for automatic web scraping

The top three leading grocery and convenience store chains in each country were identified using country-specific 2023 Euromonitor International Passport data.[226] Store locations for sampling were chosen to maximize capture of available products by focusing on population and presence of a sugar-related policy (SSB tax or FOPL). For Australia, Chile, Mexico, and the UK, the four most populous regions and two most populous cities within each region were determined, and one of the cities per region was randomly selected for inclusion in the study, resulting in four locations per store. Because Canada and the US had sub-national SSB taxes at the time of data collection, samples for these countries included the three most populous regions and a region with a sub-national tax for a separate study on sugar concentrations outside of this thesis. When a retailer was not present in a selected city, another city or the next-most populous region was used (Canada: one grocery store; Chile: one grocery store; Mexico: three convenience stores; the UK: two convenience stores; and the US: two grocery and two convenience stores). Technical limitations prevented the scraping of Walmart in four countries (Canada, Chile, Mexico, and the US), resulting in only two grocery store chains being included. Due to the lack of product listings on convenience store websites, leading food delivery company websites in each country (identified by online searches) were used to obtain product information, with convenience store addresses as search locations (see Table B-2 in Appendix B).

2.2.4 Non-alcoholic, pre-packaged beverage data

Non-alcoholic, pre-packaged beverages were those with <0.5% alcohol by volume and that are ready to consume (i.e., no mixing or dilution needed before consumption). Information was scraped from the websites of brands, grocery stores, and food delivery platforms (to access convenience store product listings) for a census of non-alcoholic, pre-packaged beverages. Information collected for each beverage from both the manual and automatic web scrapes, when available, included the ingredient list, sugar content ('per 100mL' and/or 'per serving'), and product characteristics (e.g., brand, name, flavour, variety, container size, and serving size). Sugar was the only nutrient collected in the manual scrape due

to available resources and was used as a proxy to determine serving size format (i.e., if listed as 'per 100mL', 'per serving', or both). Only text-based information was scraped; links to product images were recorded but not analyzed. Multi- and variety-packs were included in the scrape, with manual checks completed by KH to identify different products (e.g., identifying varying flavours within packs and adding each to the dataset).

2.2.5 Data cleaning and management

For comparability across beverages, serving and container sizes were standardized to mL and sugar concentrations to g/100mL, with all values rounded to the nearest integer. Brands (such as 'Pepsi' or 'Tropicana'), flavours (the taste descriptor, such as 'cherry' or 'vanilla'), and varieties (the version, such as 'regular' or 'diet') were manually reviewed and consolidated for consistency (e.g., combining 'Coke' and 'Coca Cola').

Products were divided into eight categories: carbonated/mixer drink, coffee drink, dairy & alternatives drink, energy drink, juice/juice drink, low/no-alcohol drink, sports drink, and water drink. These categories were developed based on existing literature, grocery store websites, and policy regulations (e.g., products subject to SSB taxes and FOPL; see Table 2-2)[227–229]. Certain categories were purposefully excluded (e.g., >0.5% alcohol by volume, beverage mixes, syrups, powders, and concentrates), based on the study's definition of non-alcoholic, pre-packaged beverages. Non-alcoholic mixers were included if they did not have to be reconstituted (e.g., syrups), as they may be consumed without added alcohol.

Table 2-2. Overview of category definitions and example products.

Category	Definition	Examples
Carbonated/mixer drink	• Sold/marketed as carbonated drinks • Includes non-alcoholic mixers (which can be consumed alone or with added alcohol)	• Cola • Ginger beer • Mixers • Seltzer water • Tonic water
Coffee drink	• Sold/marketed as 'coffee' drinks • Includes coffee-flavoured milk drinks if the brand sells 'coffee' drinks	• Cappuccino • Cold-brew coffee • Iced coffee • Latte
Dairy & alternatives drink	• Sold/marketed as 'dairy' drinks • Includes probiotic/fermented dairy drinks • Includes coffee-flavoured milk drinks if the brand sells 'dairy' drinks	• Animal milks • Coffee-flavoured milk • Plant milks • Kefir • Milk/whey-based protein shakes • Yogurt
Energy drink	• Sold/marketed as energy drinks	• Monster • Rockstar • V
Juice/juice drink	• Sold/marketed as fruit/vegetable/herbal-based drinks • Includes water-juice drinks if the brand sells 'juice drinks' • Includes drinks with 'natural' sources of energy if the brand highlights herbs (e.g., yerba mate)	• 100% juice or vegetable drinks • Fruit drinks • Nectars • Herbal-based drinks • Iced tea • Juice-based smoothies • Kombucha • Lemonade
Low/no-alcohol drink	• Low/no alcohol (≤0.5% alcohol by volume) • Includes ciders if the brand sells alcoholic drinks (otherwise, ciders are juice)	• Beers • Ciders • Spirits • Wines
Sports drink	• Sold/marketed as sports drinks • Includes water with electrolytes if the brand focuses on sports/performance	• Gatorade • Powerade

Water drink	• Sold/marketed as water • Includes drinks with added ingredients (e.g., caffeine, flavour or electrolytes) if the brand sells water or focuses on hydration	• Aloe water • Coconut water • Flavoured water • Mineral water • Sparkling water • Spring water • Vitamin water

2.2.5.1 Data quality

To maximize automatic web scraping accuracy, 5% of beverages from each store were randomly selected and compared against website content; scraping scripts were updated and rerun as needed. Metrics (e.g., mean, median, and ranges of serving and container sizes and sugar concentrations) for each beverage category were compared across countries using the full dataset: differences >10% were investigated and product information was updated to match website content as needed.

2.3 Study 1: International differences in sugar concentrations of pre-packaged beverages: a market scan in Australia, Canada, Chile, Mexico, the United Kingdom, and the United States.

2.3.1 Research objectives

The overall objective of Study 1 was to examine sugar concentrations in non-alcoholic pre-packaged beverages available on retailer and brand websites in six countries with different sugar-related policies. The study had two specific research questions:

1) Are there differences in mean sugar concentrations (g/100mL) across countries and beverage categories?
2) Are there differences in sugar concentrations based on thresholds used in SSB taxes (Chile and the UK) and sugar FOPLs (Chile and the UK)?

2.3.2 Design and sample

Study 1 consisted of a cross-sectional analysis of data from the market scan conducted between 2023 and 2025. Data on 106,476 beverages were collected across countries from three store types (grocery stores, convenience stores via food delivery platforms, and brands): Australia (n=21,046), Canada (n=14,366), Chile (n=10,066), Mexico (12,607), UK (22,018), and US (26,373). Beverages were excluded from analysis when container sizes >2.5 gallons (9,463.5mL; foodservice rather than consumer-facing formats; n=151), or missing container sizes (n=1,762) or total sugar concentrations

(g/100mL; n=37,760; Australia: 7,668; Canada: 6,317; Chile: 2,735; Mexico: 5,942; the UK: 6,634; and the US: 8,464). Beverages with the same brand, country, flavour, variety, and container size were considered duplicates and grouped. Sugar concentrations were standardized and one beverage with the most scraped information in each group (including sugar concentration and ingredient lists) was randomly selected for analysis (termed "unique beverage"; n=17,739). Beverages with missing ingredient lists (including null values, such as 'NA'; n=2,099) were excluded to maximize consistency between reported sugar concentrations and ingredients, leaving a final sample of 15,640.

2.3.3 Measures

2.3.3.1 Outcomes

Sugar concentrations were obtained from product pages on retailer or brand websites, where values were reported as either 'per 100mL' or 'per serving.' Mean sugar concentration (continuous; g/100mL) was calculated for each country and beverage category.

2.3.3.2 Covariates

Covariates included country (categorical), beverage category (categorical), and store type (categorical; to account for potential differences in the availability of beverages across online sources).

2.3.4 Analysis

Four analyses were conducted: **1) Sugar concentration (descriptive):** Mean sugar concentration was compared via descriptive statistics (mean and standard deviation) across countries and beverage categories. An exploratory analysis examined sugar concentrations in regions with and

without subnational SSB taxes in Canada and the US; however, as no differences were observed, results are not reported. **2) Sugar concentration (regression):** Linear regression examined mean sugar concentrations between countries and beverage category, adjusting for store type. Unadjusted and adjusted means (estimated marginal means calculated from observed marginal covariate distributions) are reported, with betas and corresponding 95% confidence intervals (95% CI). **3) Sugar concentrations by thresholds (descriptive):** Sugar concentrations were compared against sugar thresholds implemented as part of the following policies: 1) SSB taxes in Chile and the UK; and 2) sugar FOPLs in Chile and the UK (see Table C-1 in Appendix C for a summary of policies across the countries studied). Mexico's sugar FOPL, Australia's FOPL, and Mexico's SSB tax were not examined, as they are based on energy from free sugars, a nutrient profiling algorithm, and added sugars presence, respectively, rather than sugar concentrations directly. Sensitivity analyses were conducted by excluding the dairy & alternatives drink category on the basis that these beverages are exempted from most SSB tax policies worldwide, including in Chile, Mexico, and the UK.[230] The proportions of beverages with sugar concentrations within each threshold were calculated in all countries. **4) 'Clustering' of sugar concentrations around thresholds (descriptive):** 1.0g intervals were defined below and above each policy threshold. For example, the UK's green FOPL threshold is ≤2.5g/100mL, so the lower interval was (1.50-≤2.50) and the upper was (>2.50-≤3.50). 1.0g intervals were used to capture policy-relevant differences in sugar concentrations around thresholds, where small changes in sugar concentrations may influence label or tax classification and create incentives for product (re)formulation. These thresholds were also used to examine whether a greater proportion of beverages 'cluster' just below (or at) versus just above policy thresholds. A greater proportion of beverages 'clustering' just below (or at) thresholds in countries with the relevant policy, compared to those without the policy, was considered consistent with (re)formulation to remain below (or at) regulatory limits. Within-country differences in the proportion of beverages below (or at) versus above thresholds were assessed using chi-square tests, with statistical significance defined as $p<0.05$. All analyses were conducted using SAS v9.4 (SAS Institute Inc., North Carolina).

2.4 Study 2: International differences in the presence of sweeteners in pre-packaged beverages: a market scan in Australia, Canada, Chile, Mexico, the United Kingdom, and the United States.

2.4.1 Research objectives

The overall objective of Study 2 was to examine sweetener use in non-alcoholic, pre-packaged beverages available on retailer and brand websites in six countries with different sugar-related policies. The study had two specific research questions:

1) Are there differences in the proportion of beverages containing LNCS and added sugars across countries and categories?
2) What are the most common sweeteners in beverages across countries and categories?

2.4.2 Design and sample

Study 2 consisted of a cross-sectional analysis of data from the market scan conducted between 2023 and 2025. Data on 106,476 beverages were collected across countries from three store types (grocery stores, convenience stores via food delivery platforms, and brands): Australia (n=21,046), Canada (n=14,366), Chile (n=10,066), Mexico (n=12,607), UK (n=22,018), and US (n=26,373). Beverages were excluded from analyses when missing container sizes (n=1,762) or container sizes >2.5 gallons (9,463.5mL; n=151), as these were foodservice rather than consumer-facing formats. Beverages with the same brand, country, flavour, variety, and container size were considered duplicates and grouped, and one beverage with the most scraped information in each group (including sugar concentration and ingredient lists) was randomly selected for analysis (termed "unique beverage"; n=26,552). Beverages missing either ingredient lists (including null values, such as 'NA') or sugar amounts (g 'per serving' or 'per 100mL'; to verify ingredient-based sugar classification) were excluded (n=10,558), leaving a final sample of 15,994.

2.4.3 Measures

2.4.3.1 Outcomes

Presence of LNCS and/or added sugars, as well as sweetener descriptors (all categorical), was determined by searching ingredient lists obtained from product pages on retailer or brand websites for predefined sweetener terms.

2.4.3.2 Covariates

Covariates included country (categorical), beverage category (categorical), and store type (categorical; to account for potential differences in the availability of beverages across online sources).

2.4.4 Analysis

Lists of terms commonly used to describe sweeteners were developed in English, French, and Spanish, based on existing literature.[231,232] Ingredient lists of beverages were then searched to determine the presence and type of sweetener used; exceptions were made when terms solely reflected technical roles (e.g., 'caramel for colour' describes an additive, rather than a sugar-based ingredient)[233,234] or regulatory requirements (e.g., 'Sugars' and 'Added sugars' appear before grouped listing of sugars in Canada and Mexico and do not reflect specific sugar descriptors).[131,233] Three sweetener profiles were examined:

1) LNCS (NSS or sugar alcohols)
2) Added sugars (including rare sugars)
3) Combination of LNCS and added sugars

Descriptive statistics compared the proportion of beverages containing LNCS and added sugars, as well as the most common sweetener descriptor (added or intrinsic sugars, NSS, and sugar alcohols), by country and category. Three binary logistic regression models were fitted to examine the odds of

beverages containing: 1) LNCS (presence of NSS or sugar alcohols, alone or in combination with other sweeteners); 2) added sugars (presence alone or in combination with other sweeteners); or 3) combined LNCS and added sugars (presence of NSS or sugar alcohols in combination with added sugars). Reference groups were Chile (highest presence of LNCS across countries) and water (plain water is the recommended beverage among health organizations,[7] although this category included both sweetened and unsweetened water). Models were adjusted for country, beverage category, and store type, and were subsequently stratified by beverage category and sugar-related policy presence (countries with ≥1 mandatory policy: Chile, Mexico, the UK versus no mandatory policy: Australia, Canada, the US). Adjusted odds ratios and corresponding 95% confidence intervals (95% CI) are presented. Data cleaning, management, and analyses were conducted in SAS v9.4 (SAS Institute Inc., North Carolina).

2.5 Study 3: International differences in serving size labelling for non-alcoholic beverages: a market scan of online information in Australia, Canada, Chile, Mexico, the United Kingdom, and the United States.

2.5.1 Research objectives

The overall objective of Study 3 was to compare the serving sizes of non-alcoholic, pre-packaged beverages available on retailer and brand websites in six countries with different sugar-related policies. The study had two specific research questions:

1) Are there differences in the proportions of beverages using 'per 100mL', 'per serving', or both serving size formats across countries with different labelling policies?

2) Are there differences in voluntary serving sizes selected by brands, including the proportion of beverages ≤600mL that are labelled as multiple servings per container?

2.5.2 Design and sample

Study 3 consisted of a cross-sectional analysis of data from the market scan conducted between 2023 and 2025. Three subsamples were used for analyses: 1) Container size: derived from the set of unique beverages identified in Study 2 after removal of duplicate entries based on brand, country, flavour, variety, and container size (n = 26,552); 2) Serving size format: unique beverages missing sugar content 'per 100mL' and 'per serving' were excluded from analyses (n=8,587), resulting in a subsample of 17,965; and 3) Serving size, including containers with multiple servings: unique beverages with missing serving sizes were excluded (n=7,849). Serving sizes within 10% of container sizes were set to equal the container size (n=464) and amounts greater were excluded from analyses (n=31). Beverages available outside of Canada and the US with 'per 100mL' serving sizes (and 'per 200mL' in Chile) that were sold in containers of different sizes (i.e., not 100mL or 200mL) were further excluded from analyses because they cannot be used to evaluate voluntary brand-selected serving sizes (n=4,094). These exclusions resulted in a subsample of 14,578 unique beverages.

2.5.3 Measures

2.5.3.1 Outcomes

Serving size format (categorical) was determined from product pages on retailer or brand websites listing sugar content 'per 100mL', 'per serving', or both. Serving size (continuous; mL) was defined as the reported serving size or 100mL reference amount. Container size (continuous; mL) was defined as the total container volume; for multipacks, container size reflected the volume of one unit. Container sizes were grouped based on distribution and the Australian threshold for multiple servings per container: ≤355mL, >355-600mL, >600mL-1,000mL, and >1,000mL. Multiple servings per container were determined by calculating the serving to container size ratio, with values <1 representing more than one serving per container.

2.5.3.2 Covariates

Covariates included country (categorical), beverage category (categorical), and store type (categorical; to account for potential differences in the availability of beverages across online sources).

2.5.4 Analysis

Unique beverages were compared across countries and beverage categories based on serving size formats and amounts, container sizes, and containers with multiple servings, using descriptive statistics (mean, standard deviation**,** and proportions). Adjusted means were reported for cross-country comparisons that controlled for category and store type.

Two linear regression models examined mean serving and container size (mL). Models were adjusted for country, beverage category, and store type, and were subsequently stratified by beverage category. Unadjusted and estimated marginal means calculated from observed marginal covariate distributions were presented to account for confounding and unbalanced sample sizes across country, beverage category, and store combinations, along with betas and corresponding 95% confidence intervals (95% CI). Container size was examined as a secondary outcome, with results presented in Table E-2 in Appendix E. Data cleaning, management, and analyses were conducted in SAS v9.4 (SAS Institute Inc., North Carolina).

Chapter 3: DIFFERENCES IN SUGAR CONCENTRATIONS ACROSS COUNTRIES

3.1 Study 1: International differences in sugar concentrations of non-alcoholic beverages: a market scan in Australia, Canada, Chile, Mexico, the United Kingdom, and the United States.

Status: in preparation

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3.1.1 Overview

Background: Little is known about differences in sugar concentrations of non-alcoholic beverages across countries, particularly in relation to sugar-related policy thresholds.

Objective: To examine sugar concentrations in non-alcoholic, pre-packaged beverages in six countries with different sugar-related policies during 2023-2025: mandatory or voluntary sugar front-of-package nutrition labels (FOPLs; Australia, Chile, Mexico, the United Kingdom (UK)), mandatory sugar-sweetened beverage (SSB) taxes (Chile, Mexico, the UK), and no national-level tax or FOPL (Canada, the United States (US)).

Methods: Data were collected by web scraping retailer and brand websites for 15,640 beverages from Australia (n=1,728), Canada (n=2,643), Chile (n=1,242), Mexico (n=1,588), the UK (n=2,598), and the US (n=5,841), during October 2023-February 2025. Linear regression examined cross-country differences in sugar concentrations, adjusting for beverage category and retail source. Proportions of beverages within 1.0g/100mL below (or at) versus above country-specific sugar concentration thresholds were also examined.

Results: Sugar concentrations differed across countries and by policy design. Adjusted mean sugar concentrations were lowest in countries with SSB tax or sugar FOPL policies triggered by sugar-concentration thresholds (the UK: 4.3g/100mL; Chile: 4.3g/100mL) versus other countries (the US: 5.2g/100mL; Mexico: 5.5g/100mL; Australia: 5.5g/100mL; Canada: 6.0g/100mL; all pairwise contrasts $p<0.05$, except Chile versus the UK). The proportion of beverages with sugar concentrations that were 1.0g below (or at) the 5.0g/100mL threshold used by the UK tax and Chile sugar FOPL (versus above) was greatest in the UK (21.6-23.7%) and Chile (23.8-31.7%) versus other countries (≤12.0-15.2%).

Conclusions: Sugar concentrations were lower in countries with threshold-based SSB taxes and sugar FOPLs, with greater proportions just below (or at) these thresholds. Findings are consistent with possible (re)formulation in response to these policies.

3.1.2 Introduction

Sugar-sweetened beverages (SSBs) are a significant source of sugars in diets worldwide and have been linked with adverse health conditions such as obesity, type 2 diabetes, cardiovascular disease, and dental caries.[235–237] As such, the World Health Organization recommends that adults consume less than 5%-10% of their total energy from free sugars (those added or naturally found in honey, syrups, and fruit juices), equivalent to about 25-50g daily for a 2,000-calorie diet.[10] Despite growing awareness of the health effects of sugar intake, SSB sales worldwide increased between 2010 and 2024,[238] with the global non-alcoholic beverage market expected to grow from over USD$1.2 trillion in 2025 to over USD$1.6 trillion by 2030.[28]

To date, more than 100 jurisdictions around the world have implemented policies to encourage beverage (re)formulation and nudge consumers to select lower sugar options, such as SSB taxes and front-of-package nutrition labels (FOPLs).[190,209] However, implementation of these policies has varied across jurisdictions (see Table C-1 in Appendix C for a summary of select SSB tax and FOPL policies). For taxes, countries like Chile and the United Kingdom (UK) have mandatory SSB taxes based on sugar concentration thresholds (which apply higher tax rates to higher-sugar beverages), countries like Mexico have a mandatory flat-rate volumetric tax (which applies the same rate per unit volume, regardless of sugar concentration), countries like Canada and the United States (US) have or had sub-national SSB taxes implemented in select jurisdictions, and other countries, like Australia, lack national-level taxes.[190,209] For sugar FOPLs, countries like Chile and Mexico have mandatory black octagonal warning labels, the UK has a voluntary traffic light system, Canada introduced a mandatory magnifying glass in 2022 with mandatory implementation by 2026, Australia has a voluntary Health Star Rating system, and the US lacks a national-level label system.[190,209]

Differences in policy design may influence manufacturer (re)formulation strategies. For example, recent real-world evidence suggests that manufacturers may be more incentivized to reduce sugar

concentrations in response to mandatory policies versus voluntary industry commitments, or sugar concentration thresholds versus flat-rate volumetric taxes.[171–174] A longitudinal analysis of worldwide beverage sales data between 2007 and 2019 reported that the presence of multiple policy actions (e.g., advertising restrictions and promoting healthy food availability in public settings) was associated with reduced added sugars and increased use of low/no-calorie sweeteners, particularly in high-income countries.[16]

Few studies have directly compared the global SSB market to date. The Global Access to Nutrition Index 2024 is one of the most comprehensive, examining over 50,000 products from the world's 30 largest food and beverage manufacturers across 25 countries according to mean sales-weighted Health Star Rating values (the FOPL system that rates the nutritional profile of products according to healthfulness, from 0.5 to 5 stars).[153] This study found large differences in the nutrient profile of beverages across countries and categories, such as a 1.5 star rating for juices in Mexico versus 3.2 stars in the UK.[153] Previous research has also found that multinational corporations may use different sugar concentrations in formulations across countries, resulting in cross-country variations within brands.[154,155] However, the extent to which differences are driven by SSB tax and FOPL policies remains unclear and cross-country analyses overall and by policy thresholds remain scarce. Such examinations are critical to inform policy development.

The current study examined sugar concentrations in non-alcoholic pre-packaged beverages available on retailer and brand websites in six countries with different sugar-related policies: Australia, Canada, Chile, Mexico, the UK, and the US. The study had two primary objectives: 1) compare mean sugar concentrations (g/100mL) across countries and beverage categories; and 2) examine differences in sugar concentrations based on thresholds used in SSB taxes (Chile and the UK) and sugar FOPLs (Chile and the UK).

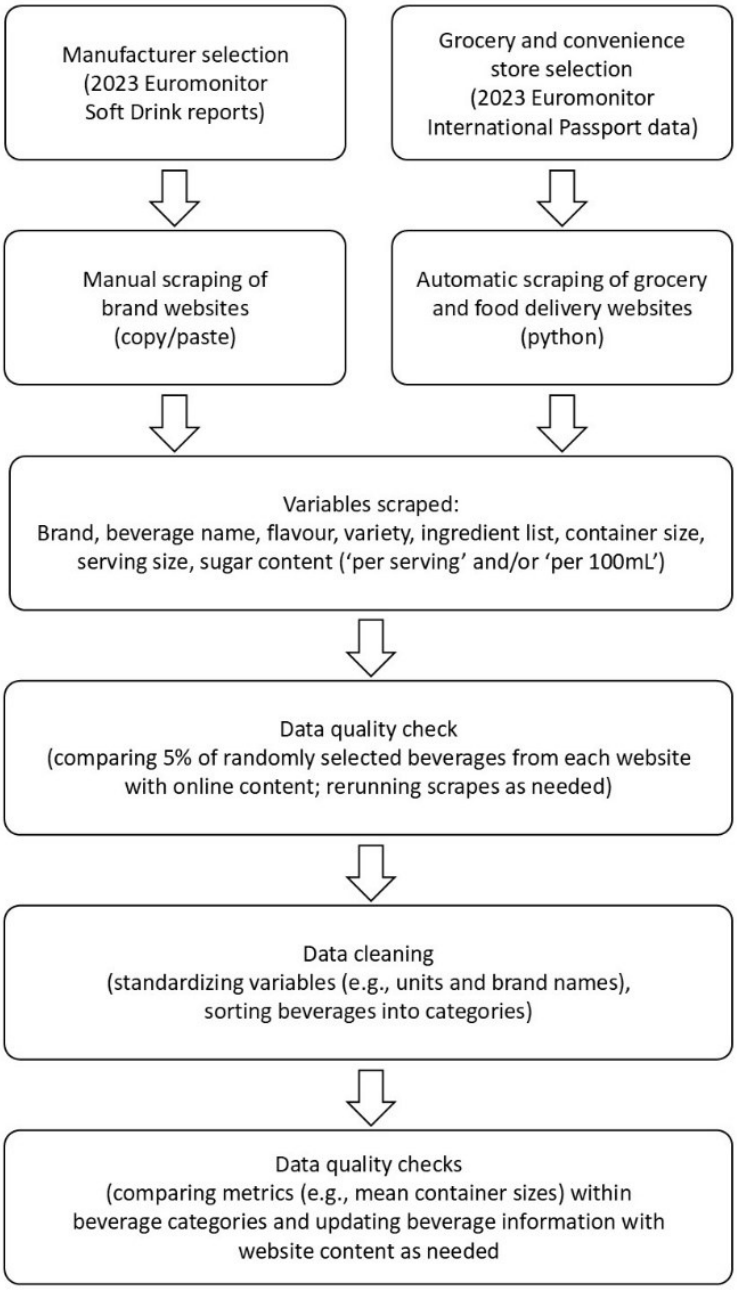
3.1.3 Methods

3.1.3.1 Overview of methods

A market scan was conducted to determine sugar concentrations in non-alcoholic, pre-packaged beverages available across six countries: Australia, Canada, Chile, Mexico, the UK, and the US. These countries were selected to align with those involved in the International Food Policy Study, an annual repeat cross-sectional study that evaluates the impact of national-level food policies on dietary qualities and perceptions.[219] The countries have diverse policy environments, including variations in SSB taxes and sugar FOPLs, allowing examination of whether sugar concentrations differ across policy contexts and providing evidence to inform policy development. Non-alcoholic, pre-packaged beverages were defined as alcohol by volume <0.5% and sold without further preparation needed before consumption (i.e., no mixing or dilution).

Figure 3-1 shows a flowchart of the methods used in the current study. Data collection occurred on retailer and brand websites between October 2023 and February 2025 using two approaches: manual web scraping (i.e., copying data from brand websites) and automatic web scraping (i.e., applying Python 3.13 scripts to grocery store and food delivery websites). Web scraping is an established method to obtain online information,[204,212,213] and has been previously used to collect data from online food retailers, including price, images, nutrition information, and product availability.[198,206,214,215] Grocery store and food delivery websites were scraped, as prior literature has found that product availability and the healthfulness of food and beverages may differ by store type across regions.[216–218] Although little research has examined differences in beverage composition within cities, multiple retail sources (i.e., grocery store, food delivery, and brand websites) were included to maximize product coverage.

Figure 3-1. Flowchart of study methods.



3.1.3.2 Manufacturer selection for manual web scraping

Leading manufacturers were identified using data from country-specific 2023 Euromonitor Soft Drink reports, which provide information on market sales and trends.[220–225] Websites of all manufacturers listed in the reports were searched to identify all brands in each country. Together, these manufacturers accounted for most of the pre-packaged beverage market in 2022: 70.6% (UK), 75.4% (US), 80.3% (Canada), 80.9% (Australia), 82.7% (Chile), and 88.3% (Mexico); private label/other brands accounted for the remainder.[220–225]

3.1.3.3 Grocery and convenience store selection for automatic web scraping

The top three leading grocery and convenience store chains in each country were identified using country-specific 2023 Euromonitor International Passport data.[226] Store locations for sampling were chosen to maximize capture of available products by focusing on population and presence of a sugar-related policy (SSB tax or FOPL). For Australia, Chile, Mexico, and the UK, the four most populous regions and two most populous cities within each region were determined, and one of the cities per region was randomly selected for inclusion in the study, resulting in four locations per store. Because Canada and the US had sub-national SSB taxes at the time of data collection, samples for these countries included the three most populous regions and a region with a sub-national tax for a separate study on sugar concentrations.

Beverage data were collected from individual store locations (see Table B-2 in Appendix B). When product listings were unavailable for scraping (e.g., not listed online), an alternative city or the next-most populous region was used, depending on data availability. Technical limitations (i.e., inability to accurately extract text from labels displayed as images) prevented the scraping of Walmart websites in four countries (Canada, Chile, Mexico, and the US), resulting in only two grocery store chains being included. Due to the lack of product listings on convenience store websites, product information was obtained from leading food delivery platform websites in each country (identified by online searches), using convenience store addresses as search locations.

3.1.3.4 Non-alcoholic, pre-packaged beverage data

Information was scraped from the websites of brands, grocery stores, and food delivery platforms (to access convenience store product listings) for a census of non-alcoholic, pre-packaged beverages. Information collected for each beverage from both the manual and automatic web scrapes, when available, included the ingredient list, sugar content ('per 100mL' and/or 'per serving'), and product characteristics (e.g., brand, name, flavour, variety, container size, and serving size). Automatic web scraping captured full nutrient label information if available, while sugar was the only nutrient collected in the manual scrape due to available resources. Only text-based information was scraped. Multi- and variety-packs were included in the scrape, with manual checks completed by KH to identify different products (e.g., identifying varying flavours within packs and adding each to the dataset).

3.1.3.5 Data cleaning and management

For comparability across beverages, sugar concentrations were standardized (converted to g/100mL and rounded to the nearest integer). Brands (the product name, such as 'Pepsi' or 'Tropicana'), flavours (the taste descriptor, such as 'cherry' or 'vanilla'), and varieties (the version, such as 'regular' or 'diet') were manually reviewed and consolidated for consistency (e.g., combining 'Coke' and 'Coca Cola').

Products were divided into eight categories: carbonated/mixer drink, coffee drink, dairy & alternatives drink, energy drink, juice/juice drink, low/no-alcohol drink, sports drink, and water drink. These categories were developed based on existing literature, grocery store websites, and policy regulations (e.g., products subject to SSB taxes and FOPLs; see Table 3-1).[227–229] Certain categories were purposefully excluded (e.g., >0.5% alcohol by volume, beverage mixes, syrups, powders, and concentrates), based on the study's definition of non-alcoholic, pre-packaged

beverages. Non-alcoholic mixers were included if they did not have to be reconstituted (e.g., syrups), as they may be consumed without added alcohol.

Table 3-1. Overview of category definitions and example products.

Category	Definition	Examples
Carbonated/mixer drink	• Sold/marketed as carbonated drinks • Includes non-alcoholic mixers (which can be consumed alone or with added alcohol)	• Cola • Ginger beer • Mixers • Seltzer water • Tonic water
Coffee drink	• Sold/marketed as 'coffee' drinks • Includes coffee-flavoured milk drinks if the brand sells 'coffee' drinks	• Cappuccino • Cold-brew coffee • Iced coffee • Latte
Dairy & alternatives drink	• Sold/marketed as 'dairy' drinks • Includes probiotic/fermented dairy drinks • Includes coffee-flavoured milk drinks if the brand sells 'dairy' drinks	• Animal milks • Coffee-flavoured milk • Plant milks • Kefir • Milk/whey-based protein shakes • Yogurt
Energy drink	• Sold/marketed as energy drinks	• Monster • Rockstar • V
Juice/juice drink	• Sold/marketed as fruit/vegetable/herbal-based drinks • Includes water-juice drinks if the brand sells 'juice drinks' • Includes drinks with 'natural' sources of energy if the brand highlights herbs (e.g., yerba mate)	• 100% juice or vegetable drinks • Fruit drinks • Nectars • Herbal-based drinks • Iced tea • Juice-based smoothies • Kombucha • Lemonade
Low/no-alcohol drink	• Low/no alcohol (≤0.5% alcohol by volume) • Includes ciders if the brand sells alcoholic drinks (otherwise, ciders are juice)	• Beers • Ciders • Spirits • Wines
Sports drink	• Sold/marketed as sports drinks • Includes water with electrolytes if the brand focuses on sports/performance	• Gatorade • Powerade
Water drink	• Sold/marketed as water	• Aloe water • Coconut water

	• Includes drinks with added ingredients (e.g., caffeine, flavour or electrolytes) if the brand sells water or focuses on hydration	• Flavoured water • Mineral water • Sparkling water • Spring water • Vitamin water

Data quality

To maximize automatic web scraping accuracy, 5% of beverages from each store were randomly selected and compared against website content; scraping scripts were updated and rerun as needed. Metrics (e.g., mean, median, and ranges of serving and container sizes and sugar concentrations) for each beverage category were compared across countries using the full dataset: differences >10% were investigated and product information was updated to match website content as needed.

3.1.3.6 Measures

Outcomes

Sugar concentrations were obtained from product pages on retailer or brand websites, where values were reported as either 'per 100mL' or 'per serving.' Mean sugar concentration (continuous; g/100mL) was the dependent variable and calculated for each country and beverage category.

Independent variables and covariate

Independent variables were country (categorical) and beverage category (categorical). Store type (categorical) was included as a covariate to account for potential differences in the availability of beverages across online sources.

3.1.3.7 Analysis

Data on 106,476 beverages were collected across countries from the three store types (grocery stores, convenience stores via food delivery platforms, and brands): Australia (n=21,046), Canada (n=14,366), Chile (n=10,066), Mexico (n=12,607), UK (n=22,018), and US (n=26,373). Beverages were excluded from analysis when container sizes >2.5 gallons (9,463.5mL; n=151; foodservice rather than consumer-facing formats), or missing container sizes (n=1,762) or total sugar concentrations (g/100mL; n=37,760; Australia: 7,668; Canada: 6,317; Chile: 2,735; Mexico: 5,942; the UK: 6,634; and the US: 8,464). Beverages with the same brand, country, flavour, variety, and container size were grouped, and one beverage with the most available scraped information in each group

(including sugar concentration and ingredient list) was randomly selected for analysis (termed "unique beverage"; n=17,739). Beverages with missing ingredient lists (including null values, such as 'NA'; n=2,099) were excluded to maximize consistency between reported sugar concentrations and ingredients, leaving a final sample of 15,640.

Four analyses were conducted: **1) Sugar concentration (descriptive):** Mean sugar concentration was compared via descriptive statistics (mean and standard deviation) across countries and beverage categories. An exploratory analysis examined sugar concentrations in regions with and without subnational SSB taxes in Canada and the US; however, as no differences were observed, results are not reported. **2) Sugar concentration (regression):** Linear regression examined mean sugar concentrations between countries and beverage category, adjusting for store type. For each variable, the reference group was selected based on the lowest observed mean sugar concentration. Unadjusted and adjusted means (estimated marginal means calculated from observed marginal covariate distributions) are reported, with betas and corresponding 95% confidence intervals (95% CI). **3) Sugar concentrations by thresholds (descriptive):** Sugar concentrations were compared against sugar thresholds implemented as part of the following policies: 1) SSB taxes in Chile and the UK; and 2) sugar FOPLs in Chile and the UK (see Table C-1 in Appendix C for a summary of policies across the countries studied). Mexico's sugar FOPL, Australia's FOPL, and Mexico's SSB tax were not examined, as they are based on energy from free sugars, a nutrient profiling algorithm, and added sugars presence, respectively, rather than sugar concentrations directly. Sensitivity analyses were conducted by excluding the dairy & alternatives drink category on the basis that these beverages are exempted from most SSB tax policies worldwide, including in Chile, Mexico, and the UK.[230] The proportions of beverages with sugar concentrations within each threshold were calculated in all countries. **4) 'Clustering' of sugar concentrations around thresholds (descriptive):** 1.0g intervals were defined below and above each policy threshold. For example, the UK's green FOPL threshold is ≤2.5g/100mL, so the lower interval was (1.50-≤2.50) and the upper was (>2.50-≤3.50). 1.0g intervals were used to capture policy-relevant differences in sugar concentrations around thresholds, where small changes in sugar concentrations may influence label or tax classification and create incentives

for product reformulation. These thresholds were also used to examine whether a greater proportion of beverages 'cluster' just below (or at) versus just above policy thresholds. A greater proportion of beverages 'clustering' just below (or at) thresholds in countries with the relevant policy, compared to those without the policy, was considered consistent with (re)formulation to remain below (or at) regulatory limits. Within-country differences in the proportion of beverages below (or at) versus above thresholds were assessed using chi-square tests, with statistical significance defined as $p<0.05$. All analyses were conducted using SAS v9.4 (SAS Institute Inc., North Carolina).

3.1.4 Results

3.1.4.1 Sample characteristics

Table 3-2 shows sample characteristics overall, by beverage category, and by store type. Juice/juice drinks had the highest number of unique beverages across stores in all countries except Mexico, where the highest was dairy & alternatives drinks. Across countries, most unique beverages were scraped from grocery stores, with none from convenience stores due to the lack of sugar concentrations listed online (as text or images).

Table 3-2. Characteristics of unique non-alcoholic, pre-packaged beverages, by store type and country, 2023-2025 (N=15,640)

	Overall	Australia	Canada	Chile	Mexico	United Kingdom	United States
Unique beverages % (n)	100.0% n=15,640	11.1% n=1,728	16.9% n=2,643	7.9% n=1,242	10.2% n=1,588	16.6% n=2,598	37.4% n=5,841
Beverage category % (n)							
Juice/juice drink	30.8% n=4,812	34.6% n=598	36.3% n=959	32.4% n=402	20.4% n=324	32.6% n=847	28.8% n=1,682
Carbonated/mixer drink	21.7% n=3,386	16.3% n=282	17.3% n=458	21.6% n=268	22.5% n=358	23.6% n=614	24.1% n=1,406
Dairy & alternatives drink	21.4% n=3,348	26.5% n=457	26.3% n=694	23.1% n=287	33.1% n=525	19.2% n=498	15.2% n=887
Water drink	11.6% n=1,815	8.2% n=141	11.3% n=299	13.6% n=169	18.0% n=286	7.0% n=183	12.6% n=737
Energy drink	5.5% n=855	5.6% n=96	2.8% n=74	4.0% n=50	2.0% n=31	8.1% n=211	6.7% n=393
Sports drink	4.3% n=675	2.0% n=35	2.5% n=66	3.5% n=44	3.6% n=57	0.9% n=24	7.7% n=449
Coffee drink	3.1% n=489	3.6% n=62	1.5% n=40	0.0% n=0	0.4% n=6	4.1% n=106	4.7% n=275
Low/no-alcohol drink	1.7% n=260	3.3% n=57	2.0% n=53	1.8% n=22	0.1% n=1	4.4% n=115	0.2% n=12
Store type % (n)							
Grocery store website	63.1% n=9,868	55.8% n=965	72.1% n=1,905	71.3% n=885	79.8% n=1,267	68.8% n=1,786	52.4% n=3,060
Brand website	36.9% n=5,772	44.2% n=763	27.9% n=738	28.7% n=357	20.2% n=321	31.3% n=812	47.6% n=2,781

3.1.4.2 Sugar concentrations, by country and beverage category

Differences in sugar concentrations by country and beverage category are shown in Figure 3-2, with unadjusted and adjusted means shown in Table 3-3. Table 3-4 provides unadjusted means and medians by category within country. Overall, adjusted mean sugar concentrations across all beverage categories were lowest in Chile and the UK (4.3g/100mL), followed by the US (5.2 g/100mL), Australia and Mexico (5.5 g/100mL), and were highest in Canada (6.0 g/100mL; all contrasts $p<0.001$ versus Chile, except the UK, and all other pairwise contrasts $p<0.05$, except Australia and Mexico). Similar patterns were observed when dairy & alternatives drinks were excluded (results of the sensitivity analysis are detailed in Table C-2 in Appendix C).

Across all countries, adjusted sugar concentrations varied by beverage category, including lowest in water drinks (1.1 g/100mL), sports drinks (3.3 g/100mL), low/no-alcohol drinks and energy drinks (both 4.5 g/100mL) to highest in dairy & alternatives drinks (5.1 g/100mL), carbonated/mixer drinks (5.6 g/100mL), coffee drinks (6.0 g/100mL), and juice/juice drinks (6.8 g/100mL; all contrasts $p<0.001$ versus water drinks and all pairwise contrasts $p<0.05$, except energy drinks and low/no-alcohol drinks; Table 3-3).

Figure 3-2. Boxplot of sugar concentrations (g/100mL) of non-alcoholic, pre-packaged beverages, by country and category, 2023-2025 (N=15,640)

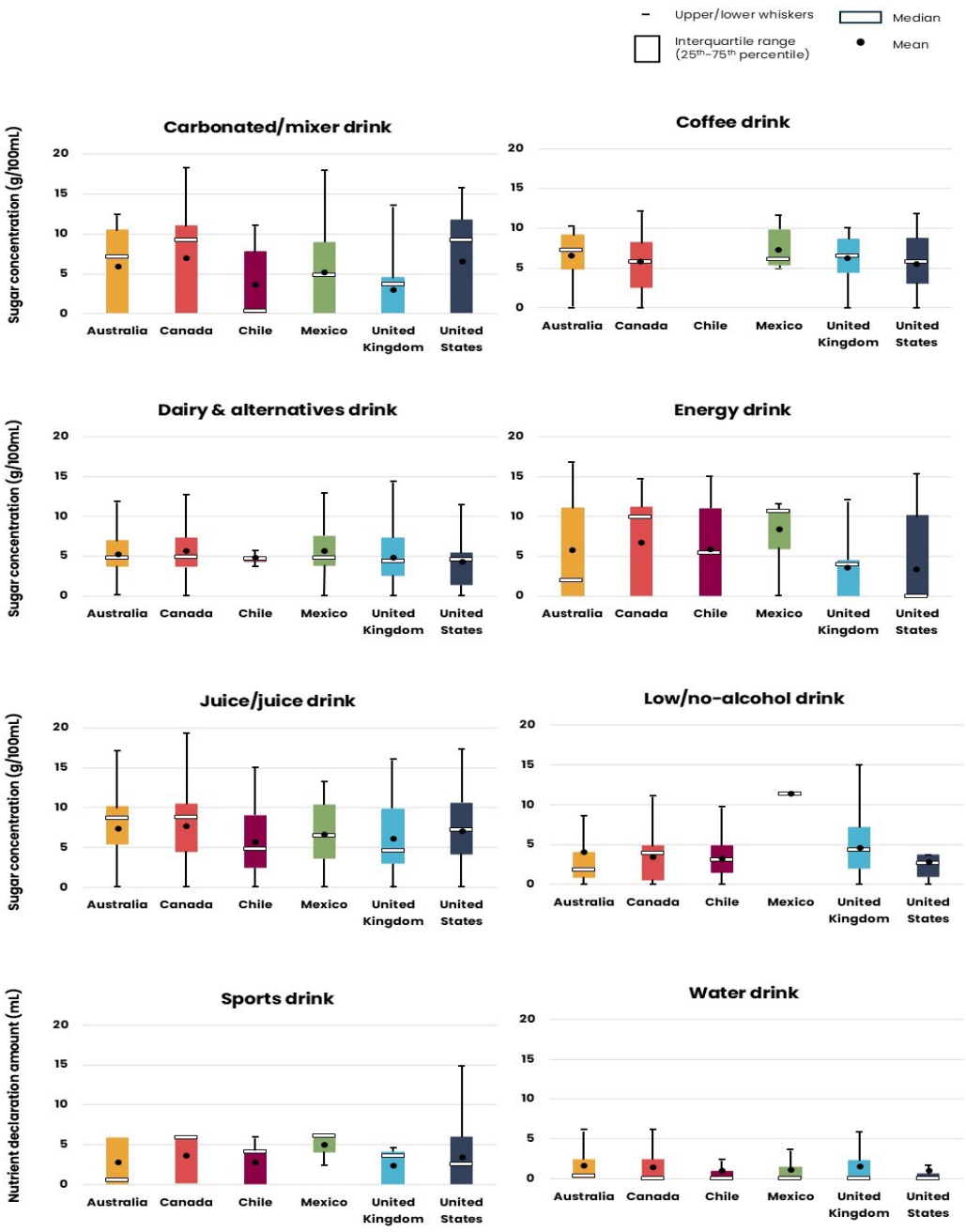


Table 3-3. Linear regression model investigating mean sugar concentrations (g/100mL) of non-alcoholic, pre-packaged beverages, by country, beverage category, and store type, 2023-2025 (N=15,640)

	Mean (St dev) (St error)	**Adjusted mean (St error) (95% CI)[a]**	**Parameter estimate (β)**	**(95% CI)[a]**	***p* value**
Country					
Chile	4.3 (3.7) (0.1)	4.3 (0.1) (4.12, 4.57)	Reference	-	-
United Kingdom	4.5 (3.8) (0.1)	4.3 (0.1) (4.12, 4.43)	-0.07	(-0.34, 0.20)	0.601
Mexico	5.0 (4.2) (0.1)	5.5 (0.1) (5.26, 5.66)	1.12	(0.82, 1.42)	<0.001
United States	5.2 (4.7) (0.1)	5.2 (0.1) (5.11, 5.32)	0.87	(0.62, 1.12)	<0.001
Australia	5.8 (4.4) (0.1)	5.5 (0.1) (5.35, 5.73)	1.19	(0.90, 1.48)	<0.001
Canada	6.1 (4.3) (0.1)	6.0 (0.1) (5.82, 6.12)	1.63	(1.36, 1.89)	<0.001
Category					
Water drink	1.1 (2.2) (0.1)	1.1 (0.1) (0.91, 1.28)	Reference	-	-
Sports drink	3.4 (2.8) (0.1)	3.3 (0.2) (2.97, 3.57)	2.17	(1.82, 2.53)	<0.001
Low/no-alcohol drink	4.2 (3.9) (0.2)	4.5 (0.2) (4.00, 4.98)	3.39	(2.87, 3.92)	<0.001

Energy drink	4.3 (5.1) (0.2)	4.5 (0.1) (4.19, 4.73)	3.37	(3.04, 3.69)	<0.001
Dairy & alternatives drink	5.1 (3.3) (0.1)	5.1 (0.1) (4.94, 5.22)	3.99	(3.76, 4.22)	<0.001
Carbonated/mixer drink	5.6 (5.2) (0.1)	5.6 (0.1) (5.45, 5.72)	4.49	(4.27, 4.72)	<0.001
Coffee drink	5.9 (3.4) (0.2)	6.0 (0.2) (5.68, 6.39)	4.94	(4.54, 5.34)	<0.001
Juice/juice drink	6.9 (4.1) (0.1)	6.8 (0.1) (6.73, 6.95)	5.75	(5.53, 5.96)	<0.001
Store type					
Grocery store website	5 (4.2) (0)	5.0 (0.0) (4.95, 5.11)	Reference	-	-
Brand website	5.5 (4.6) (0.1)	5.4 (0.1) (5.33, 5.54)	0.40	(0.27, 0.54)	<0.001

[a] CI=confidence interval

Table 3-4. Descriptive statistics of sugar concentrations (g/100mL) of non-alcoholic, pre-packaged beverages, by country and category, 2023-2025 (N=15,640)

	Overall Mean (SD) Median (minimum, maximum) (n)	Chile Mean (SD) Median (minimum, maximum) (n)	United Kingdom Mean (SD) Median (minimum, maximum) (n)	Mexico Mean (SD) Median (minimum, maximum) (n)	United States Mean (SD) Median (minimum, maximum) (n)	Australia Mean (SD) Median (minimum, maximum) (n)	Canada Mean (SD) Median (minimum, maximum) (n)
Overall	5.2 (4.4) 4.7 (0.0, 48.0) n=15,640	4.3 (3.7) 4.4 (0.0, 18.0) n=1,242	4.5 (3.8) 4.3 (0.0, 18.5) n=2,598	5.0 (4.2) 4.8 (0.0, 48.0) n=1,588	5.2 (4.7) 4.6 (0.0, 19.4) n=5,841	5.8 (4.4) 5.6 (0.0, 41.7) n=1,728	6.1 (4.3) 5.4 (0.0, 23.3) n=2,643
Category							
Water drink	1.1 (2.2) 0.0 (0.0, 18.0) n=1,815	1.0 (2.4) 0.0 (0.0, 18.0) n=169	1.5 (2.4) 0.0 (0.0, 12.5) n=183	1.0 (1.8) 0.0 (0.0, 8.0) n=286	1.0 (2.0) 0.0 (0.0, 12.5) n=737	1.6 (2.5) 0.3 (0.0, 10.8) n=141	1.4 (2.4) 0.0 (0.0, 11.5) n=299
Sports drink	3.4 (2.8) 4.2 (0.0, 19.4) n=675	2.7 (2.2) 4.0 (0.0, 5.8) n=44	2.3 (2.0) 3.5 (0.0, 4.5) n=24	5.0 (2.0) 6.0 (0.0, 6.3) n=57	3.3 (2.9) 2.5 (0.0, 19.4) n=449	2.7 (2.9) 0.5 (0.0, 6.0) n=35	3.6 (2.7) 5.8 (0.0, 5.9) n=66
Low/no-alcohol drink	4.2 (3.9) 3.8 (0.0, 22.0) n=260	3.3 (2.3) 3.2 (0.0, 9.6) n=22	4.7 (3.4) 4.4 (0.0, 15.0) n=115	11.5 (0) 11.5 (11.5, 11.5) n=1	2.9 (2.8) 2.8 (0.0, 10.6) n=12	4.1 (5.5) 1.9 (0.0, 22.0) n=57	3.6 (3.1) 4.0 (0.0, 12.8) n=53
Energy drink	4.3 (5.1) 0.5 (0.0, 16.7) n=855	5.9 (5.2) 5.4 (0.0, 15.0) n=50	3.6 (3.6) 4.0 (0.0, 12.0) n=211	8.4 (4.0)	3.4 (5.1) 0.0 (0.0, 15.3) n=393	5.8 (6.1) 2.0 (0.0, 16.7) n=96	6.7 (5.5) 9.9 (0.0, 14.6) n=74

				10.7 (0.0, 11.5) n=31			
Dairy & alternatives drink	5.1 (3.3) 4.8 (0.0, 48.0) n=3,348	4.8 (1.8) 4.7 (0.0, 11.9) n=287	4.9 (3.2) 4.4 (0.0, 14.5) n=498	5.7 (3.7) 4.8 (0.0, 48.0) n=525	4.4 (3.4) 4.6 (0.0, 16.9) n=887	5.3 (2.8) 4.8 (0.1, 17.2) n=457	5.6 (3.4) 4.9 (0.0, 16.8) n=694
Carbonated/mixer drink	5.6 (5.2) 4.6 (0.0, 41.7) n=3,386	3.6 (4.1) 0.3 (0.0, 11.0) n=268	3.0 (3.5) 3.7 (0.0, 18.5) n=614	5.3 (4.4) 4.9 (0.0, 18.0) n=358	6.6 (5.6) 9.3 (0.0, 15.8) n=1,406	5.9 (5.6) 7.2 (0.0, 41.7) n=282	7.0 (5.1) 9.3 (0.0, 18.3) n=458
Coffee drink	5.9 (3.4) 6.1 (0.0, 12.1) n=489	n=0	6.4 (2.2) 6.7 (0.0, 10.0) n=106	7.4 (2.7) 6.2 (5.0, 11.6) n=6	5.6 (3.8) 5.9 (0.0, 11.8) n=275	6.6 (3.0) 7.4 (0.0, 10.2) n=62	5.9 (3.9) 5.9 (0.0, 12.1) n=40
Juice/juice drink	6.9 (4.1) 7.6 (0.0, 23.3) n=4,812	5.6 (3.9) 4.8 (0.0, 15.0) n=402	6.1 (3.9) 4.6 (0.0, 16.0) n=847	6.6 (4.2) 6.5 (0.0, 13.2) n=324	7.0 (4.2) 7.2 (0.0, 17.3) n=1,682	7.3 (4.1) 8.7 (0.0, 17.1) n=598	7.6 (3.8) 8.8 (0.0, 23.3) n=959

3.1.4.3 Sugar concentration by the UK's policy status

3.1.4.4 The UK's sugar FOPL thresholds

Table C-1 in Appendix C shows the thresholds used by the UK's sugar FOPL. As shown in Table C-3 in Appendix C, 4.0% of beverages in the UK had sugar concentrations >11.25g/100mL compared with 5.4% in Chile, 6.5% in Australia, 9.6% in Mexico, 10.5% in Canada, and 14.6% in the US. The proportion of beverages with sugar concentrations ≤2.5g/100mL ranged from 25.8% in Canada to 40.0% in the US, while the proportion with >2.5 to 11.25g/100mL ranged from 45.5% in the US to 63.7% in Canada.

3.1.4.5 The UK's SSB tax thresholds

Table C-1 in Appendix C shows the thresholds used by the UK's SSB tax. The lower SSB thresholds are near those used by the Chile sugar FOPL (unlabeled versus labeled: ≤5g/100mL versus >5g/100mL). As shown in Table C-4 in Appendix C, 68.6% of beverages in the UK were below the lower tax threshold, compared with 72.3% in Chile, 57.1% in Mexico, 51.4% in the US, 46.0% in Australia, and 44.0% in Canada. The proportion of beverages within the lower threshold band ranged from 8.8% in Chile and the UK to 18.2% in Mexico, while the proportion within the higher tax threshold band ranged from 18.9% in Chile to 40.2% in Canada. In the UK, 62.1% of tax-exempt beverages (i.e., dairy & alternatives drinks) were below the lower tax threshold compared to 70.1% of non-exempt beverages (i.e., all other categories).

3.1.4.6 'Clustering' around the UK's SSB tax and sugar FOPL thresholds

The proportion of beverages with sugar concentrations up to 1.0g below (or at) versus above country-specific policy thresholds was tested as a potential indicator of (re)formulation in response to policies. As shown in Figure C-1 in Appendix C, beverages in the UK were far more likely to 'cluster' immediately below versus above the UK's SSB tax threshold of ≥5g/100mL. The difference in the proportion of beverages just below (or at) versus just above the 5.0g/100mL threshold in the UK was greatest in Chile (23.8%), followed by the UK (21.6%), Mexico (12.0%), Australia (4.5%),

Canada (2.3%), and the US (-3.2%; Table 3-5; $p<0.05$ for all within-country contrasts). In contrast, differences in the proportion of beverages just below (or at) versus just above the UK sugar FOPL thresholds were smaller across countries (Table 3-5).

Table 3-5. Distribution of non-alcoholic, pre-packaged beverages within ±1g of sugar thresholds for sugar-sweetened beverage tax and front-of-package sugar labeling policies implemented in Chile and the United Kingdom, by country (N=15,640)[a]

Sugar Thresholds		≤2.5g/100mL (UK FOPL)[b]			<5.0g/100mL (UK tax)[c]			≤5.0g/100mL (Chile FOPL)[d]			<6.25g/100mL (Chile tax)[e]			<8g/100mL (UK tax)[c]			≤11.25g/100mL (UK FOPL)[b]	
	% Within 1 g below threshold	% Within 1 g above threshold	% Difference	% Within 1 g below threshold	% Within 1 g above threshold	% Difference	% Within 1 g below threshold	% Within 1 g above threshold	% Difference	% Within 1 g below threshold	% Within 1 g above threshold	% Difference	% Within 1 g below threshold	% Within 1 g above threshold	% Difference	% Within 1 g below threshold	% Within 1 g above threshold	% Difference
	1.50-≤2.50	>2.50-≤3.50	Below – Above	4.00-<5.00	≥5.00-<6.00	Below – Above	4.00-≤5.00	>5.00-≤6.00	Below – Above	5.25-<6.25	≥6.25-<7.25	Below – Above	7.00-<8.00	≥8.00-<9.0	Below – Above	10.25-≤11.25	>11.25-≤12.25	Below – Above
United Kingdom	5.2	7.5	-2.3[f]	24.2	2.7	21.6[f]	25.4	1.7	23.7[f]	1.2	2.0	-0.8[f]	4.7	5.5	-0.8	5.9	1.9	4.0[f]
Chile	5.6	4.2	1.4	29.2	5.5	23.8[f]	33.3	1.6	31.7[f]	1.8	1.2	0.6	2.7	2.3	0.4	4.3	2.8	1.5[f]
United States	4.2	3.1	1.1[f]	7.1	10.4	-3.2[f]	10.2	7.5	2.7[f]	7.4	3.1	4.4[f]	2.8	2.7	0.1	7.1	6.7	0.4
Mexico	3.4	2.4	1.0	19.0	6.9	12.0[f]	21.7	6.5	15.2[f]	6.5	4.8	1.7[f]	5.2	3.2	2.0[f]	7.1	3.8	3.3[f]
Australia	4.4	2.8	1.6[f]	10.5	6.1	4.5[f]	12.1	5.3	6.8[f]	5.0	4.0	1.0	6.7	8.2	-1.6	10.4	3.1	7.2[f]
Canada	3.1	4.4	-1.4[f]	11.8	9.6	2.3[f]	12.6	9.3	3.2[f]	6.7	3.0	3.8[f]	3.4	4.8	-1.4[f]	10.3	5.3	5.0[f]

[a] % represent the proportion of beverages 1g below or above each policy threshold (g/100mL). % Difference = % below - % above.

[b] United Kingdom (UK) front-of-package nutrition label (FOPL): ≤2.5g/100mL (green label); >2.5 to ≤11.25g/100mL (yellow label); >11.25g/100mL (red label).

[c] United Kingdom sugar-sweetened beverage (SSB) tax: <5g/100mL (untaxed); ≥5 to <8g/100mL (lower tax threshold); ≥8g/100mL (higher tax threshold).

[d] Chile (CHI) front-of-package nutrition label: ≤5g/100mL (unlabeled); >5g/100mL (labeled).

[e] Chile sugar-sweetened beverage tax: <6.25g/100mL (lower tax threshold); ≥6.25g/100mL (higher tax threshold).

[f] $p<0.05$ 1g below versus 1g above threshold

3.1.4.7 Sugar concentration by Chile's policy status

3.1.4.8 Chile's sugar FOPL thresholds

Table C-1 in Appendix C shows the thresholds used by Chile's sugar FOPL. As shown in Table C-5 in Appendix C, 76.4% of all beverages in Chile were below the sugar FOPL threshold compared with 69.7% of beverages in the UK, 59.8% in Mexico, 54.4% in the US, 47.6% in Australia, and 44.7% in Canada.

3.1.4.9 Chile's SSB tax thresholds

Table C-1 in Appendix C shows the thresholds used by the Chile's SSB tax. As shown in Table C-6 in Appendix C, 78.2% of all beverages in Chile had sugar concentrations below the tax threshold, compared with 71.6% in the UK, 67.1% in Mexico, 62.9% in the US, 54.3% in Canada, and 53.3% in Australia. In Chile, 74.5% of tax-exempt beverages (i.e., dairy & alternatives drinks) were below the tax threshold compared to 90.6% of non-exempt beverages (i.e., all other categories).

3.1.4.10 'Clustering' around Chile's SSB tax and sugar FOPL thresholds

As shown in Figure C-1 in Appendix C, beverages in Chile were far more likely to 'cluster' immediately below than above the Chilean sugar FOPL threshold of ≤5g/100mL. The difference in the proportion of beverages just below (or at) versus just above the 5.0g/100mL threshold in Chile was greatest in Chile (31.7%), followed by the UK (23.7%), Mexico (15.2%), Australia (6.8%), Canada (3.2%), and the US (2.7%; Table 3-4; $p<0.05$ for all within-country contrasts). In contrast, differences in the proportion of beverages just below (or at) versus just above Chile's SSB tax threshold of ≥6.25g/100mL were smaller, ranging from -0.8% in the UK to 4.4% in the US (Table 3-5).

3.1.5 Discussion

The current study is among the few to directly compare sugar concentrations across countries with and without sugar-based policies. The findings indicate that sugar concentrations of beverages

are lower in countries with mandatory threshold-based SSB taxes and/or sugar FOPL policies (Chile and the UK) compared to countries without such policies (Australia, Canada, Mexico, and the US). While the cross-sectional design did not assess sugar concentrations before and after policy implementation, the distribution of sugar concentrations across countries and 'clustering' close to mandatory sugar thresholds were consistent with patterns that may reflect potential (re)formulation in response to SSB tax and sugar FOPL policies.

Across all countries examined, those with threshold-based SSB taxes and sugar FOPLs, such as the UK and Chile, had lower mean sugar concentrations. This finding aligns with previous cross-country research showing greater decreases in sugar concentrations of UK beverages pre-post policy announcement and implementation (13-31% per year from 2015 to 2019) versus minimal changes in countries with a flat-rate tax (France, 2012-2015) or voluntary industry sugar-reduction commitments (the Netherlands, 2014-2019); however, sugar concentrations decreased by 6% between 2017 and 2018 after France adopted a threshold-based tax.[174] Sustained decreases in sugar concentrations in UK soft drinks have been observed, with a government analysis reporting a 47% mean reduction in sugar across taxable beverages between 2015 and 2024.[175] Evidence in South Africa further supports the potential for threshold-based SSB taxes to stimulate (re)formulation. A pre-post study reported that the proportion of taxable beverages reformulated to lower sugar concentrations increased from 5.2% to 17.1% between policy announcement and implementation.[239] Previous research in Chile also reported decreases in the proportion of 'high in sugar' beverages from pre- to one or two years post-implementation of the law mandating FOPLs and marketing restrictions for unhealthy food and beverages, particularly among beverages near the threshold.[240] Like Chile, Mexico has a mandatory SSB tax and sugar FOPL policy; however, adjusted mean sugar concentrations were higher than in the US, which lacks national-level policies. This finding may reflect differences in policy design. For example, Mexico's flat-rate volumetric tax applies to beverages with 'any' added sugars, which may offer less incentive for sugar reductions than threshold-specific targets.

'Clustering' patterns observed in the current study are consistent with evidence suggesting that brands may be incentivized to (re)formulate below (or at) the 5.0g/100mL threshold used by the UK tax and Chile sugar FOPL policies. Nearly one-quarter of beverages in the UK sample 'clustered' 1g below (or at) this threshold, with little 'clustering' observed below (or at) the higher tax threshold (8g/100mL). The UK government has reported similar 'clustering' patterns. For example, nearly 65% of soft drinks containing sugar concentrations >5g/100mL were (re)formulated to below the threshold between 2015 and 2019,[175] and a 2024 report found 'clustering' under 5g/100mL and minimal 'clustering' under 8g/100mL.[172] In contrast to the SSB tax, the current study found minimal 'clustering' below UK sugar FOPL thresholds (2.5g/100mL and 11.25g/100mL). This finding may reflect the voluntary nature of the FOPL policy, consistent with limited (re)formulation observed with the UK's voluntary sugar reduction program (e.g., 2% sugar reduction in juices from 2015-2024).[172] In Chile, the observed 'clustering' below the sugar FOPL threshold but not the higher SSB tax threshold (6.25g/100mL) suggests that brands may prioritize (re)formulating under 5g/100mL to evade consequences of both the sugar FOPL and SSB tax.

About one in five beverages in Mexico 'clustered' below the 5g/100mL threshold used by Chile's sugar FOPL—about twice the proportion of countries without policies, such as the US, Australia, and Canada. Several Latin American countries other than Chile use a 5g/100mL threshold for SSB taxes (e.g., Colombia and Peru)[210] and similar thresholds for sugar FOPLs (e.g., Peru: 5g/100mL and Venezuela: 5.5g/100mL),[191] indicating that multinational corporations may have implemented product changes across the broader region to meet existing sugar thresholds and in anticipation of future policies. However, other factors, such as baseline sweetness, consumer sweetness preferences, and brand strategy, may play a role[166] in the observed patterns and require further investigation.

Countries without mandatory sugar-related policies (Australia, Canada, and the US) had higher adjusted mean sugar concentrations than Chile and the UK and displayed little 'clustering' below thresholds. While these countries have voluntary industry commitments to reduce sugar

consumption,[241–243] these initiatives may offer weaker (re)formulation incentives than mandatory policies. For instance, the Australian Beverages Council Limited's voluntary pledge in 2018 was associated with modest decreases in sugar concentrations between 2015 and 2019 (8.1 to 7.3g/100mL), with greater decreases observed among non-signatories versus signatories during this timeframe (11% versus 4%).[171] However, more recent industry reports suggest larger decreases among signatories (nearly 20% between 2015 and 2024).[241] As industry commitments in Canada and the US focus on reducing energy from beverages, data are not provided on changes in sugar concentrations over time.[242,243]

Across all countries, median sugar concentrations from the current study are lower than estimates reported in a cross-country evaluation between 2013 and 2018 [Australia (5.6g versus 7.0g/100mL), Canada (5.4 versus 9.6g/100mL), Chile (4.4 versus 8.0g/100mL), Mexico (4.8 versus 7.3g/100mL), the UK (4.3 versus 7.2g/100mL), and US (4.6 versus 7.4g/100mL)],[244] but similar to more recent evaluations in Australia (5.6 versus 6.4 g/100mL) and the UK (apart from 'coffee' drinks).[245–247] Differences across studies may result from temporal changes in the beverage market, including (re)formulation and increasing government and/or consumer demand for lower sugar/calorie options. Differences may also reflect study methods, such as beverage categorization and coverage of retailers or beverages. For instance, inclusion of traditionally higher-sugar beverage categories could increase mean sugar concentrations, while different retailers may influence the composition of beverages sampled across countries. Across categories, mean sugar concentrations were lowest for water drinks and highest for juice/juice drinks and coffee drinks, in line with previous research in Australia, Canada, Slovenia, and the UK.[248–250] Findings also align with a cross-country study reporting lower mean sugar concentrations in carbonated soda, fruit juices, and sports/energy drinks in the UK versus countries without mandatory threshold-based policies, such as Australia and Canada.[248,251]

Globally, nearly 70% of SSB taxes exempt sugar-sweetened dairy & alternatives drinks.[210,230] These beverages may be exempt due to their nutritional value (e.g., source of calcium),[252] complex

definition (e.g., minimum milk or calcium content), and/or industry pressure.[253,254] In the current study, 53% of dairy & alternatives drinks contained added sugars across all countries. Expanding tax criteria to include sugar-sweetened dairy & alternatives drinks could more comprehensively reduce free sugar intake, aligning with World Health Organization recommendations.[230] As such, the UK will remove exemptions on pre-packaged dairy & alternatives drinks with added sugars in 2028.[175]

The current study also found that juice/juice drinks had the highest adjusted mean sugar concentrations across categories. Although the proportion of 100% juices versus juice drinks was not examined, both contain free sugars and are recommended as taxable beverages by the World Health Organization.[255] A modelling study in Canada reported greater health and economic benefits of a tax that included juice compared to only SSBs, including nearly CAD$55 versus CAD$37 billion in healthcare cost savings and revenue over 25 years.[256]

3.1.5.1 Limitations

The current study is subject to limitations common to web scraping research. First, the scan did not capture all beverages sold in each country. Beverages may have been missed due to technical limitations (e.g., inability to extract data from images) and were limited to non-alcoholic, pre-packaged options. The number of retailers in each country was also limited and did not include niche retailers (e.g., ethnic grocery or health food stores), vending machines, or food-service establishments, potentially underrepresenting niche- or region-specific products. While beverage availability may vary across retail settings,[216–218] the inclusion of multiple retail sources (i.e., grocery store and brand websites) increased coverage of the pre-packaged beverage market. Additionally, the scrape included a majority of brands from leading manufacturers on country-specific 2022 Euromonitor market share reports: 68.5% (Canada), 68.6% (UK), 74.5% (US), 77.5% (Australia), 80.3% (Mexico), and 82.2% (Chile),[220–225] supporting representativeness of major market beverages.

Data captured by web scraping may differ from product labels if online information was not updated to reflect product changes. As such, the findings may underestimate recent reductions in sugar concentrations. However, evidence suggests this limitation may be modest: although few studies have compared products in-store and online, an evaluation of UK supermarkets reported similar product availability across the sources, with 85% of items matched with nearly identical nutritional information.[257]

The cross-sectional design limits insight into changing product availability and composition over time, including seasonally-marketed, new, and discontinued products,[247] and prevents causal conclusions about the impact of sugar-related policies on (re)formulation. Additionally, the lack of purchase and consumption data limits conclusions on health effects. Low/no-calorie sweetener concentrations or their FOPLs were not assessed, preventing characterization of the overall sweetener composition of beverages. Furthermore, (re)formulation may result from factors beyond tax and label policies, including industry practices, cultural preferences for sweetness, consumer demand for lower/no-sugar options, consumer perceptions of sweetener healthfulness, ingredient prices, and brand strategy,[166] which were not examined. However, the inclusion of six countries with varying policy environments (e.g., mandatory, voluntary, and no national-level sugar-related policies) provided insight into how policy design may shape the beverage supply, while standardized methods of data collection and analysis improved comparability across countries. Moving forward, longitudinal studies are needed to better understand how sugar-related policies and other market factors influence beverage (re)formulation and health outcomes over time.

Despite the rise in online beverage purchasing and Codex Alimentarius recommendations for clear and transparent labelling both in-store and online,[258,259] only a limited number of jurisdictions, including Chile, the European Union, and the UK, require nutrition information to be displayed in both settings, though enforcement mechanisms are unclear.[260–262] In the current study, a large proportion of beverages were excluded due to missing sugar concentrations, which reflected the absence of this information on retailer and brand websites. Missing data may have affected the

findings if beverages with and without available sugar information differed systematically; however, the direction and magnitude of any resulting bias cannot be determined. The extent of missingness highlights the importance of improving the completeness of online nutrition data. The Canadian and US governments held consultations with stakeholders in 2022 and 2023 to explore the development of best-practices for providing nutrition information online,[263,264] suggesting the potential to improve consumer understanding of beverage composition and support future research using online product composition data.

3.1.6 Conclusion

The current study found lower sugar concentrations and evidence consistent with beverage (re)formulation to below (or at) 5g/100mL thresholds in countries with mandatory threshold-based SSB tax and sugar FOPL policies. These findings add evidence that policy design, particularly using sugar thresholds, may incentivize (re)formulation to lower sugar options. Countries worldwide are updating policy thresholds and expanding the scope of beverages covered by SSB taxes and FOPLs. In 2026, Canada implemented national-level FOPLs, while Mexico increased the tax rate and introduced a tax on beverages with low/no-calorie sweeteners.[265] In the coming years, Australia's FOPL system is set to become mandatory,[266] the US has proposed mandatory FOPLs,[267] and the UK will lower the SSB tax threshold from 5g to 4.5g/100mL in 2028.[175] Longitudinal studies are needed to examine pre-post changes in sugar and low/no-calorie sweetener concentrations in beverages and their implications for population health.

Chapter 4: DIFFERENCES IN SWEETENER PRESENCE ACROSS COUNTRIES

4.1 Study 2: International differences in the presence of sweeteners in non-alcoholic beverages: a market scan in Australia, Canada, Chile, Mexico, the United Kingdom, and the United States.

Status: in preparation

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4.1.1 Overview

Background: The presence of low/no-calorie sweeteners (LNCS) in non-alcoholic beverages has increased in response to growing consumer demand for low-calorie and low-sugar options. Few studies have examined how the presence of beverage sweeteners differs across countries, including countries with and without sugar-sweetened beverage (SSB) tax and front-of-package nutrition labelling (FOPL) policies.

Objective: To examine LNCS and added sugars presence in non-alcoholic, pre-packaged beverages in six countries with differing national-level sugar-related policies.

Methods: Data were collected by web scraping retailer and brand websites for 15,994 beverages from Australia (n=2,105), Canada (n=2,672), Chile (n=1,229), Mexico (n=1,564), the United Kingdom (n=2,587), and the United States (US; n=5,837) between October 2023 and February 2025. Binary regression models examined differences in sweetener presence between countries and beverage categories.

Results: The percentage of beverages with LNCS was highest in countries with mandatory SSB taxes and/or sugar FOPLs (Chile: 64.7%; UK: 48.8%; Mexico: 45.3%) versus countries without mandatory policies (US: 36.1%; Australia: 24.4%; Canada: 17.5%; $p<0.001$). Similar patterns were observed for combined presence of LNCS and added sugars (Chile: 31.7%; UK: 27.1%; Mexico: 26.5% vs US: 17.4%; Australia: 8.4%; Canada: 7.5%; $p<0.001$). Patterns were less consistent for added sugars without LNCS (Chile: 45.2%; UK: 59.2%; Mexico: 58.9% vs US: 56.3%; Australia: 46.8%; Canada: 56.4%; $p=0.002$). Across all countries, LNCS presence was highest in energy drinks (75.2% vs ≤49.5% in other categories) and added sugars presence was lowest in water drinks (36.7% vs ≥52.9% in other categories).

Conclusions: Brands may be replacing added sugars with LNCS in response to SSB tax and/or sugar FOPL policies. Continued research is needed to monitor changes in beverage formulations and understand health implications of LNCS.

4.1.2 Introduction

The global non-alcoholic pre-packaged beverage market includes a wide variety of products (e.g., water, juice, dairy & alternatives, sports, energy, and soft drinks) containing a range of sweeteners.[268] While some beverages provide beneficial nutrients, such as vitamin C and calcium, sugar-sweetened beverages (SSBs) are a primary source of sugars and calories,[235] and have been associated with obesity, cardiovascular disease, type 2 diabetes, and dental caries.[236,237] Growing awareness of these health risks has increased government and consumer demand for beverages with reduced sugar content.[15] In response, manufacturers have introduced smaller container sizes and (re)formulated products to contain less sugar, including substituting sugar with alternative sweeteners.[7]

Sweeteners contribute sweetness and may improve the texture and mouthfeel of beverages.[268] Sweeteners can be classified in multiple ways, including by caloric value (nutritive versus low/no-calorie sweeteners, LNCS).[6,7] Nutritive sweeteners include regular sugars (e.g., sucrose, high-fructose corn syrup, and honey) and rare sugars (e.g., allulose, tagatose, and xylose), which provide less sweetness and fewer calories than sucrose.[7] In contrast, LNCS include non-sugar sweeteners (NSS; e.g., aspartame, sucralose, and stevia), which are often intensely sweeter than sucrose[8] and provide little or no calories, as well as sugar alcohols (also called 'polyols'; e.g., xylitol, sorbitol, and erythritol) that provide less or the same sweetness and fewer calories than sucrose.[7,9]

Safety assessments of LNCS are conducted by regulatory organizations prior to use; however, their health effects remain uncertain.[11] For example, LNCS have been associated with an increased risk of type 2 diabetes, cardiovascular disease, and mortality in prospective cohort studies, yet these associations were not observed in randomized controlled studies.[269] In turn, the World Health Organization advised against using LNCS for weight control or reducing the risk of non-communicable diseases.[269] This uncertainty is further complicated by little research on the long-term health implications of consuming multiple sweeteners, including LNCS combinations.

Despite their mixed health effects, research has found increasing presence of LNCS in beverages worldwide.[16] In a longitudinal study of sales data from 2007 to 2019, per capita amounts of added sugars sold in beverages decreased in high-income countries, while LNCS sales amounts increased.[16] The global increase in LNCS was mainly driven by increases in the use of natural sweeteners such as stevia and erythritol,[16] which are perceived as healthier than artificial sweeteners by consumers.[15,270] LNCS may still be combined with added sugars to improve sensory experiences and beverage stability, including masking LNCS bitterness or aftertastes.[9]

The presence of LNCS in beverages may be influenced by national sugar-related policies.[16] To date, more than 100 jurisdictions around the world have implemented policies to encourage beverage (re)formulation and nudge consumers to select lower sugar options, such as SSB taxes and front-of-package nutrition labels (FOPLs).[190,209] However, implementation of these policies has varied across jurisdictions. For taxes, countries like Chile and the United Kingdom (UK) have mandatory SSB taxes based on sugar concentration thresholds (which apply higher tax rates to higher-sugar beverages), countries like Mexico have a mandatory flat-rate volumetric tax (which applies the same rate per unit volume, regardless of sugar concentration), countries like the United States (US) have sub-national SSB taxes implemented in select jurisdictions only, and other countries, like Australia and Canada, lack national-level taxes.[190,209] For sugar FOPLs, countries like Chile and Mexico have mandatory black octagonal warning labels, the UK has a voluntary traffic light system, Canada has a mandatory magnifying glass-shaped label, Australia has a voluntary Health Star Rating system, and the US lacks a national-level label system.[190,209] Some jurisdictions have also implemented FOPL sweetener warnings, including Mexico, Argentina, and Colombia.[209]

Policy design may differentially influence the presence of sweeteners in beverages. For instance, brands may be more incentivized to replace sugar with LNCS in countries with mandatory policies versus voluntary industry commitments, sugar concentration thresholds versus flat-rate volumetric taxes, or policies that discourage LNCS use (e.g., sweetener FOPLs).[171–174] As sugar-related policies

often target added sugars, rather than free sugars (those added and naturally present in honey, syrup, and juices; not intrinsic to milk) or total sugars (added and naturally present; including all intrinsic sugars),[7,190,191] LNCS may also be more prevalent in beverage categories that traditionally contain added sugars, such as coffee, energy drinks, sports drinks, soft drinks, or flavoured waters.[192] However, the extent to which sugar-related policies drive differences in sweetener presence across countries and categories remains unclear. Other factors may also influence sweetener presence, including industry practices, cultural preferences for sweetness, consumer demand for lower/no-sugar options, consumer perceptions of sweetener healthfulness, and ingredient prices.[166]

Although LNCS are increasingly used in non-alcoholic, pre-packaged beverages around the world,[271–275] product-level differences across countries and between categories remain understudied. Such examinations are critical to determine consumer exposure to sweeteners and inform policy development. Thus, this study examined sweetener presence in non-alcoholic, pre-packaged beverages available on retailer and brand websites in six countries with different sugar-related policies: Australia, Canada, Chile, Mexico, the UK, and the US. The study had two primary objectives: 1) to compare the proportion of beverages containing LNCS and added sugars across countries and categories; and 2) to identify the most common sweeteners in beverages across countries and categories.

4.1.3 Methods

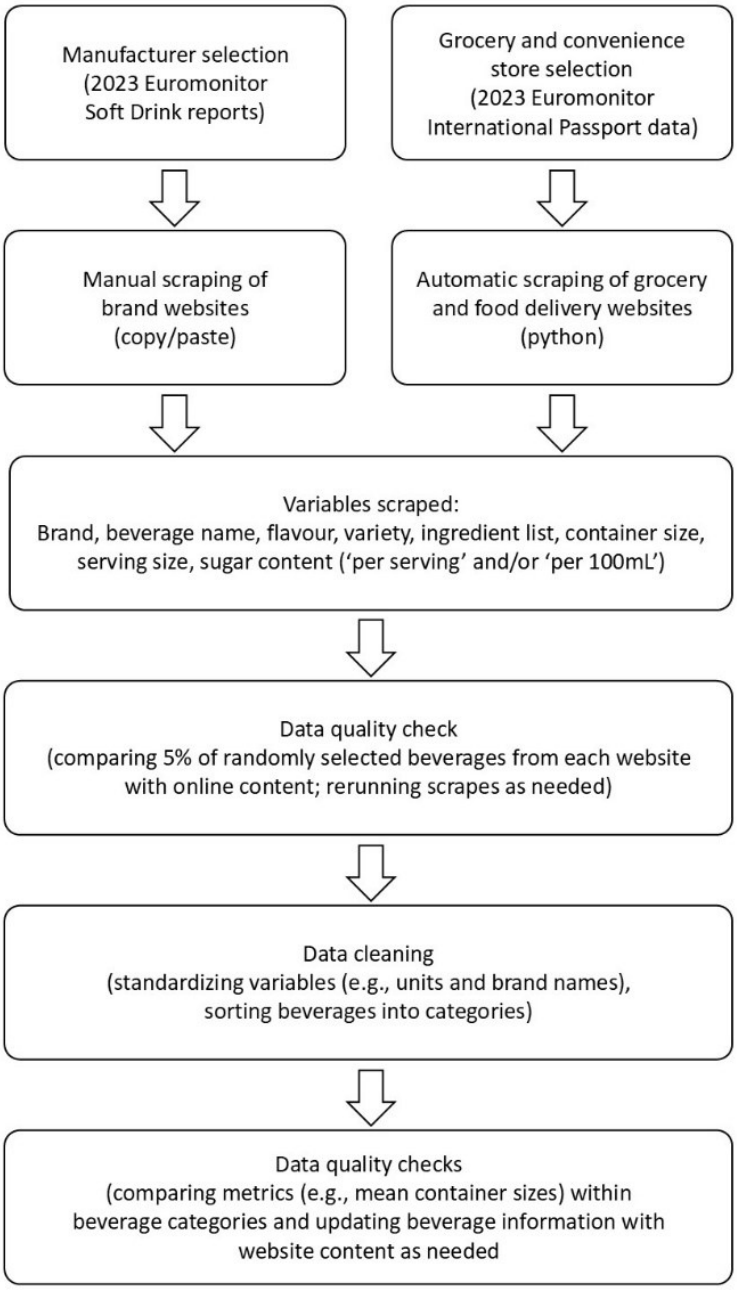
4.1.3.1 Overview of methods

A market scan was conducted to determine sweetener presence in non-alcoholic, pre-packaged beverages available across six countries: Australia, Canada, Chile, Mexico, the UK, and the US. These countries were selected to align with those involved in the International Food Policy Study, an annual repeat cross-sectional study that evaluates the impact of national-level food policies on

dietary qualities and perceptions.[219] The countries also have diverse policy approaches, including variations in SSB taxes and FOPLs, allowing examination of whether sweetener presence differs across policy contexts and providing evidence to inform policy development. Non-alcoholic, pre-packaged beverages were defined as alcohol by volume <0.5% and sold without further preparation needed before consumption (i.e., no mixing or dilution).

Figure 4-1 shows a flowchart of the methods used in the current study. Data collection occurred on retailer and brand websites between October 2023 and February 2025 using two approaches: manual web scraping (i.e., copying data from brand websites) and automatic web scraping (i.e., applying Python 3.13 scripts to grocery store and food delivery websites). Web scraping is an established method to obtain online information,[204,212,213] and has been previously used to collect data from online food retailers, including price, images, nutrition information, and product availability.[198,206,214,215]

Figure 4-1. Flowchart of study methods.



4.1.3.2 Manufacturer selection for manual web scraping

Leading manufacturers were identified using data from country-specific 2023 Euromonitor Soft Drink reports, which provide information on market sales and trends.[220–225] Websites of all manufacturers listed in the reports were searched to identify all brands in each country. Together, these manufacturers accounted for most of the beverage market in 2022: 70.6% (UK), 75.4% (US), 80.3% (Canada), 80.9% (Australia), 82.7% (Chile), and 88.3% (Mexico); private/other brands accounted for the remainder.[220–225]

4.1.3.3 Grocery and convenience store selection for automatic web scraping

The top three leading grocery and convenience store chains in each country were identified using country-specific 2023 Euromonitor International Passport data.[226] Store locations for sampling were chosen to maximize capture of available products by focusing on population and presence of a sugar-related policy (SSB tax or FOPL). For Australia, Chile, Mexico, and the UK, the four most populous regions and two most populous cities within each region were determined, and one of the cities per region was randomly selected for inclusion in the study, resulting in four locations per store. Because Canada and the US had sub-national SSB taxes at the time of data collection, samples for these countries included the three most populous regions and a region with a sub-national tax for a separate study on sugar concentrations.

Beverage data were collected from individual store locations (see Table B-2 in Appendix B). When product listings were unavailable for scraping (e.g., not listed online), an alternative city or the next-most populous region was used, depending on availability. Technical limitations (i.e., inability to accurately extract text from labels displayed as images) prevented the scraping of Walmart websites in four countries (Canada, Chile, Mexico, and the US), resulting in only two grocery store chains being included. Due to the lack of product listings on convenience store websites, product

information was obtained from leading food delivery platform websites in each country (identified by online searches), using convenience store addresses as search locations.

4.1.3.4 Non-alcoholic, pre-packaged beverage data

Information was scraped from the websites of brands, grocery stores, and food delivery platforms (to access convenience store product listings) for a census of non-alcoholic, pre-packaged beverages. Information collected for each beverage from both the manual and automatic web scrapes, when available, included the ingredient list, sugar content ('per 100mL' and/or 'per serving'), and product characteristics (e.g., brand, name, flavour, variety, container size, and serving size). Automatic web scraping captured full nutrient label information if available, while sugar was the only nutrient collected in the manual scrape due to available resources. Only text-based information was scraped. Multi- and variety-packs were included in the scrape, with manual checks completed by KH to identify different products (e.g., identifying varying flavours within packs and adding each to the dataset).

4.1.3.5 Data cleaning and management

Brands (such as 'Pepsi' or 'Tropicana'), flavours (the taste descriptor, such as 'cherry' or 'vanilla'), and varieties (the version, such as 'regular' or 'diet') were manually reviewed and consolidated for consistency (e.g., combining 'Coke' and 'Coca Cola').

Products were divided into eight categories: carbonated/mixer drink, coffee drink, dairy & alternatives drink, energy drink, juice/juice drink, low/no-alcohol drink, sports drink, and water drink. These categories were developed based on existing literature, grocery store websites, and policy regulations (e.g., products subject to SSB taxes and FOPL; see Table 4-1).[227–229] Certain categories were purposefully excluded (e.g., >0.5% alcohol by volume, beverage mixes, syrups, powders, and concentrates), based on the study's definition of non-alcoholic, pre-packaged

beverages. Non-alcoholic mixers were included if they did not have to be reconstituted (e.g., syrups), as they may be consumed without added alcohol.

Table 4-1. Overview of category definitions and example products.

Category	Definition	Examples
Carbonated/mixer drink	• Sold/marketed as carbonated drinks • Includes non-alcoholic mixers (which can be consumed alone or with added alcohol)	• Cola • Ginger beer • Mixers • Seltzer water • Tonic water
Coffee drink	• Sold/marketed as 'coffee' drinks • Includes coffee-flavoured milk drinks if the brand sells 'coffee' drinks	• Cappuccino • Cold-brew coffee • Iced coffee • Latte
Dairy & alternatives drink	• Sold/marketed as 'dairy' drinks • Includes probiotic/fermented dairy drinks • Includes coffee-flavoured milk drinks if the brand sells 'dairy' drinks	• Animal milks • Coffee-flavoured milk • Plant milks • Kefir • Milk/whey-based protein shakes • Yogurt
Energy drink	• Sold/marketed as energy drinks	• Monster • Rockstar • V
Juice/juice drink	• Sold/marketed as fruit/vegetable/herbal-based drinks • Includes water-juice drinks if the brand sells 'juice drinks' • Includes drinks with 'natural' sources of energy if the brand highlights herbs (e.g., yerba mate)	• 100% juice or vegetable drinks • Fruit drinks • Nectars • Herbal-based drinks • Iced tea • Juice-based smoothies • Kombucha • Lemonade
Low/no-alcohol drink	• Low/no alcohol (≤0.5% alcohol by volume) • Includes ciders if the brand sells alcoholic drinks (otherwise, ciders are juice)	• Beers • Ciders • Spirits • Wines
Sports drink	• Sold/marketed as sports drinks • Includes water with electrolytes if the brand focuses on sports/performance	• Gatorade • Powerade
Water drink	• Sold/marketed as water	• Aloe water • Coconut water

	• Includes drinks with added ingredients (e.g., caffeine, flavour or electrolytes) if the brand sells water or focuses on hydration	• Flavoured water • Mineral water • Sparkling water • Spring water • Vitamin water

Data quality

To maximize automatic web scraping accuracy, 5% of beverages from each store were randomly selected and compared against website content; scraping scripts were updated and rerun as needed. Metrics (e.g., mean, median, and ranges of serving and container sizes and sugar concentrations) for each beverage category were compared across countries using the full dataset: differences >10% were investigated and product information was updated to match website content as needed.

4.1.3.6 Measures

Outcomes

Presence of LNCS and/or added sugars, and sweetener descriptors (all categorical), were the dependent variables and determined by searching ingredient lists for predefined sweetener terms (see Table D-1 in Appendix D for terms used).

Independent variables and covariate

Independent variables were country (categorical) and beverage category (categorical). Store type (categorical) was included as a covariate to account for potential differences in the availability of beverages across online sources.

4.1.3.7 Analysis

Data on 106,476 beverages were collected across countries from the three store types (grocery stores, convenience stores via food delivery platforms, and brands): Australia (n=21,046), Canada (n=14,366), Chile (n=10,066), Mexico (n=12,607), UK (n=22,018), and US (n=26,373). Beverages were excluded from analyses when missing container sizes (n=1,762) or container sizes >2.5 gallons (9,463.5mL; n=151), as these were foodservice rather than consumer-facing formats. Beverages with the same brand, country, flavour, variety, and container size were considered duplicates and grouped, and one beverage with the most scraped information in each group (including sugar concentration and ingredient lists) was randomly selected for analysis (termed “unique beverage”;

n=26,552). Beverages missing either ingredient lists (including null values, such as 'NA') or sugar amounts (g 'per serving' or 'per 100mL'; to verify ingredient-based sugar classification) were excluded (n=10,558), leaving a final sample of 15,994.

Lists of terms commonly used to describe sweeteners were developed in English, French, and Spanish, based on existing literature.[231,232] Ingredient lists of beverages were then searched to determine the presence and type of sweetener used; exceptions were made when terms solely reflected technical roles (e.g., 'caramel for colour' describes an additive, rather than a sugar-based ingredient)[233,234] or regulatory requirements (e.g., 'Sugars' and 'Added sugars' appear before grouped listing of sugars in Canada and Mexico and do not reflect specific sugar descriptors).[131,233] Three sweetener profiles were examined:

1) LNCS (NSS or sugar alcohols)
2) Added sugars (including rare sugars)
3) Combination of LNCS and added sugars

Descriptive statistics compared the proportion of beverages containing LNCS and added sugars, as well as the most common sweetener descriptor (added and intrinsic sugars, NSS, and sugar alcohols), by country and category. Three binary logistic regression models were fitted to examine the odds of beverages containing: 1) LNCS (presence of NSS or sugar alcohols, alone or in combination with other sweeteners); 2) added sugars (presence alone or in combination with other sweeteners); or 3) combined LNCS and added sugars (presence of NSS or sugar alcohols in combination with added sugars). Reference groups were Chile (country; highest presence of LNCS across countries), water (beverage category; plain water is the recommended beverage among health organizations,[7] although this category included both sweetened and unsweetened water), and grocery store websites only (store type; lowest LNCS presence). Models were adjusted for country, beverage category, and store type, and were subsequently stratified by beverage category and sugar-related policy presence (countries with ≥1 mandatory policy: Chile, Mexico, the UK versus no mandatory policy: Australia, Canada, the US). Adjusted odds ratios and corresponding 95%

confidence intervals (95% CI) are presented. Data cleaning, management, and analyses were conducted in SAS v9.4 (SAS Institute Inc., North Carolina).

4.1.4 Results

4.1.4.1 Sample characteristics

Table 4-2 shows sample characteristics overall and across country, and by category and store type. Over one-third of beverages were from the US (36.5%) and nearly three-quarters were juice/juice drinks, carbonated/mixer drinks, and dairy & alternatives drinks (73.9%). Also, over half of the sample came from 'grocery store websites only' (54.8%), with none from 'convenience store websites only.' These patterns were consistent across countries.

Table 4-2. Characteristics of the sample of unique non-alcoholic, pre-packaged beverages from online retailer and brand websites, by store type and country (N=15,994)

	Overall	Australia	Canada	Chile	Mexico	United Kingdom	United States
Unique beverages % (n)	100.0% n=15,994	13.2% n=2,105	16.7% n=2,672	7.7% n=1,229	9.8% n=1,564	16.2% n=2,587	36.5% n=5,837
Beverage category % (n)							
Juice/juice drink	30.7% n=4,909	33.1% n=697	35.9% n=960	32.6% n=401	20.6% n=322	32.7% n=847	28.8% n=1,682
Carbonated/mixer drink	21.7% n=3,464	17.7% n=372	17.4% n=465	21.3% n=262	22.1% n=346	23.6% n=611	24.1% n=1,408
Dairy & alternatives drink	21.5% n=3,444	27.1% n=571	26.2% n=700	23.4% n=287	32.5% n=508	19.1% n=493	15.2% n=885
Water drink	11.4% n=1,825	7.1% n=150	11.4% n=305	13.5% n=166	18.7% n=292	7.0% n=182	12.5% n=730
Energy drink	5.5% n=882	5.7% n=120	2.9% n=77	4.1% n=50	2.0% n=31	8.0% n=208	6.8% n=396
Sports drink	4.3% n=692	2.6% n=54	2.5% n=67	3.3% n=41	3.7% n=58	0.9% n=24	7.7% n=448
Coffee drink	3.2% n=504	3.6% n=76	1.5% n=40	0.0% n=0	0.4% n=6	4.1% n=106	4.7% n=276
Low/no-alcohol drink	1.7% n=274	3.1% n=65	2.2% n=58	1.8% n=22	0.1% n=1	4.5% n=116	0.2% n=12
Store type % (n)							
Grocery store websites only	54.8% n=8,757	53.8% n=1,132	65.1% n=1,740	53.2% n=654	68.2% n=1,067	60.5% n=1,566	44.5% n=2,598
Brand websites only	30.5% n=4,883	26.0% n=547	22.1% n=590	23.0% n=283	18.8% n=294	24.0% n=622	43.6% n=2,547
Grocery store and brand websites only	8.7% n=1,391	12.9% n=271	8.8% n=235	9.9% n=122	8.1% n=127	7.1% n=183	7.8% n=453
Grocery and convenience store websites only	3.1% n=500	3.3% n=69	2.7% n=73	7.2% n=89	3.7% n=58	5.0% n=130	1.4% n=81
All three websites types	2.3% n=367	3.7% n=78	0.8% n=22	5.3% n=65	1.2% n=18	2.6% n=68	2.0% n=116

Brand and convenience store websites only	0.6% n=96	0.4% n=8	0.5% n=12	1.3% n=16	0.0% n=0	0.7% n=18	0.7% n=42
Convenience store website only	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0

4.1.4.2 Sweetener presence by country

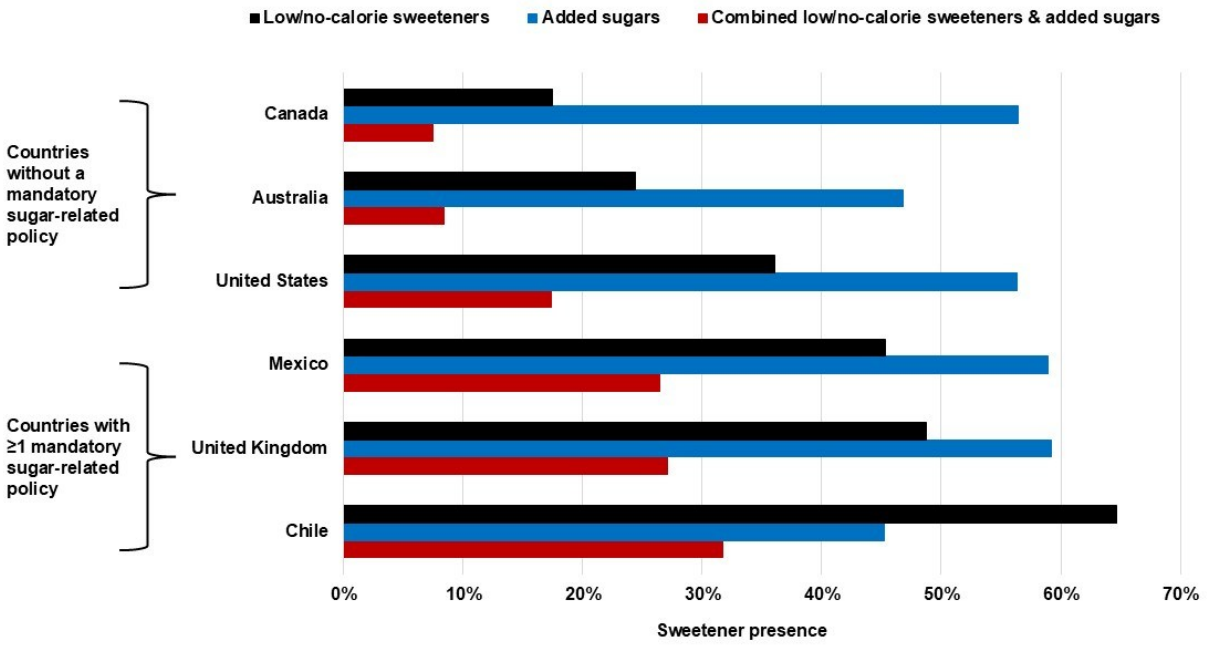
Figure 4-2 and Table 4-3 show the proportion of beverages containing sweeteners, by country. Across all countries, the presence of LNCS was 36.6%. This proportion was lowest in Canada (17.5%), Australia (24.4%), and the US (36.1%), and highest in Mexico (45.3%), the UK (48.8%), and Chile (64.7%; all contrasts p≤0.001 versus Chile; see Table 4-3 for the binary logistic regression analyses). Subsequent analyses found higher presence of LNCS among countries with ≥1 mandatory policy (Chile, Mexico, and the UK) versus countries without a mandatory policy (Australia, Canada, United States; aOR=3.77; 95% CI: (3.47, 4.09); p<0.001; data not shown).

Across all countries, the presence of added sugars was 54.9%. This proportion was lowest in Chile (45.2%) and Australia (46.8%), and highest in the US (56.3%), Canada (56.4%), Mexico (58.9%), the UK (59.2%; all contrasts p≤0.001 versus Chile, except Australia: p>0.05). Subsequent analyses found higher presence of added sugars among countries with ≥1 mandatory policy (Chile, Mexico, and the UK) versus countries without a mandatory policy (Australia, Canada, United States; aOR=1.13; 95% CI: (1.05, 1.21); p=0.002; data not shown).

Across all countries, the combined presence of LNCS and added sugars was 18.1%. This proportion was lowest in Canada (7.5%), Australia (8.4%), and the US (17.4%), and highest in Mexico (26.5%), the UK (27.1%), and Chile (31.7%; all contrasts p≤0.001 versus Chile, except Mexico: p>0.05). Subsequent analyses found higher combined presence of LNCS and added sugars among countries

with ≥1 mandatory policy (Chile, Mexico, and the UK) versus countries without a mandatory policy (Australia, Canada, United States; aOR=3.67; 95% CI: (3.32, 4.05); p<0.001; data not shown).

Figure 4-2. Proportion of unique non-alcoholic, pre-packaged beverages from online retailer and brand websites containing sweeteners (% yes), by country (N=15,994)[a]



[a] Low/no-calorie sweeteners included non-sugar sweeteners and sugar alcohols (alone or combined with other sweeteners); added sugars included sugars added to beverages (alone or combined with low/no-calorie sweeteners; not those intrinsic to unsweetened dairy & alternatives drinks or 100% juices). Sugar-related policies included a national-level sugar-sweetened beverage tax (mandatory in Chile, Mexico, and the United Kingdom) or front-of-package nutrition label (mandatory in Chile and Mexico; voluntary in Australia and the United Kingdom) implemented during data collection (i.e., pre-implementation of Canada's mandatory front-of-package nutrition label in 2026).

Table 4-3. Proportion of unique non-alcoholic, pre-packaged beverages from online retailer and brand websites containing sweeteners (% yes), by country and category, with binary logistic regression analyses of sweetener use (N=15,994)[a]

	Low/no-calorie sweeteners				Added sugars				Combined low/no-calorie sweeteners & added sugars			
	% (n)	**aOR[b]**	**(95% CI)[b]**	***p* value**	**% (n)**	**aOR[b]**	**(95% CI)[b]**	***p* value**	**% (n)**	**aOR[b]**	**(95% CI)[b]**	***p* value**
Overall	36.6% (n=5,855)	-	-	-	54.9% (n=8,783)	-	-	-	18.1% (n=2,897)	-	-	-
Country												
Chile	64.7% (n=795)	Reference	-	-	45.2% (n=556)	Reference	-	-	31.7% (n=389)	Reference	-	-
United Kingdom	48.8% (n=1,262)	0.49	(0.42, 0.57)	<0.001	59.2% (n=1,531)	1.60	(1.39, 1.84)	<0.001	27.1% (n=701)	0.80	(0.69, 0.94)	0.146
Mexico	45.3% (n=708)	0.46	(0.39, 0.54)	<0.001	58.9% (n=921)	2.02	(1.73, 2.36)	<0.001	26.5% (n=415)	0.88	(0.75, 1.05)	<0.001
United States	36.1% (n=2,108)	0.24	(0.21, 0.28)	<0.001	56.3% (n=3,284)	1.40	(1.23, 1.59)	<0.001	17.4% (n=1,015)	0.41	(0.36, 0.48)	0.005
Australia	24.4% (n=514)	0.16	(0.14, 0.19)	<0.001	46.8% (n=984)	0.98	(0.85, 1.13)	0.767	8.4% (n=176)	0.20	(0.16, 0.24)	<0.001
Canada	17.5% (n=468)	0.11	(0.09, 0.13)	<0.001	56.4% (n=1,507)	1.65	(1.43, 1.90)	<0.001	7.5% (n=201)	0.18	(0.15, 0.22)	<0.001
Category												
Water drink	43.2% (n=789)	Reference	-	-	37.9% (n=692)	Reference	-	-	20.8% (n=380)	Reference	-	-
Low/no-alcohol drink	16.4% (n=45)	0.22	(0.16, 0.32)	<0.001	89.4% (n=245)	16.28	(10.91, 24.29)	<0.001	10.2% (n=28)	0.45	(0.29, 0.68)	<0.001
Coffee drink	18.3% (n=92)	0.31	(0.25, 0.40)	<0.001	88.5% (n=446)	13.76	(10.28, 18.43)	<0.001	17.1% (n=86)	0.90	(0.69, 1.18)	0.442
Dairy & alternatives drink	18.4% (n=632)	0.28	(0.25, 0.32)	<0.001	46.6% (n=1,605)	1.57	(1.39, 1.77)	<0.001	10.5% (n=363)	0.47	(0.40, 0.56)	<0.001

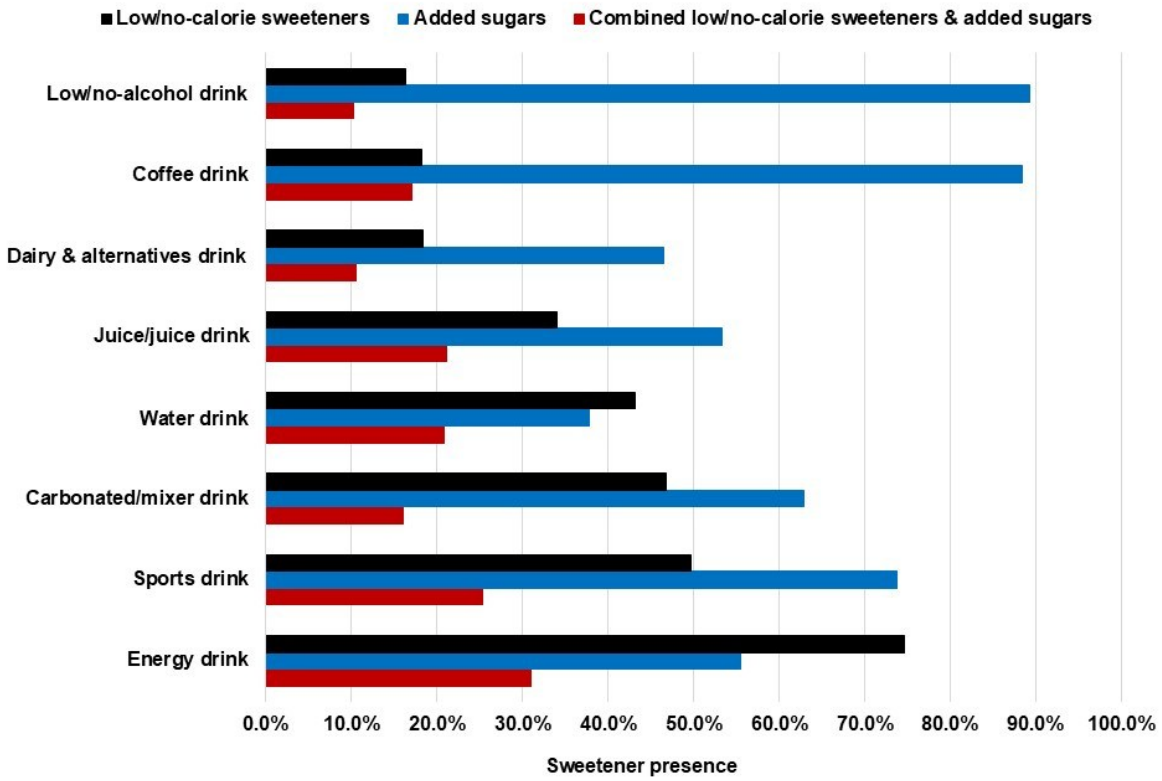
Juice/juice drink	34.0% (n=1,668)	0.70	(0.62, 0.79)	<0.001	53.3% (n=2,617)	1.97	(1.76, 2.20)	<0.001	21.1% (n=1,034)	1.13	(0.98, 1.29)	0.095
Carbonated/mixer drink	46.9% (n=1,626)	1.16	(1.03, 1.30)	0.018	62.9% (n=2,177)	2.78	(2.47, 3.13)	<0.001	16.1% (n=557)	0.70	(0.61, 0.82)	<0.001
Sports drink	49.7% (n=344)	1.42	(1.18, 1.71)	<0.001	73.8% (n=511)	4.53	(3.72, 5.51)	<0.001	25.4% (n=176)	1.40	(1.13, 1.73)	0.002
Energy drink	74.7% (n=659)	4.14	(3.43, 4.99)	-	55.6% (n=490)	2.05	(1.73, 2.42)	<0.001	31.0% (n=273)	1.71	(1.41, 2.08)	<0.001
Store type												
Grocery store websites only	33.1% (n=2,895)	Reference	-	-	51.6% (n=4,518)	Reference	-	-	51.6% (n=4,518)	Reference	-	-
Brand websites only	38.1% (n=1,860)	1.04	(0.95, 1.12)	0.407	58.3% (n=2,846)	1.30	(1.20, 1.40)	<0.001	58.3% (n=2,846)	1.19	(1.08, 1.31)	0.129
Grocery store and brand websites only	41.6% (n=578)	1.18	(1.04, 1.34)	0.010	58.5% (n=813)	1.30	(1.15, 1.47)	<0.001	58.5% (n=813)	1.13	(0.97, 1.31)	0.001
Brand and convenience store websites only	53.1% (n=51)	1.25	(0.80, 1.96)	0.319	72.9% (n=70)	2.44	(1.53, 3.89)	<0.001	72.9% (n=70)	2.22	(1.42, 3.48)	0.001
All three website types	54.0% (n=198)	1.00	(0.78, 1.26)	0.971	63.2% (n=232)	1.43	(1.14, 1.81)	<0.001	63.2% (n=232)	1.15	(0.88, 1.50)	0.299
Grocery and convenience store websites only	54.6% (n=273)	1.29	(1.05, 1.58)	0.015	60.8% (n=304)	1.41	(1.17, 1.71)	<0.001	60.8% (n=304)	1.67	(1.35, 2.07)	<0.001

[a] Low/no-calorie sweeteners included non-sugar sweeteners and sugar alcohols (alone or combined with other sweeteners); added sugars included sugars added to beverages (alone or combined with low/no-calorie sweeteners; not those intrinsic to unsweetened dairy & alternatives drinks or 100% juices). Separate binary logistic regression models investigated the presence of low/no-calorie sweeteners, added sugars, or combined low/no-calorie sweeteners & added sugars among unique non-alcoholic, pre-packaged beverages from online retailer and brand websites.
[b] aOR: adjusted odds ratio; CI=confidence interval

Sweetener use by beverage category

Figure 4-3 and Table 4-3 show the proportion of beverages containing sweeteners, by category. By beverage category, the presence of LNCS was lowest in low/no-alcohol drinks (16.4%), coffee drinks (18.3%), dairy & alternatives drinks (18.4%), and juice/juice drinks (34.0%), and highest in water drinks (43.2%), carbonated/mixer drinks (46.9%), sports drinks (49.7%), and energy drinks (74.7%; all contrasts $p \leq 0.018$ versus water drinks). The presence of added sugars was lowest in water drinks (37.9%), dairy & alternatives drinks (46.6%), juice/juice drinks (53.3%), energy drinks (55.6%), and highest in carbonated/mixer drinks (62.9%), sports drinks (73.8%), coffee drinks (88.5%), and low/no-alcohol drinks (89.4%; all contrasts $p \leq 0.001$ versus water drinks). The combined presence of LNCS and added sugars was lowest in low/no-alcohol drinks (10.2%), dairy & alternatives drinks (10.5%), carbonated/mixer drinks (16.1%), coffee drinks (17.1%), and highest in water drinks (20.8%), juice/juice drinks (21.1%), sports drinks (25.4%), and energy drinks (31.0%; all contrasts $p < 0.05$ versus water drinks, except coffee drinks and juice/juice drinks).

Figure 4-3. Proportion of unique non-alcoholic, pre-packaged beverages from online retailer and brand websites containing sweeteners (% yes), by category (N=15,994)[a]



[a] Low/no-calorie sweeteners included non-sugar sweeteners and sugar alcohols (alone or combined with other sweeteners); added sugars included sugars added to beverages (alone or combined with low/no-calorie sweeteners; not those intrinsic to unsweetened dairy & alternatives drinks or 100% juices.

Sweetener descriptors by country and category

Table D-1 in Appendix D shows sweetener descriptors identified from the ingredient lists of beverages, by country. Overall, references to sugar descriptors (including added and intrinsic sugars) were found in 79.8% of ingredient lists, ranging from 75.3% in the US to 84.8% in Canada. Among all beverages, the most common sugar descriptors (alone or combined with other sweetener descriptors) included “fruit juice concentrate” (32.9%), followed by “sugar” (27.9%), and “high-fructose corn syrup” (8.6%). “Lactose” was only mentioned in 1.0% of ingredient lists, while 18.4% had reference to “milk” and were coded as having “intrinsic milk sugar.” The most common combinations of sugar descriptors were "fruit juice concentrate and sugar" (6.5%); “intrinsic milk sugar and sugar" (4.6%); and "fruit juice concentrate and high fructose corn syrup" (2.6%; data not shown). Similar patterns were observed across countries, with notable exceptions: “high-fructose corn syrup” was more prevalent in the US (20.6% versus ≤8.8% in other countries); “fructose” was more prevalent in Mexico (18.3% versus ≤8.3% in other countries); and “glucose-fructose" was more prevalent in Canada (17.7% versus ≤1.1% in other countries).

Over one-third of ingredient lists contained NSS descriptors (36.4%), with 15.0% containing one NSS, 19.0% containing two NSS, 2.2% containing three NSS, and 0.3% containing four NSS (no beverages contained >4 NSS; data not shown). Among all beverages, the most common descriptor was “sucralose” (22.3%), followed by “acesulfame K” (19.4%), “stevia” (8.9%), and “aspartame” (7.0%), with other NSS descriptors rarely used (≤1.2%). The most common combinations of NSS descriptors were "acesulfame K and sucralose" (11.8%); "acesulfame K and aspartame" (4.8%); and "stevia and sucralose" (1.4%) (data not shown). Similar patterns were observed across country.

Among all beverages, few ingredient lists contained sugar alcohol descriptors (3.1%). Of all ingredient lists, the most common descriptor was “erythritol” (3.0%), ranging from 1.0% in Mexico to 9.1% in Australia, with other sugar alcohols rarely used (≤0.1%). The most common combination of sugar alcohol descriptors was "erythritol and sorbitol" (0.02%).

Few ingredient lists contained a combination of sugar and LNCS descriptors. Among all beverages, the most common combination of sugar and NSS descriptors included "fruit juice concentrate, acesulfame K, and sucralose" (1.5%), "fruit juice concentrate and stevia" (1.4%); and "fruit juice concentrate and sucralose" (1.2%), while the most common combinations of sugar and sugar alcohol descriptors was "fruit juice concentrate and erythritol" (0.5%) and NSS and sugar alcohols was "stevia and erythritol" (1.9%; data not shown). Table D-2 in Appendix D shows sweetener descriptors identified from the ingredient lists of beverages, by category.

4.1.5 Discussion

The current study is among the few to directly compare the type and presence of sweeteners in beverages across countries and categories. Overall, the presence of sweeteners in beverages was widespread: more than one-third included LNCS (37%) and over half contained added sugars (55%). However, differences across countries suggest sugar-related policies may play a role in shaping sweetener presence, with implications for policy development described below.

Across the six countries examined, LNCS presence was higher in countries with ≥1 mandatory sugar-related policy, ranging from 45-65% of beverages in Chile, Mexico, and the UK versus 18-36% in the other countries. This pattern aligns with previous cross-country[192] and pre-post evaluations showing increased NSS use in beverages after implementation of mandatory SSB taxes and/or FOPL policies in countries such as Argentina, Chile, Mexico, and the UK.[207,276,277] While the current study did not examine sweetener concentrations, evidence collectively suggests that brands may use LNCS to avoid consequences of SSB taxes and/or FOPLs. Consistent with previous research, NSS presence, particularly "sucralose", "acesulfame K", "stevia", and "aspartame," was greater than sugar alcohols.[207,271,273,274,277,278(p2),279–281] Although the presence of the sugar alcohol "erythritol" was low overall in the current study (3%), it may become more widespread in beverages[278] due to its ability to mask the bitterness of NSS.[282] Future longitudinal research is therefore needed to monitor the

presence and concentrations of sweeteners, along with sales-weighted and consumption data, to better characterize population exposure to LNCS and their potential health effects.

Policy design may also influence the type of sweetener used in beverages across countries. Countries with ≥1 mandatory policy had a higher presence of added sugars (45-59% versus 47-56% in the other countries) and combined presence of LNCS and added sugars (27-32% versus 8-17% in the other countries). This finding may reflect partial substitution of added sugars with LNCS, rather than complete replacement. However, because sweetener presence was assessed as a binary measure, the current study cannot determine whether beverages containing both sweetener types had lower concentrations of added sugars than those with only added sugars. Notably, Chile had the lowest presence of added sugars and highest combined sweetener presence, a pattern consistent with previous pre-post research indicating potential substitution of sugar with LNCS in beverages.[207,240,281] Brands in Chile may be more incentivized to replace added sugars with LNCS due to the comprehensive suite of policies implemented, including mandatory FOPLs, concentration-based SSB tax, and marketing restrictions versus the UK (where FOPLs are voluntary) and Mexico (where the SSB tax is flat-rate volumetric).[84,210] In contrast, lower presence of LNCS in Australia may suggest that voluntary FOPLs provide weaker (re)formulation incentives versus mandatory policies, in line with previous research.[280]

Among countries with ≥1 mandatory policy, Mexico had the lowest presence of LNCS and combined sweeteners. This may partly reflect Mexico's FOPL for LNCS, which may disincentivize their use, as demonstrated in a pre-post study.[283] However, contrasting evidence from a pre-post study in Argentina indicated that LNCS use may increase despite LNCS FOPLs.[284] Nonetheless, LNCS presence in the current study was higher in Mexico than countries without a mandatory sugar-related policy. These findings suggest that greater transparency from FOPLs does not consistently reduce LNCS use[284] and highlight the role of other drivers in (re)formulation, such as consumer demand for low/no-sugar or -calorie options,[193] cultural differences in sweetness preferences, and LNCS perceptions.[192]

Beyond sweetener type, sugar-related policies may influence consumer understanding of beverage content. The current study observed over 30 distinct sugar descriptors in ingredient lists, most commonly "fruit juice concentrate," "sugar", and "high-fructose corn syrup," in line with previous research across Canada, Turkey, and Saudi Arabia.[231(p201),232,285,286] This diversity of descriptors may hinder consumers' ability to identify sugar content and limit added sugars intake.[231,285] Consequently, policies that involve grouping sugar-based ingredients, as in Canada,[233] and explicitly identifying 'added sugars'[131(p51)] in ingredient lists, as in Mexico, may improve label clarity. Requiring declarations of added sugars concentrations on NFPs, as in Mexico and the US, may further support understanding of beverage content among consumers.[131,287]

Similar approaches could be applied to LNCS. LNCS are typically listed in ingredient lists, yet only a few countries, like Chile and Mexico, also mandate listing their concentrations (e.g., stevia (2.6mg/100g)).[131,262] Canada previously required declarations of four LNCS (acesulfame-potassium, aspartame, neotame, and sucralose) on the front-of-package and concentrations in ingredient lists, although these measures were repealed in 2022 due to stakeholder feedback and to increase consistency with other sweetener labelling.[288,289] While these approaches may enhance transparency and support monitoring of the beverage supply, consumers often struggle to determine product healthfulness from numeric nutrition information.[88,290] Consequently, FOPLs for LNCS, in addition to those used for sugars, may better support understanding of sweetener presence in beverages.[88,290] FOPLs may be particularly important for LNCS-containing beverages, which often carry claims such as 'no' or 'less added sugar' that may signal product healthfulness despite sweetener presence.[274] Although evidence linking sweetener labelling and consumer behaviours remains mixed,[88,290] these practices may still be important given the widespread use of sweeteners[16,207,278] and consumer preferences to avoid certain LNCS.[291]

Overall, LNCS presence reported in the current study was relatively consistent with previous estimates in Australia (24% versus 2019: 30% in non-dairy beverages)[278] and Canada (18% versus

2017: 18% in beverages), lower in Chile (65% versus 2015-2019: 72-83% in non-alcoholic beverages),[207,281] and higher in Mexico (45% versus 2015-2016: 36.4%), and the US (36% versus 2015-2017: 22%).[249] Differences may result from varying methods, including definitions of LNCS (e.g., NSS alone or with sugar alcohols) and beverage categories (e.g., combining carbonated and energy drinks or analyzing subcategories such as flavoured water),[281] as well as changes in market and consumer demands over time.

4.1.5.1 Limitations

The current study is subject to limitations common to web scraping research. First, the scan did not capture all beverages sold in each country. Beverages may have been missed due to technical limitations (e.g., inability to extract data from images) and were limited to non-alcoholic, pre-packaged options. The number of retailers in each country was also limited and did not include niche retailers (e.g., ethnic grocery or health food stores), vending machines, or food-service establishments, potentially underrepresenting niche- or region-specific products. While store purchases may vary due to cultural preferences, pricing, product availability, and access,[292] the inclusion of multiple retail sources (i.e., grocery store, food delivery, and brand websites) increases generalizability. Additionally, the scrape included a majority of brands from leading manufacturers on country-specific Euromonitor market share reports in 2022: 68.5% (Canada), 68.6% (UK), 74.5% (US), 77.5% (Australia), 80.3% (Mexico), and 82.2% (Chile).[220–225]

The nutrient information captured in the online scan may differ from that shown on physical product labels. Despite the rise in online beverage purchasing and Codex Alimentarius recommendations for clear and transparent labelling both in-store and online,[258,259] few regions beyond Chile, the European Union, and the UK require nutrition information to be displayed in both settings (although enforcement mechanisms are unclear).[260–262] Although few studies have compared products in-store versus online, an evaluation of UK supermarkets reported similar product availability across the sources, with 85% of items matched with nearly identical nutritional

information.[257] These findings support the use of web scraping data to determine product availability, composition, and labelling practices. Additionally, the Canadian and US governments held consultations with stakeholders in 2022 and 2023 to explore the development of best-practices for providing nutrition information online,[263,264] suggesting the potential to improve consumer understanding of beverage composition and support future research using online product composition data.

4.1.6 Conclusion

The current study found widespread presence of sweeteners in beverages across countries, including increased presence of LNCS, added sugars, and combined sweeteners in countries with ≥1 mandatory sugar-related policy. These findings add evidence that brands may partially replace added sugars with LNCS in beverages in response to SSB tax and/or FOPL policies. As countries update sugar-related policies (e.g., Canada's FOPLs in 2026, Mexico's tax on beverages with LNCS in 2026, and Chile's consideration of adopting LNCS FOPLs),[265,293,294] ongoing monitoring of the beverage supply is warranted. Future research should examine the role of LNCS FOPLs in shaping consumer understanding of beverage content and purchasing decisions in real-world settings. Additionally, longitudinal studies are needed to assess potential health implications of LNCS, especially as they become more prevalent in the beverage supply.

Chapter 5: DIFFERENCES IN SERVING SIZE LABELLING ACROSS COUNTRIES

5.1 Study 3: International differences in serving size labelling for non-alcoholic beverages: a market scan of online information in Australia, Canada, Chile, Mexico, the United Kingdom, and the United States.

Status: in preparation

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5.1.1 Overview

Background: Serving size is a key component of nutrition labels and shapes consumer understanding of beverage content, including sugar. However, cross-country differences for pre-packaged beverages remain underexplored.

Objectives: To examine beverage serving size formats ('per 100mL', 'per serving,' or both) and serving sizes, including containers with multiple servings, across six countries with differing labelling policies.

Methods: Data were collected by web scraping retailer and brand websites for 26,552 beverages from Australia (n=4,589), Canada (n=4,907), Chile (n=1,816), Mexico (n=3,430), the United Kingdom (UK; n=3,554), and the United States (US; n=8,256), during October 2023-February 2025. Linear regression examined cross-country differences in serving sizes, adjusting for beverage category and retail source. Proportions examined cross-country differences in serving size formats and containers with multiple servings.

Results: Over 60% of beverages in Australia, Chile, and the UK used both 'per 100mL' and 'per serving' sizes, while nearly half in Mexico used 'per 100mL' only, and virtually all in Canada and the US used 'per serving' only. Adjusted mean serving sizes were highest in Canada (327.4mL) and the US (340.1mL) versus other countries (≤304.3mL; all contrasts $p<0.001$). The proportion of small containers (<355mL) with multiple servings was highest in the UK (7.9%) and Mexico (16.1%) versus other countries (≤5.6%), while proportions among moderate containers >355-600mL were highest in the UK (40.1%), Chile (67.5%), and Mexico (79.8%) versus other countries (≤20.1%).

Conclusions: Serving size labelling practices differ across countries. Findings highlight opportunities to standardize the use of 'per 100mL' and 'per serving' formats, as well as serving size requirements for smaller and larger beverage containers.

5.1.2 Introduction

Nutrition labels on pre-packaged foods are the primary means of communicating ingredients and nutrient levels to consumers.[84] Labelling nutrient content is particularly important for pre-packaged beverages, given their contribution to dietary intake.[10,84] For example, while some beverages provide beneficial nutrients (e.g., vitamin C, calcium, and vitamin D), sugar-sweetened beverages (SSBs) are a primary source of sugar and calories,[235] and have been associated with obesity, cardiovascular disease, type 2 diabetes, and dental caries.[236,237] Consequently, strategies to promote healthier beverage intake include mandatory labelling policies.[138]

Serving size is a key component of nutrition labels that directly affects the nutrient levels displayed on products.[130] Currently, there is no international consensus on best practices for displaying or determining serving sizes. Countries have adopted different serving size labelling requirements across beverage container sizes and categories. Some jurisdictions, such as Chile, Mexico, and the United Kingdom (UK), mandate a standard serving size of 100mL across all container sizes and beverage categories to facilitate product comparisons.[130] Mexico and the UK also allow brands to display nutrients in a serving size of their choice, while Chile permits serving sizes by product category (e.g., 200mL for non-alcoholic pre-packaged beverages).[131–133] Other countries, including Canada and the United States (US), mandate 'per serving' labels, with serving size ranges based on reference amounts that reflect typical consumption patterns, often informed by dietary intake data for beverage categories (e.g., 250mL for juices and 375mL for carbonated beverages).[134–136] In Australia, both 'per 100mL' and 'per serving' labels are mandatory, and serving sizes are based on voluntary industry standards (e.g., 250mL for containers >600mL).[140,141] Overall, there are notable differences in serving size labelling practices across countries (see Figure E-1 in Appendix E for labelling examples).

Differences in serving size formats may impact consumer understanding of beverage content. For instance, using 'per 100mL' labelling facilitates product comparisons; however, presenting these

labels alone may be misleading if amounts do not reflect typical consumption.[137] Additionally, calculating 'per serving' amounts from 'per 100mL' labels may be challenging, especially among those with poor numeracy skills.[137,138] In contrast, 'per serving' labelling supports understanding of nutrient content for products with serving sizes above or below 100mL, and may promote awareness of nutrient intake and recommended daily intake values among consumers with dietary considerations, such as diabetes.[137] Consequently, using both 'per 100mL' and 'per serving' formats may better facilitate product comparisons and support consumer understanding of nutrient intakes than either format alone.[137]

Interpretation of nutrition information may also be affected by the relationship between serving and container size, as 'per serving' sizes typically vary by container size. For larger beverage containers, the serving size is often smaller than the container volume, resulting in containers with multiple servings. For example, a 1L beverage may display nutrient levels of a 250mL serving. In contrast, for containers with a single serving, the serving size is equivalent to the entire volume of a beverage, and the nutrient levels displayed on labels correspond to amounts consumers will ingest by drinking the entire beverage. Misalignment between serving and container sizes (e.g., small containers appearing as multiple servings or large containers appearing as a single serving) may lead to underestimation of nutrient intake and overconsumption.[138,144] Large variation in the serving sizes used within countries may further hinder consumer understanding of beverage contents.[138] For example, a cross-sectional, multi-country study reported that serving sizes for beverages with a single serving ranged from 100-568mL in the Netherlands and 118-750mL in Canada.[139] However, limited research has examined serving sizes or alignment between serving and container sizes of SSBs across countries.

Despite the importance of serving size in nutrition labelling, cross-country differences in serving size formats and amounts among beverages remain underexplored. Thus, this study examined serving sizes of non-alcoholic, pre-packaged beverages available on retailer and brand websites in six countries with different serving size regulations: Australia, Canada, Chile, Mexico, the UK, and the

US. The study had two specific objectives: 1) to assess the proportion of beverages using 'per 100mL', 'per serving', or both serving size formats, across countries; and 2) to examine differences in voluntary serving sizes selected by brands, including the proportion of beverages ≤600mL that are labelled as multiple servings. These findings can inform the development of policies that support consumer interpretation of nutrition information.

5.1.3 Methods

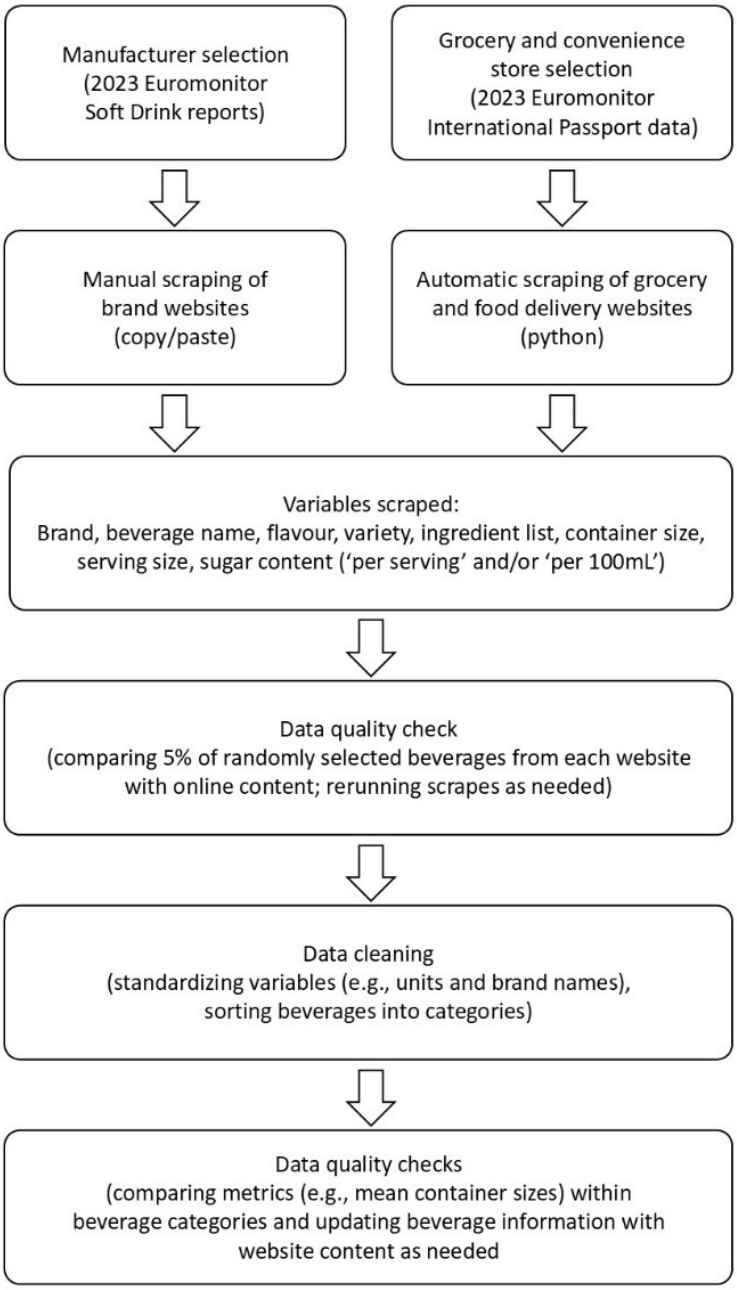
5.1.3.1 Overview of methods

A market scan was conducted to determine serving sizes of non-alcoholic, pre-packaged beverages available across six countries: Australia, Canada, Chile, Mexico, the UK, and the US. These countries were selected to align with those involved in the International Food Policy Study, an annual repeat cross-sectional study that evaluates the impact of national-level food policies on dietary qualities and perceptions.[219] The countries also have diverse policy approaches (e.g., optional, voluntary industry standards, and mandatory but flexible serving size rules), allowing examination of whether serving size amounts and the proportion of beverages labelled as multiple servings per container differ across policy contexts and providing evidence to inform policy development (see Table B-1 in Appendix B for policy details). Non-alcoholic, pre-packaged beverages were defined as alcohol by volume <0.5% and sold without further preparation needed before consumption (i.e., no mixing or dilution).

Figure 5-1 shows a flowchart of the methods used in the current study. Data collection occurred on retailer and brand websites between October 2023 and February 2025 using two approaches: manual web scraping (i.e., copying data from brand websites) and automatic web scraping (i.e., applying Python 3.13 scripts to grocery store and food delivery websites). Web scraping is an established method to obtain online information,[204,212,213] and has been previously used to collect

data from online food retailers, including price, images, nutrition information, and product availability.[198,206,214,215]

Figure 5-1. Flowchart of study methods.



5.1.3.2 Manufacturer selection for manual web scraping

Leading manufacturers were identified using data from country-specific 2023 Euromonitor Soft Drink reports, which provide information on market sales and trends.[220–225] Websites of all manufacturers listed in the reports were searched to identify all brands in each country. Together, these manufacturers accounted for most of the beverage market in 2022: 70.6% (UK), 75.4% (US), 80.3% (Canada), 80.9% (Australia), 82.7% (Chile), and 88.3% (Mexico); private/other brands accounted for the remainder.[220–225]

5.1.3.3 Grocery and convenience store selection for automatic web scraping

The top three leading grocery and convenience store chains in each country were identified using country-specific 2023 Euromonitor International Passport data.[226] Store locations for sampling were chosen to maximize capture of available products by focusing on population and presence of a sugar-related policy (SSB tax or front-of-package nutrition label (FOPL)) as part of a broader study on beverage labelling and composition across countries. For Australia, Chile, Mexico, and the UK, the four most populous regions and two most populous cities within each region were determined, and one of the cities per region was randomly selected for inclusion in the study, resulting in four locations per store. Because Canada and the US had sub-national SSB taxes at the time of data collection, samples for these countries included the three most populous regions and a region with a sub-national tax for a separate study on sugar concentrations.

Beverage data were collected from individual store locations (see Table B-2 in Appendix B). When product listings were unavailable for scraping (e.g., not listed online), an alternative city or the next-most populous region was used (depending on availability). Technical limitations (i.e., inability to accurately extract text from labels displayed as images) prevented the scraping of Walmart websites in four countries (Canada, Chile, Mexico, and the US), resulting in only two grocery store chains being included. Due to the lack of product listings on convenience store websites, product

information was obtained from leading food delivery platform websites in each country (identified by online searches), using convenience store addresses as search locations.

5.1.3.4 Non-alcoholic, pre-packaged beverage data

Information was scraped from the websites of brands, grocery stores, and food delivery platforms (to access convenience store product listings) for a census of non-alcoholic, pre-packaged beverages. Information collected for each beverage from both the manual and automatic web scrapes, when available, included the ingredient list, sugar content ('per 100mL' and/or 'per serving'), and product characteristics (e.g., brand, name, flavour, variety, container size, and serving size). Automatic web scraping captured full nutrient label information if available, while only sugar content was collected in the manual scrape due to available resources. Sugar content was used as a proxy to determine serving size format (i.e., if listed as 'per 100mL', 'per serving', or both). Only text-based information was scraped. Multi- and variety-packs were included in the scrape, with manual checks completed by KH to identify different products (e.g., identifying varying flavours within packs and adding each to the dataset).

5.1.3.5 Data cleaning and management

For comparability across beverages, serving and container sizes were standardized (converted to mL and rounded to the nearest integer). Brands (such as 'Pepsi' or 'Tropicana'), flavours (the taste descriptor, such as 'cherry' or 'vanilla'), and varieties (the version, such as 'regular' or 'diet') were manually reviewed and consolidated for consistency (e.g., combining 'Coke' and 'Coca Cola').

Products were divided into eight categories: carbonated/mixer drink, coffee drink, dairy & alternatives drink, energy drink, juice/juice drink, low/no-alcohol drink, sports drink, and water drink. These categories were developed based on existing literature, grocery store websites, and policy regulations (e.g., products subject to SSB taxes and FOPL; see Table 5-1).[227–229] Certain

categories were purposefully excluded (e.g., >0.5% alcohol by volume, beverage mixes, syrups, powders, and concentrates), based on the study's definition of non-alcoholic, pre-packaged beverages. Non-alcoholic mixers were included if they did not have to be reconstituted (e.g., syrups), as they may be consumed without added alcohol.

Table 5-1. Overview of category definitions and example products.

Category	Definition	Examples
Carbonated/mixer drink	• Sold/marketed as carbonated drinks • Includes non-alcoholic mixers (which can be consumed alone or with added alcohol)	• Cola • Ginger beer • Mixers • Seltzer water • Tonic water
Coffee drink	• Sold/marketed as 'coffee' drinks • Includes coffee-flavoured milk drinks if the brand sells 'coffee' drinks	• Cappuccino • Cold-brew coffee • Iced coffee • Latte
Dairy & alternatives drink	• Sold/marketed as 'dairy' drinks • Includes probiotic/fermented dairy drinks • Includes coffee-flavoured milk drinks if the brand sells 'dairy' drinks	• Animal milks • Coffee-flavoured milk • Plant milks • Kefir • Milk/whey-based protein shakes • Yogurt
Energy drink	• Sold/marketed as energy drinks	• Monster • Rockstar • V
Juice/juice drink	• Sold/marketed as fruit/vegetable/herbal-based drinks • Includes water-juice drinks if the brand sells 'juice drinks' • Includes drinks with 'natural' sources of energy if the brand highlights herbs (e.g., yerba mate)	• 100% juice or vegetable drinks • Fruit drinks • Nectars • Herbal-based drinks • Iced tea • Juice-based smoothies • Kombucha • Lemonade
Low/no-alcohol drink	• Low/no alcohol (≤0.5% alcohol by volume) • Includes ciders if the brand sells alcoholic drinks (otherwise, ciders are juice)	• Beers • Ciders • Spirits • Wines

Sports drink	• Sold/marketed as sports drinks • Includes water with electrolytes if the brand focuses on sports/performance	• Gatorade • Powerade
Water drink	• Sold/marketed as water • Includes drinks with added ingredients (e.g., caffeine, flavour or electrolytes) if the brand sells water or focuses on hydration	• Aloe water • Coconut water • Flavoured water • Mineral water • Sparkling water • Spring water • Vitamin water

Data quality

To maximize automatic web scraping accuracy, 5% of beverages from each store were randomly selected and compared against website content; scraping scripts were updated and rerun as needed. Metrics (e.g., mean, median, and ranges of serving and container sizes and sugar concentrations) for each beverage category were compared across countries using the full dataset: differences >10% were investigated and product information was updated to match website content as needed.

5.1.3.6 Measures

Outcomes

Serving size format (categorical) was determined from product webpages listing sugar content 'per 100mL', 'per serving', or both. Serving size (continuous; mL) was a dependent variable and defined as the reported serving size or 100mL reference amount. Container size (continuous; mL) was defined as the total container volume; for multipacks, container size reflected the volume of one unit. Container sizes were grouped based on distribution and the Australian threshold for multiple servings per container: ≤355mL, >355-600mL, >600mL-1,000mL, and >1,000mL. Multiple servings per container were determined by calculating the serving to container size ratio, with values <1 representing more than one serving per container.

Independent variables and covariate

Independent variables were country (categorical) and beverage category (categorical). Store type (categorical) was included as a covariate to account for potential differences in the availability of beverages across online sources.

5.1.3.7 Analysis

Sample

Data on 106,476 beverages were collected across countries from the three store types (grocery stores, convenience stores via food delivery platforms, and brands): Australia (n=21,046), Canada

(n=14,366), Chile (n=10,066), Mexico (n=12,607), UK (n=22,018), and US (n=26,373). Beverages were excluded from analyses when missing container sizes (n=1,762) or container sizes >2.5 gallons (9,463.5mL; n=151), as these were foodservice rather than consumer-facing formats. Beverages with the same brand, country, flavour, variety, and container size were considered duplicates and grouped, and one beverage with the most scraped information in each group (including sugar content and serving size) was randomly selected for analysis (termed "unique beverage"; n=26,552).

Three sub-samples were used for analyses: 1) Container size: the unique beverage dataset (n=26,552). 2) Serving size format: unique beverages missing sugar content 'per 100mL' and 'per serving' were excluded from analyses (n=8,587), resulting in a subsample of 17,965 (see Table 5-2 for full sample details). 3) Serving size, including containers with multiple servings: unique beverage with missing serving sizes were excluded (n=7,849). Serving sizes within 10% of container sizes were set to equal the container size (n=464) and amounts greater were excluded from analyses (n=31). Beverages available outside of Canada and the US with 'per 100mL' serving sizes (and 'per 200mL' in Chile) that were sold in containers of different sizes (i.e., not 100mL or 200mL) were further excluded from analyses because they cannot be used to evaluate voluntary brand-selected serving sizes (n=4,094). This resulted in a final sample of 14,578 unique beverages.

Statistical analysis

Unique beverages were compared across countries and beverage categories based on serving size formats and amounts, container sizes, and containers with multiple servings, using descriptive statistics (mean, standard deviation**,** and proportions). Adjusted means were reported for cross-country comparisons that controlled for category and store type. Container size was examined as a secondary outcome, with results presented in Table E-2 in Appendix E.

A linear regression model examined mean serving size (mL). The model was adjusted for country, beverage category, and store type, and subsequently stratified by beverage category. Unadjusted

and estimated marginal means calculated from observed marginal covariate distributions were presented to account for confounding and unbalanced sample sizes across country, beverage category, and store combinations, along with betas and corresponding 95% confidence intervals (95% CI). Reference groups were selected based on the observed mean serving size: the US (country) had the highest mean serving size, while dairy & alternatives (beverage category) and grocery store websites only (store type) had the lowest mean serving size. Data cleaning, management, and analyses were conducted in SAS v9.4 (SAS Institute Inc., North Carolina).

5.1.4 Results

5.1.4.1 Sample characteristics

Table 5-2 shows sample characteristics overall and by store type. Most beverages were sourced from grocery store websites only, with the fewest beverages from 'brand and convenience store websites' only. These patterns were consistent across countries.

Table 5-2. Characteristics of the serving size format sample of unique non-alcoholic, pre-packaged beverages from online retailer and brand websites, by country (n=17,965)

	Overall	United States	Canada	Australia	United Kingdom	Mexico	Chile
Unique beverages % (n)	100.0% n=17,965	33.7% n=6,054	17.0% n=3,062	16.0% n=2,876	15.9% n=2,847	10.4% n=1,872	7.0% n=1,254
Beverage category % (n)							
Juice/juice drink	31.3% n=5,614	30.0% n=1,813	36.1% n=1,106	33.2% n=954	33.5% n=955	20.3% n=380	32.4% n=406
Dairy & alternatives drink	22.5% n=4,042	15.0% n=908	26.5% n=811	27.1% n=779	20.8% n=593	35.5% n=664	22.9% n=287
Carbonated/mixer drink	20.8% n=3,744	23.5% n=1,421	17.1% n=523	17.9% n=516	22.2% n=631	20.8% n=390	21.0% n=263
Water drink	11.0% n=1,968	12.3% n=743	10.6% n=323	6.4% n=183	7.2% n=205	17.8% n=333	14.4% n=181
Energy drink	5.4% n=968	6.9% n=416	3.0% n=93	5.5% n=159	7.4% n=211	2.0% n=37	4.2% n=52
Sports drink	4.2% n=746	7.6% n=457	2.6% n=78	3.0% n=86	0.8% n=24	3.1% n=58	3.4% n=43
Coffee drink	3.1% n=554	4.7% n=283	1.5% n=45	3.9% n=111	3.7% n=106	0.5% n=9	0.0% n=0
Low/no-alcohol drink	1.8% n=329	0.2% n=13	2.7% n=83	3.1% n=88	4.3% n=122	0.1% n=1	1.8% n=22
Unique container sizes (n)	n=246	n=114	n=97	n=58	n=73	n=90	n=54
Container size							

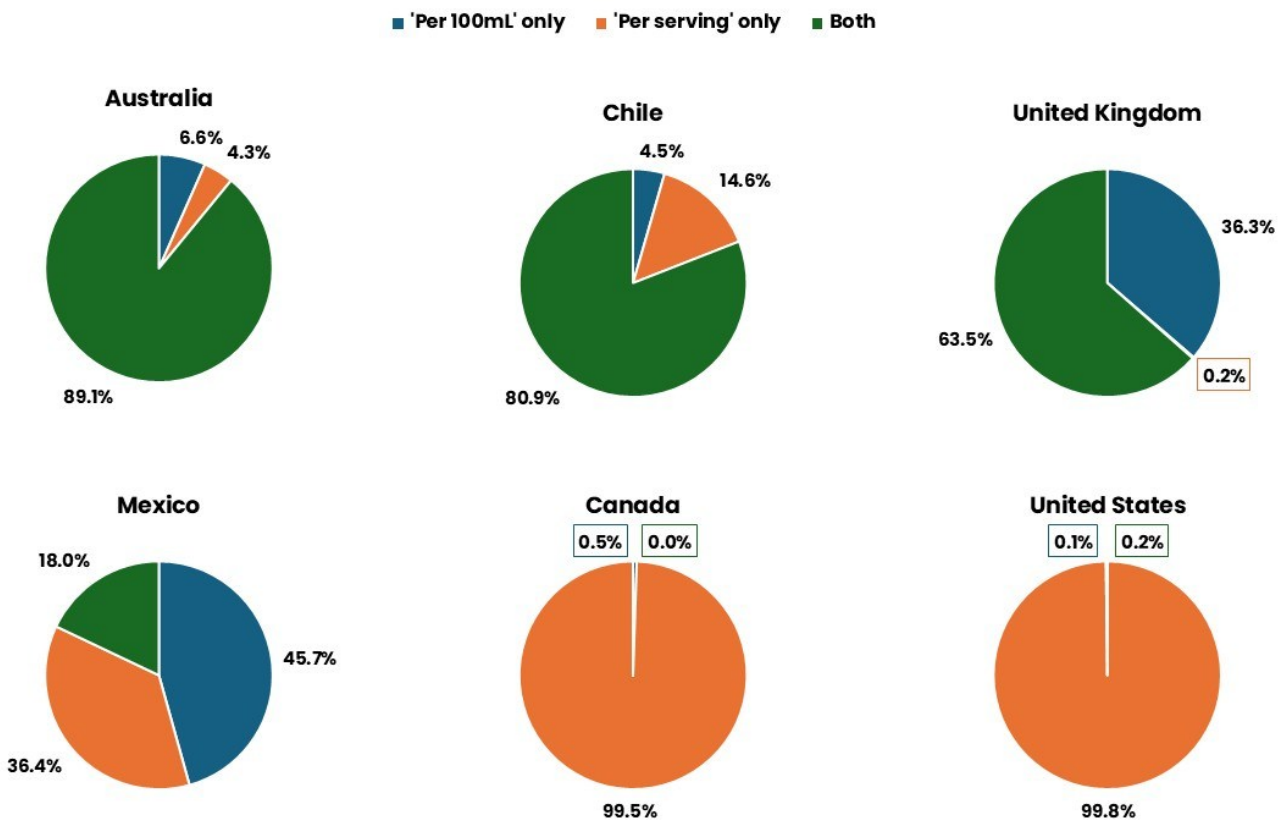
% (n)							
≤355mL	11.6%	10.7%	11.7%	5.5%	12.8%	18.6%	17.2%
	n=2,088	n=647	n=357	n=157	n=364	n=348	n=215
>355-600mL	29.7%	36.8%	25.9%	31.9%	29.2%	20.0%	15.2%
	n=5,335	n=2,227	n=792	n=918	n=832	n=375	n=191
>600-1,000mL	23.4%	26.1%	23.2%	19.5%	25.5%	24.2%	13.8%
	n=4,203	n=1,581	n=709	n=562	n=725	n=453	n=173
>1,000mL	35.3%	26.4%	39.3%	43.1%	32.5%	37.2%	53.8%
	n=6,339	n=1,599	n=1,204	n=1,239	n=926	n=696	n=675
Store type							
% (n)							
Grocery store websites only	57.1% n=10,255	44.9% n=2,720	65.7% n=2,013	62.8% n=1,806	63.4% n=1,805	67.0% n=1,255	52.3% n=656
Brand websites only	29.0% n=5,205	43.5% n=2,631	22.7% n=695	20.3% n=583	22.2% n=633	19.3% n=362	24.0% n=301
Grocery store and brand websites only	8.2% n=1,470	7.6% n=459	7.9% n=241	10.3% n=297	6.7% n=190	8.6% n=161	9.7% n=122
Convenience store websites only	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Grocery and convenience store websites only	3.1% n=551	1.4% n=86	2.6% n=78	3.4% n=99	4.7% n=133	3.5% n=66	7.1% n=89
All three website types	2.1% n=380	1.9% n=116	0.7% n=22	2.9% n=82	2.4% n=68	1.4% n=27	5.2% n=65

Brand and convenience store websites only	0.6% n=104	0.7% n=42	0.4% n=13	0.3% n=9	0.6% n=18	0.1% n=1	1.7% n=21

5.1.4.2 Serving size formats (‘per 100mL,’ ‘per serving,’ or both)

Figure 5-2 shows serving size formats of beverages in each country. Serving size formats reflected differences in labelling policies in each country. The percentage of beverages displaying serving size ‘per 100mL’ was highest in the four countries where this format was mandated: Australia, Chile, UK, and Mexico. Most beverages displayed both ‘per 100mL’ and ‘per serving’ amounts in Australia (89.1%) and Chile (80.9%), compared to 63.5% in the UK and 18.0% in Mexico. Serving sizes that only displayed ‘per 100mL’ were more common in Mexico (45.7%) and the UK (36.3%). In contrast, virtually all beverages in Canada (99.5%) and the US (99.8%) displayed sugar ‘per serving,’ as required. Table E-1 in Appendix E shows serving size formats by category and store type.

Figure 5-2. Proportion of unique non-alcoholic, pre-packaged beverages from online retailer and brand websites with serving size amounts 'per 100mL', 'per serving', or both, by country (n=17,965)

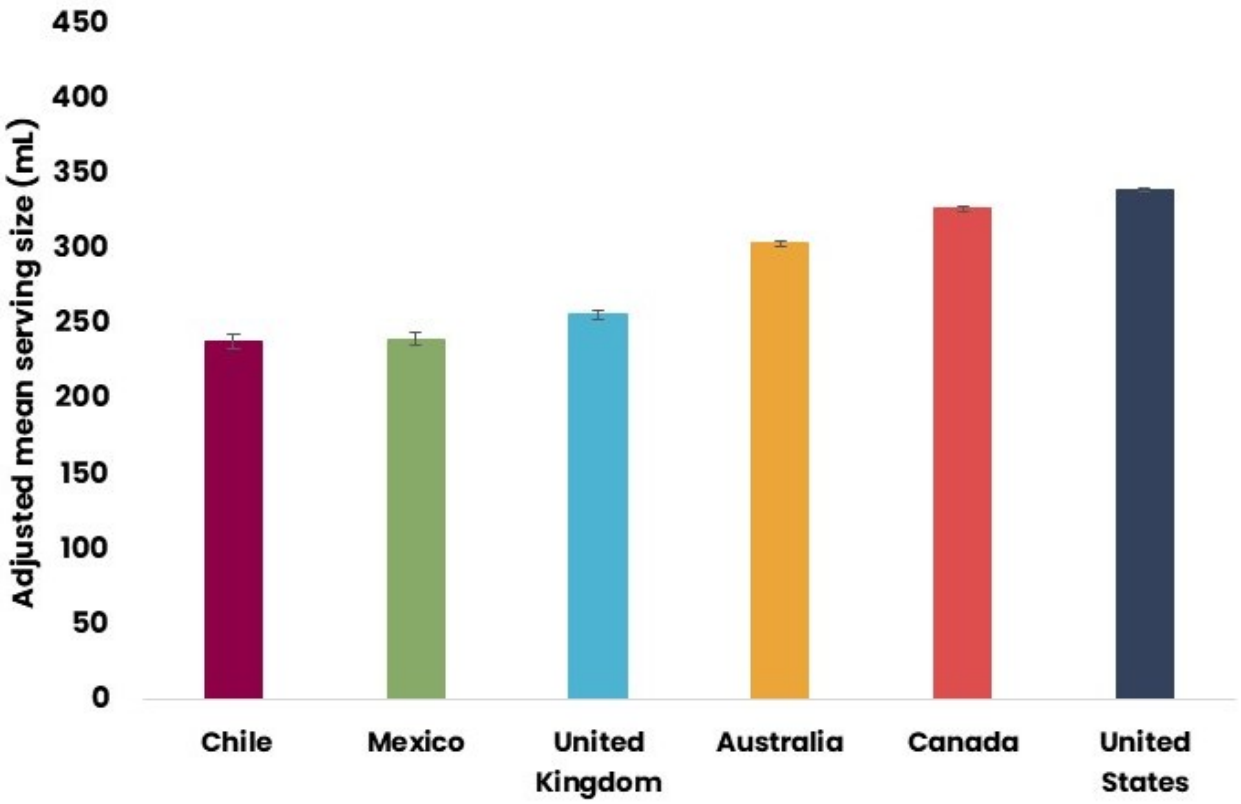


5.1.4.3 Differences in voluntary 'per serving' size by country

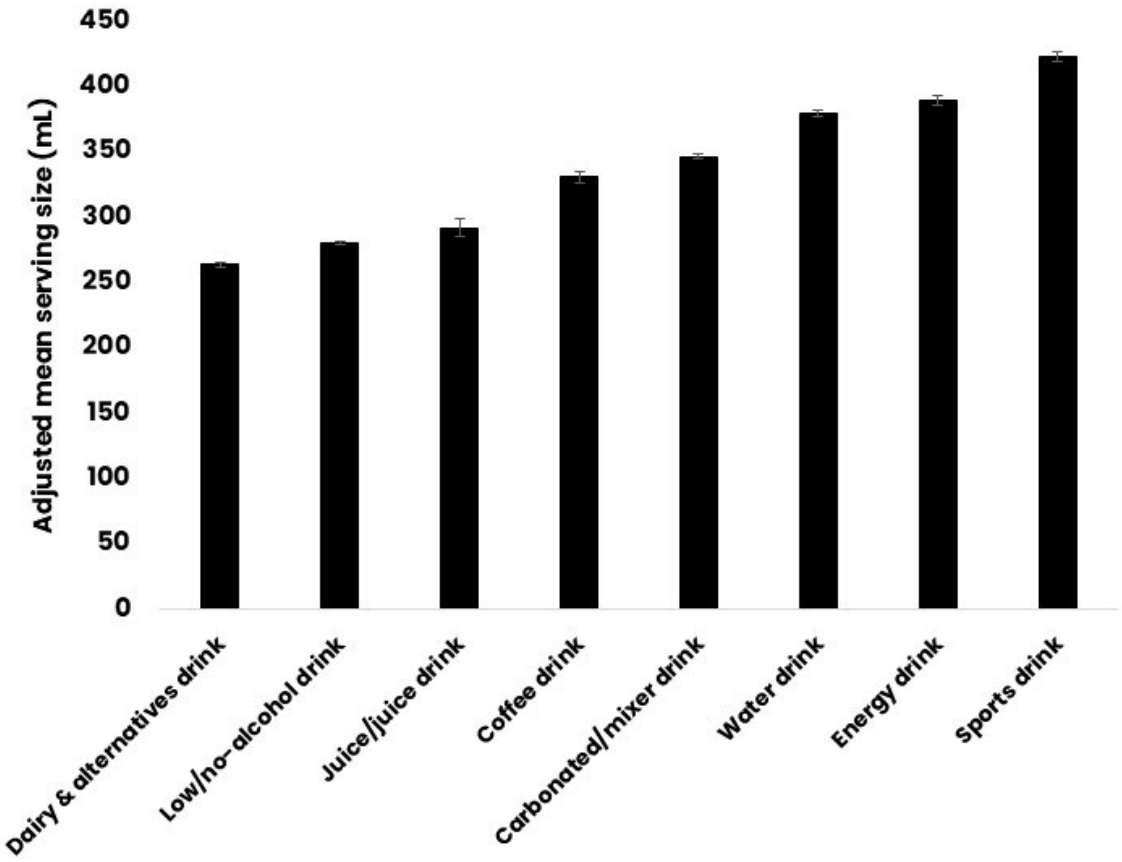
Analyses were conducted on the subsample of beverages that displayed 'per serving' formats to examine differences in serving sizes used by brands. Figure 5-3 shows adjusted mean serving sizes by country and category, while Table 5-3 shows results from the linear regression model by country, category, and store type. Across all beverage types, adjusted mean serving sizes were lowest in Chile (238.9mL), Mexico (240.5mL), and the UK (256.8mL), and highest in Australia (304.3mL), Canada (327.4mL), and the US (340.1mL; all contrasts $p \leq 0.001$ versus the US). By beverage category, adjusted mean serving sizes were lowest for dairy & alternatives drinks (264.3mL), low/no-alcohol drinks (292.2mL), juice/juice drinks (280.7mL), coffee drinks (330.8), and carbonated/mixer drinks (346.5mL), and highest in energy drinks (389.7mL), water drinks (380.1mL), and sports drinks (422.9mL; all contrasts $p \leq 0.001$ versus dairy & alternatives drinks). Additionally, mean serving sizes were relatively consistent across all countries for dairy & alternatives drinks and juice/juice drinks, with the greatest variability for sports drinks (see Figure 5-4 for boxplots of serving sizes across country by category). Adjusted mean serving sizes ranged from the lowest among beverages available only on grocery store websites (303.2mL) to highest among those available in all three store types (368.7mL; all store type contrasts $p \leq 0.001$ versus grocery store websites only).

Figure 5-3. Adjusted mean (standard error) serving sizes of unique non-alcoholic, pre-packaged beverages from online retailer and brand websites, by country and beverage category (n=14,578)[a]

A) By country



B) By category



[a] Analyses were conducted on the subsample of beverages that displayed 'per serving' formats to examine differences in serving sizes used by brands

Table 5-3. Mean and linear regression model investigating serving sizes of unique non-alcoholic, pre-packaged beverages from online retailer and brand websites (N=14,578)[a]

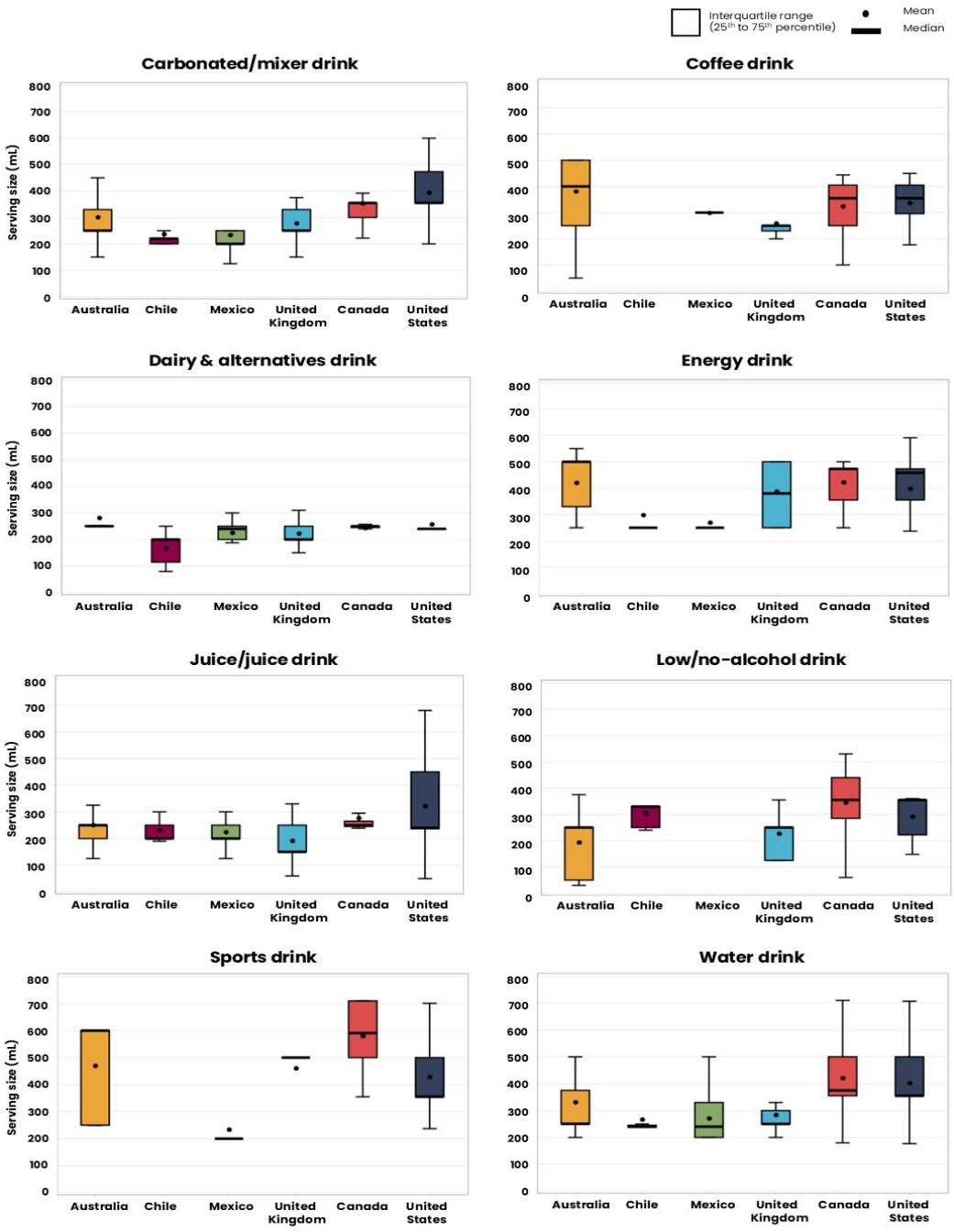
	Unadjusted mean (St dev) (mL)	Adjusted mean (St error) (mL)	Parameter estimate (β)	(95% CI)	*p* value
Country					
United States	355.6 (118.7)	340.1 (1.3)	Reference	Reference	Reference
Canada	314.1 (120.4)	327.4 (1.7)	-12.68	-17.00, -8.36	<0.001
Australia	291.0 (112.1)	304.3 (2.0)	-35.78	-40.54, -31.01	<0.001
United Kingdom	250.7 (105.6)	256.8 (2.8)	-83.25	-89.46, -77.04	<0.001
Mexico	235.9 (77.1)	240.5 (4.4)	-99.55	-108.57, -90.53	<0.001
Chile	222.1 (79.5)	238.9 (5.2)	-101.23	-111.80, -90.66	<0.001
Category					
Dairy & alternatives drink	251.2 (79.3)	264.3 (1.9)	Reference	Reference	Reference
Low/no-alcohol drink	273.2 (121.5)	292.2 (6.5)	27.87	-61.15, -34.42	<0.001
Juice/juice drink	278.9 (109.3)	280.7 (1.5)	16.39	11.71, 21.07	<0.001
Coffee drink	340.1 (92.3)	330.8 (4.5)	66.49	56.88, 76.10	<0.001
Carbonated/mixer drink	352.9 (113.3)	346.5 (1.9)	82.18	76.91, 87.45	<0.001
Water drink	385.2 (122.2)	380.1 (2.4)	47.59	109.75, 121.73	<0.001
Energy drink	398.0 (105.4)	389.7 (3.5)	125.41	117.50, 133.31	<0.001
Sports drink	444.2 (132.4)	422.9 (3.9)	158.59	149.92, 167.25	<0.001

Store type					
Grocery store websites only	290.4 (108.3)	303.2 (1.1)	Reference	Reference	Reference
Brand websites only	349.4 (125.9)	333.1 (1.6)	29.88	25.93, 33.83	<0.001
Convenience store websites only	-	-	-	-	-
Grocery store and brand websites only	347.8 (129.9)	332.2 (3.0)	28.96	22.64, 35.28	<0.001
Grocery and convenience store websites only	377.9 (143.3)	358.7 (5.4)	55.52	44.71, 66.33	<0.001
Brand and convenience store websites only	425.4 (128.3)	389.6 (11.7)	86.40	63.33, 109.48	<0.001
All three website types	414.4 (130.3)	368.7 (6.3)	65.55	52.96, 78.15	<0.001

CI=confidence interval

[a] Analyses were conducted on the subsample of beverages that displayed 'per serving' formats to examine differences in serving sizes used by brands.

Figure 5-4. Box plot of serving sizes of unique non-alcoholic, pre-packaged beverages from online retailer and brand websites, by country and beverage category (n=14,578)[a]



[a] Beverages available outside of Canada and the US with 'per 100mL' serving sizes (and 'per 200mL' in Chile) that were sold in containers of different sizes (i.e., not 100mL or 200mL) were excluded from analyses because they cannot be used to evaluate voluntary brand-selected serving-sizes. Boxes show the interquartile range (25th–75th percentile), circles show means, horizontal lines show medians, and whiskers

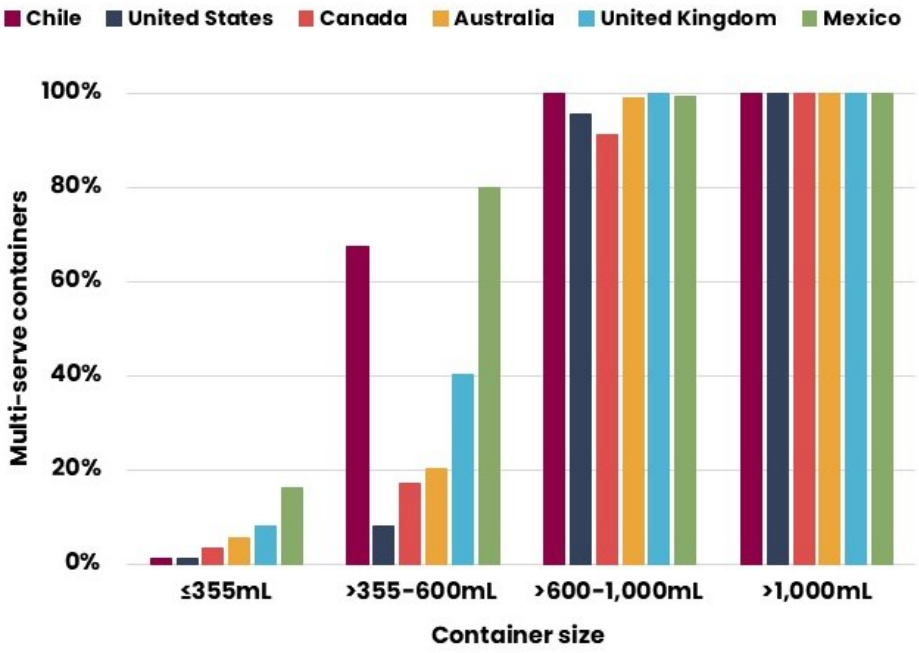
extend to the most extreme values within 1.5 times the interquartile range; outliers are not included. Countries showing only mean and median had low sample sizes, and countries without plot elements had no available data.

5.1.4.4 Containers with multiple servings

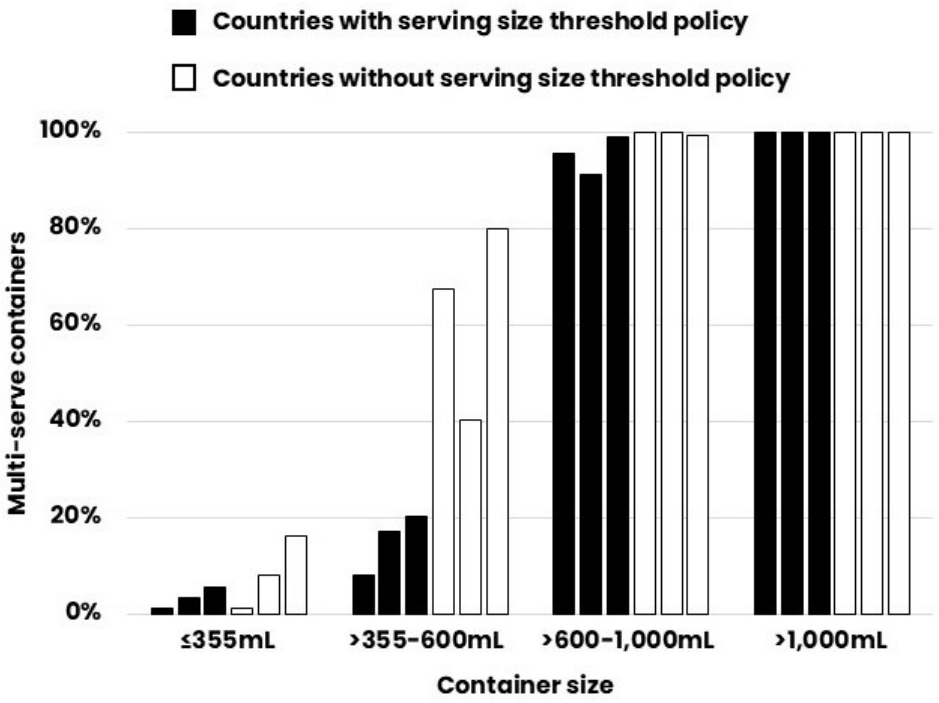
Table E-2 in Appendix E shows mean container sizes by country, category, and store type. Containers with multiple servings were defined as beverages with serving sizes smaller than container sizes. Figure 5-5 shows the distribution of beverages with multiple servings across container size categories, by country and serving size policy, with Table 5-4 providing additional details by country and beverage category. Across all countries, 46.6% of beverages had multiple servings, including 3.4% of containers ≤355mL, 16.6% of containers >355-600mL, 95.9% of containers >600-1,000mL, and 100.0% of containers >1,000mL. The proportion of small containers ≤355mL with multiple servings was highest in the UK (7.9%) and Mexico (16.1%) versus other countries (≤5.6%), while the proportion among moderate containers >355-600mL was highest in the UK (40.1%), Chile (67.5%), and Mexico (79.8%) versus other countries (≤20.1%). Across all countries, 95.9% of beverages in larger containers (>600-1,000mL) had multiple servings, ranging from 91.1% in Canada to 100.0% in Chile and the UK. All beverages in extra-large containers (>1,000mL) had multiple servings. By category, the proportion of beverages with multiple servings among small containers ≤355mL was highest in juice/juice drinks (8.3% versus ≤3.1% in other categories), while the proportion among moderate containers >355-600mL was highest in juice/juice drinks (26.6%) and dairy & alternatives drinks (32.6%) versus other categories (≤14.6%).

Figure 5-5. Proportion of containers with multiple servings among unique non-alcoholic, pre-packaged beverages from online retailer and brand websites, by country and serving size policy (N=14,578)[a]

A) By country



B) By serving size policy[b]



[a] Beverages available outside of Canada and the US with 'per 100mL' serving sizes (and 'per 200mL' in Chile) that were sold in containers of different sizes (i.e., not 100mL or 200mL) were excluded from analyses because they cannot be used to evaluate voluntary brand-selected serving-sizes.

[b] Countries with a serving size policy based on container size thresholds include Australia, Canada, and the United States. Countries without serving size policies based on container size thresholds include Chile, Mexico, and the United Kingdom.

Table 5-4. **Proportion of containers with multiple servings among unique non-alcoholic, pre-packaged beverages from online retailer and brand websites** (N=14,578)[a]

	Overall % (n)	% with multiple servings among ≤355mL containers (n)	% with multiple servings among >355-600mL containers (n)	% with multiple servings among >600-1,000mL containers (n)	% with multiple servings among >1,000mL containers (n)
Overall	46.6% (6,796)	3.4% (167)	16.6% (576)	95.9% (2,672)	100.0% (3,381)
Country					
Mexico	65.2% (344)	16.1% (31)	79.8% (83)	99.3% (140)	100.0% (90)
United Kingdom	56.4% (721)	7.9% (36)	40.1% (93)	100% (394)	100.0% (198)
Australia	54.5% (1,416)	5.6% (42)	20.1% (118)	98.9% (616)	100.0% (640)
Canada	53.8% (1,891)	3.2% (34)	17.0% (105)	91.1% (729)	100.0% (1,023)
United States	37.3% (2,345)	1.0% (21)	7.9% (150)	95.5% (762)	100.0% (1,412)
Chile	21.1% (79)	1.1% (3)	67.5% (27)	100% (31)	100.0% (18)
Category					
Dairy & alternatives	66.3% (2,065)	0.8% (7)	32.6% (103)	99.9% (956)	100.0% (999)
Juice/juice drinks	59.6% (2,701)	8.3% (112)	26.6% (203)	96.6% (892)	100.0% (1,494)
Sports	41.1% (276)	0% (0)	9.1% (27)	88.2% (231)	100.0% (18)
Low/no-alcohol	41.0% (100)	1.7% (2)	6.1% (2)	100% (96)	0.0% (0)
Coffee	33.5% (167)	3.1% (6)	2.0% (3)	100% (42)	100.0% (116)
Water	32.2% (567)	2.6% (16)	14.3% (94)	89% (282)	100.0% (175)
Soft drinks	29.8% (863)	1.4% (20)	14.6% (112)	92.7% (153)	100.0% (578)
Energy	6.7% (57)	1.2% (4)	6.5% (32)	80% (20)	100.0% (1)

[a] Beverages available outside of Canada and the US with 'per 100mL' serving sizes (and 'per 200mL' in Chile) that were sold in containers of different sizes (i.e., not 100mL or 200mL) were excluded from analyses because they cannot be used to evaluate voluntary brand-selected serving-sizes.

5.1.5 Discussion

The current study is among the first to directly compare serving size labelling practices of non-alcoholic pre-packaged beverages across countries and categories. The findings highlight cross-country differences in serving size formats and amounts, with implications for policy implementation described below.

Across the six countries examined, consumers received nutrient information in different serving size formats depending on the policy environment: Australia, Chile, Mexico, and the UK displayed information 'per 100mL' and often 'per serving,' while beverages in Canada and the US displayed nutrients 'per serving.' Beverages in Australia displayed both serving size formats, including on containers as small as 60mL,[295] demonstrating feasibility for other regions. The current study found that two of the three countries requiring only 'per 100mL' labelling often voluntarily displayed both formats (the UK: 64% and Chile: 96%). This finding highlights opportunities to require both 'per 100mL' and 'per serving' formats on beverage labels in the UK and Chile, which may in turn support product comparisons and consumer understanding of nutrient intake.[137] To further promote informed decision-making, serving sizes should include intuitive formats, such as standardized units and consistent increments.[136]

Differences in mean serving sizes observed across countries may be partly explained by mandated serving sizes. For example, Chile mandates 200mL on beverages and had the lowest adjusted mean serving size, while Canada and the US allow greater flexibility, which may partly account for their higher adjusted mean values. This finding may be particularly relevant as consumers in North America often interpret serving sizes as recommended intakes,[138] despite these amounts often exceeding dietary guidelines.[296] Consequently, removing the flexibility of container sizes for beverages with single servings, along with education campaigns on interpreting label information and dietary recommendations, may help consumers understand appropriate consumption amounts. Standardizing 'per serving' formats may also limit brands from selecting smaller serving sizes to make beverages appear healthier and appeal to 'health conscious' consumers (i.e., by reducing sugar/calorie amounts on labels).[130,146]

Consumer confusion about serving size may occur when small or moderate containers (e.g., ≤600mL) appear as multiple servings or large containers appear as single servings. Across all countries, beverages with multiple servings were common, particularly among moderate containers >355-600mL (17%). The proportion of beverages in moderate containers >355-600mL with multiple servings differed by country, ranging from lowest in the US (7.9%), Canada (17.0%), and Australia (20.1%), to highest in the UK (40.1%), Chile (67.5%), and Mexico (79.8%). Using serving sizes equivalent to the entire container for small or moderate containers (as in Australia, Canada, and the US) may reduce this misalignment. In contrast, serving sizes less than the entire volume of small or moderate containers may contribute to misalignment (e.g., 200mL requirements in Chile, regardless of container size).

The findings provide support for making the serving size equivalent to the entire container for small or moderate beverages below a certain size (e.g., ≤600mL) and standardizing serving sizes for larger containers (e.g., 250mL serving sizes for containers >600mL). Small or moderate beverages could be defined using uniform thresholds, such as containers ≤600mL, or category-specific thresholds (without flexibility). In turn, this would reduce the wide range of serving sizes observed in the current study, as well as the occurrence of misaligned serving and container sizes. As the proportion of beverages in moderate containers ≤600mL with more than one serving was highest in juice/juice drinks (27%) and dairy & alternatives drinks (33%) versus other categories (≤15%), mandating 'per serving' labels for containers with one serving may be particularly relevant for these categories. Additionally, if Canada and the US do not implement uniform or category-specific thresholds, flexibility for container sizes of beverages with single servings should be removed or dual-column labels should be implemented in Canada. Dual-column labels are currently required in the US to display 'per serving' and 'per container' amounts for larger containers consumed in one sitting (i.e., 200-300% of reference values)[136] and have been shown to increase accuracy of calorie estimation.[142,143]

Countries have also adopted other approaches to support consumer understanding of serving size information. For example, some jurisdictions require the number of 'servings per container' on labels,[130,135,297] yet they have not been shown to improve consumer understanding of calories.[142] Alternatively, some regions requiring only 'per 100mL' labels display select nutrients (e.g., energy) 'per 100mL' and 'per container,'[131] which may be particularly useful on beverages with misaligned serving and container sizes. Interpretive front-of-package nutrition labels that do not require numeracy, such as octagon warnings, traffic lights, or Health Star Ratings, may also help consumers assess product healthfulness.[298] Collectively, combined labelling strategies on the front and back of products may reduce misinterpretation of nutrition information, limit overconsumption, and encourage healthier beverage choices.

5.1.5.1 Limitations

The current study is subject to limitations common to web scraping research. First, the scan did not capture all beverages sold in each country. Beverages may have been missed due to technical limitations (e.g., inability to extract data from images) and were limited to non-alcoholic, pre-packaged options. The number of retailers in each country was also limited and did not include niche retailers (e.g., ethnic grocery or health food stores), vending machines, or food-service establishments, potentially underrepresenting niche- or region-specific products. While store purchases may vary due to cultural preferences, pricing, product availability, and access,[292] the inclusion of multiple retail sources (i.e., grocery store, food delivery, and brand websites) increases generalizability. Additionally, the scrape included a majority of brands from leading manufacturers on country-specific Euromonitor market share reports in 2022: 68.5% (Canada), 68.6% (UK), 74.5% (US), 77.5% (Australia), 80.3% (Mexico), and 82.2% (Chile).[220–225]

The nutrient information captured in the online scan may differ from that shown on physical product labels. Despite the rise in online beverage purchasing and Codex Alimentarius recommendations for clear and transparent labelling both in-store and online,[258,259] few regions

beyond Chile, the European Union, and the UK require nutrition information to be displayed in both settings (although enforcement mechanisms are unclear).[260–262] Although few studies have compared products in-store versus online, an evaluation of UK supermarkets reported similar product availability across the sources, with 85% of items matched with nearly identical nutritional information.[257] These findings support the use of web scraping data to determine product availability and labelling practices. Additionally, the Canadian and US governments held consultations with stakeholders in 2022 and 2023 to explore the development of best-practices for providing nutrition information online,[263,264] suggesting the potential to improve consumer understanding of beverage composition and support future research using online product composition data.

5.1.6 Conclusion

There are notable differences in serving size regulations across countries, which may influence the nutrient amounts displayed on products and consumer interpretation of beverage contents. The findings of the current study highlight the potential to standardize serving size regulations for beverages within and across countries. In particular, two approaches may support clearer interpretation of serving size information: 1) providing nutrient information in both 'per 100mL' and 'per serving' formats; and 2) aligning serving sizes with container volumes for small or moderate beverages (e.g., ≤600mL), while standardizing serving sizes for larger containers (e.g., 250mL serving sizes for containers >600mL).[138] Additionally, future research is needed to examine how these serving size labelling practices influence beverage purchases and consumption in real-world settings. Given the expected growth in digital retail,[28] ensuring that serving size information is clear and consistently available both in-store and online may help promote healthier beverage choices worldwide.

Chapter 6: DISCUSSION

6.1 Overview

Consumer nutrition environments worldwide are characterized by a wide availability of less healthful food and beverages, which are important sources of sugars and LNCS.[2,3] Concurrently, there is growing consumer and government awareness of the adverse health effects of sugar consumption, particularly from SSBs.[2] This awareness has contributed to rising demand for lower-sugar options and increased implementation of policy interventions aimed at reducing sugar consumption and improving consumer understanding of beverage content, such as SSB taxes, FOPLs, and serving size labelling requirements.[15,130,167,299] However, there is a lack of cross-country evidence examining how these policies influence the composition and nutrition labelling of the beverage supply: most existing studies focus on individual countries, while limited cross-country research relies on data collected at different times using non-standardized methods. Thus, the primary aim of this thesis was to examine multiple dimensions of the consumer nutrition environment, including beverage composition and nutrition labelling practices, across six countries with different policy environments.

This thesis provided a broader understanding of how nutrition policies are associated with sugar concentrations, sweetener presence, and serving size labelling practices. The findings offered novel cross-country insights showing that sugar concentrations in beverages 'clustered' around sugar-related thresholds in countries with mandatory SSB tax and/or FOPL policies; LNCS were more prevalent and frequently co-occurred with added sugars in countries with ≥1 mandatory sugar-related policy; and multiple servings were common in beverages across countries, including in containers >355-600mL. The thesis also identified implications for future policies and developed a branded beverage composition database, which can support ongoing monitoring of the beverage supply. However, the cross-sectional design of the three studies limits causal conclusions, while

other potential drivers of (re)formulation were not examined and may also contribute to the differences observed. These themes are discussed in more detail below.

6.2 Implications for policy

6.2.1 Threshold-based policies

Threshold-based policies, including SSB taxes and FOPLs, aim to modify the consumer nutrition environment by influencing product characteristics, such as sugar concentration and sweetener presence. As threshold-based policies apply different financial rates depending on sugar concentrations, they create explicit targets for (re)formulation and likely greater incentives for reducing sugar concentrations than voluntary approaches or flat-rate taxes, which apply uniformly to all products with added sugars, for example.[174] Findings from Study 1 are consistent with this mechanism and add to the growing body of evidence linking sugar-related policy thresholds and product (re)formulation.[174,175,239,240]

Among the countries examined, those with sugar-based thresholds (Chile and the UK) had the lowest mean sugar concentrations in beverages, with greater 'clustering' of beverages just below policy thresholds. In Chile, sugar content 'clustered' under the lower FOPL threshold of 5g/100mL versus the higher SSB tax threshold of 6.25g/100mL, while 'clustering' in the UK occurred under the 5g/100mL SSB tax threshold versus the higher 8g/100mL threshold. These findings are consistent with evidence of 'clustering' from studies following the UK SSB tax and reductions in sugar concentrations to below thresholds after implementation of Chilean FOPL.[175,207,240,245] Similar 'clustering' patterns of sugar concentrations below thresholds have been observed in response to FOPL policies in other countries, including Peru[300] and Singapore.[301] However, there was little 'clustering' below the lowest UK FOPL threshold of 2.5g/100mL, which may reflect the technical feasibility of reducing sugar concentrations, consumer taste perceptions, or the voluntary nature of the FOPL policy that provides less (re)formulation incentives. Additionally, despite the presence of

an SSB tax and FOPL in Mexico, adjusted mean sugar concentrations in beverages were higher than those in the US. This finding further suggests that (re)formulation can be influenced by multiple factors, such as policy design (i.e., flat-rate versus threshold-based tax), brand strategy, and consumer preferences.[166] To achieve greater reductions in sugar intake, complementary policies targeting other areas of the consumer nutrition environment, such as education, serving size regulations, and marketing restrictions, may be needed.[302]

Study 1 also found that the sugar content of beverages across Chile, Mexico, and the UK 'clustered' around 5g/100mL thresholds, suggesting a shared reference point that may inform future policy development. Currently, several Latin American countries other than Chile use a 5g/100mL threshold for SSB taxes (e.g., Colombia and Peru)[210] and similar thresholds for FOPLs (e.g., Peru: 5g/100mL and Venezuela: 5.5g/100mL).[191] This pattern may reflect how policies spread across countries, including learning from early adopters and regional guidance, such as the Pan American Health Organization Nutrient Profile Model, which has been used to inform the development of thresholds for sugar-related policies across the Americas.[303] International agencies, such as the World Health Organization and Codex Alimentarius, have also played a key role in developing guidelines to help harmonize food policy standards and address issues of low capacity across countries. For instance, the World Health Organization has guidelines on sugars intake and sugar sweeteners,[304] while Codex Alimentarius has guidelines on nutrition labelling.[305] INFORMAS offers further direction to countries regarding standardized monitoring tools to support healthy food environments, such as surveys of food composition, labelling, and availability.[306] Consequently, these policy frameworks play a key role in shaping the consumer nutrition environment by defining nutrient thresholds that guide labelling and product composition policies across countries.

6.2.2 Low/no-calorie sweetener presence and beverage (re)formulation

Beyond added sugars, this thesis suggests that sugar-related policies may influence the presence of LNCS in beverages. Study 2 found a higher presence of LNCS overall and combined with added

sugars among countries with ≥1 mandatory sugar-related policy, likely reflecting substitution of added sugars with LNCS. Cross-country differences in sweetener presence further suggest the importance of policy design in shaping beverage composition. For example, Chile had the highest presence of LNCS overall and combined with added sugars. This finding is likely driven by Chile's comprehensive policy suite, including mandatory FOPLs, concentration-based SSB tax, and marketing restrictions,[307] and is consistent with previous pre-post research suggesting potential substitution of sugar with LNCS in beverages.[207,240,281] In contrast, the substitution pattern was less pronounced in other countries, possibly due to voluntary FOPLs (e.g., Australia and the UK), LNCS FOPL (e.g., Mexico), flat-rate volumetric SSB tax (e.g., Mexico), or no national-level SSB tax or FOPL (e.g., Canada and the US).[84,210,280] Beyond policy presence and design, LNCS use may also depend on factors such as consumer demand for lower-sugar or -calorie options, and perceptions of LNCS.[166,291]

As LNCS become more prevalent in the global beverage supply, there is an increasing need to monitor their presence and concentration over time. Such monitoring efforts may be especially important as sugar-related policies evolve, including changes in the scope of targeted beverages and incorporation of sweeteners in FOPLs. For example, Mexico introduced a tax on beverages with LNCS in 2026.[265] To better support cross-country monitoring of beverage markets, LNCS concentrations could be added to nutrition labels and sweetener terminology (e.g., NSS, non-nutritive sweeteners, artificial sweeteners, or LNCS) could be standardized.[103] Longitudinal research is also needed on the health effects of LNCS, both alone and in combination with other LNCS or added sugars,[17] to further inform policy development.

6.2.3 Limitations of (re)formulation

(Re)formulation is a public health strategy used to improve the healthfulness of the food environment through changes in product composition.[184] Findings from this thesis align with the growing body of evidence showing that brands may be incentivized to reduce sugar concentrations in response to sugar-related policies (e.g., SSB taxes and FOPLs) by substituting added sugars with

LNCS.[166,207,240,281] However, there is limited consensus across countries on the role of LNCS within sugar-reduction strategies: some policy approaches allow sugar substitution with LNCS, such as in the UK,[175] whereas others explicitly aim to limit substitution, including through LNCS FOPLs.[209] Canada provides another example of this uncertainty, as its Food Guide states that LNCS do not need to be consumed to reduce free sugars intake,[309] while previous requirements to declare four LNCS (acesulfame-potassium, aspartame, neotame, and sucralose) on the front-of-package and concentrations in ingredient lists were repealed in 2022 due to stakeholder feedback and to improve consistency with other sweetener labelling.[288,289] Whether LNCS substitution represents a successful outcome of (re)formulation depends on policy objectives. For instance, if the primary goal is to reduce population-level sugar intake, then replacing added sugars with LNCS may represent an acceptable mechanism.[310] However, (re)formulation that focuses on reducing the concentration of single nutrients, such as sugar, may not address concerns over ingredient composition, level of processing, or the overall healthfulness of the food environment. Beyond single-nutrient substitution, alternative (re)formulation approaches could include shifting towards less processed ingredients,[184] although this strategy may be more challenging in beverages than foods due to the nature of beverage formulations.

Achieving broader changes to the beverage supply may require policy approaches that target multiple aspects of the food environment, such as marketing, pricing, and procurement policies that promote consumption of plain water and unsweetened beverages.[310,311] However, these approaches were outside the scope of this thesis. Given the globalized nature of the beverage industry, including multinational brands, effective policy implementation and sustainability may require coordination across countries.[311] This consideration further highlights the importance of international organizations, such as the World Health Organization, in offering policy guidance across jurisdictions, as well as the role of cross-country analyses in providing evidence to inform policy development. Depending on policy goals, policymakers may benefit from considering not only single-nutrient reductions, but also changes in ingredient composition, food processing, and

complementary policy actions when examining sugar-reduction strategies and their potential impact on the overall healthfulness of the food environment.

6.2.4 Nutrition labelling

Nutrition labelling policies are an important component of the consumer nutrition environment, as they influence how nutrition information is presented on products and interpreted by consumers. A key challenge of nutrition labelling relates to the complexity of ingredient lists. Study 2 identified more than 30 distinct sugar descriptors in ingredient lists, including "fruit juice concentrate," "sugar", and "high-fructose corn syrup." This range of descriptors may limit consumers' ability to identify sugar content and limit added sugars intake.[231,285] Consequently, policies that standardize the identification of added sugars may support informed decision-making, such as grouping sugar-based ingredients (as required in Canada)[233] or identifying added sugars in ingredient lists or nutrition facts tables (as required in Mexico and the US).[131,287] However, Food Standards Australia New Zealand abandoned a proposal to require declaring added sugars in nutrition facts tables in 2026 due to consumer confusion over sugar terminology and implementation costs.[312] As such, intuitive FOPLs, such as 'high in' warning labels, may complement back-of-package ingredient lists to help consumers identify sugar content and determine product healthfulness.[94] Combined labelling initiatives may also benefit from consumer education to improve understanding of sugar ingredients and support informed dietary choices.

Similar challenges were observed for LNCS labelling, suggesting that policies for added sugars could be extended to LNCS. Study 2 identified nearly 40 different LNCS descriptors in ingredient lists, which consumers may not recognize due to the range of unfamiliar chemical and brand names. While a small number of countries, including Chile and Mexico, require products to display LNCS concentrations (e.g., "stevia (2.6 mg/100 g)"),[131,262] consumers may have trouble interpreting this numeric information.[88,290] Additionally, misperceptions of product healthfulness may be driven by claims such as 'no' or 'less added sugar,' despite the presence of LNCS.[274] FOPLs for LNCS may

therefore play an important role in helping consumers identify LNCS-containing beverages. In some jurisdictions, such as Mexico, FOPL systems include warnings for products containing sweeteners.[209] While evidence on their impact on consumer understanding or purchasing behaviour in real-world settings is limited, LNCS FOPLs may be increasingly important given consumer preferences to avoid certain sweeteners.[291] Overall, evidence highlights the potential of comprehensive LNCS labelling to better inform consumers of beverage composition.

Serving size policies are another important, yet understudied component of nutrition labelling. Study 3 highlighted the lack of global consensus on the purpose of serving sizes on nutrition labels of beverages. For example, some countries require 'per 100mL' formats to facilitate comparisons across products, although they may not correspond to the amount consumed on a single occasion.[130] Other countries allow different 'per serving' amounts which better reflect typical consumption,[130] but they may limit comparability across products due to inconsistent serving sizes. As such, the findings suggest the potential to standardize serving size labelling regulations for beverages across countries by providing nutrient information in both 'per 100mL' and 'per serving' formats. As two of the three countries requiring only 'per 100mL' labelling also frequently displayed 'per serving' information voluntarily (Chile and the UK), providing both formats may be a particularly feasible approach to support both comparability and consumer understanding of nutrition information across beverages in these countries.

Beyond formats, consumer understanding of nutrition information may be influenced by misalignment between serving and container sizes (e.g., small containers appearing as multiple servings or large containers appearing as a single serving). Study 3 found that beverages with multiple servings were common across all countries, particularly among moderate containers >355-600mL, which may often be consumed in a single occasion. Policies that align serving sizes with the full container volume for small or moderate beverages (e.g., ≤600mL) may reduce this misalignment, helping consumers interpret label information and nutrient amounts consumed in a single

sitting.[138,144] For larger containers, standardized serving sizes (e.g., 250mL for beverages >600mL) may reduce variation in serving size declarations and improve comparability across products. Complementary strategies, such as dual-column labelling ('per serving' and 'per container'), may also improve consumer understanding of the nutrient content of larger container sizes.[142,143] However, evidence from real-world settings remains scarce, highlighting the need for future research to examine how these labelling practices influence beverage purchases and consumption. Additionally, there is limited consensus on optimal serving size definitions, whether based on typical consumption patterns or dietary recommendations, and limited evidence on the effect of serving size labelling on beverage intake.[138] Consequently, serving size policy design should account for serving size definitions, their relationship to container sizes and consumption patterns, and how this information is presented to consumers.

While serving size policies primarily relate to the presentation of nutrition information, container size policies may influence beverage consumption more directly.[139] Container size policies may include caps on beverages with single servings, pricing strategies that incentivize smaller sizes or penalize larger formats, and marketing restrictions on large containers.[313,314] In the only real-world examination of New York City's proposed container size cap of 16oz (473mL) on SSBs sold in food-service establishments (proposed in 2012 and struck down before implementation in 2013),[315] a sports arena adopting the policy saw decreased SSB purchases and consumption versus a control arena, without impacting arena satisfaction.[316] Furthermore, modelling studies across Australia and New Zealand have reported health and economic benefits of 250mL serving size or 375mL container size caps on SSBs with single servings, including greater impacts with limits on fruit juice and milk beverages.[317,318] However, container size policies may be associated with unintended consequences, including increased packaging waste from smaller containers; consumer compensation by drinking multiple beverages; or retailer price incentives, such as multi-drink pricing or promotions on refills.[319,320] Additional research is therefore needed to examine how brands, consumers, and retailers respond to container size policies in real-world settings.

Overall, nutrition labelling policies should not be considered in isolation, as their effectiveness depends on interactions within the broader food environment. For example, combining serving size policies with intuitive FOPLs may help consumers easily determine product healthfulness on the front of beverages and clarify consumption details using the nutrition facts table on the back of products. Additionally, threshold-based sugar-related policies may influence brand strategies related to serving and container sizes. In countries such as Australia, Canada, and the US (which lack threshold-based SSB tax and FOPL policies), beverage brands have introduced smaller container sizes as a strategy to lower 'per serving' sugar amounts without changing underlying formulations.[138,241,242,321] In contrast, threshold-based SSB tax or FOPL policies typically rely on sugar concentrations per 100mL, meaning that reductions in serving sizes do not affect policy eligibility. As such, threshold-based policies may create stronger incentives to genuinely (re)formulate beverages to avoid punitive taxes or FOPLs, rather than superficial reductions in container size that primarily improve perceived healthfulness. Mandating both 'per 100mL' and 'per serving' formats may provide further transparency by allowing consumers to compare sugar concentrations across products, regardless of container size. This highlights the importance of comprehensive nutrition information policies in supporting consumer understanding and informed decision-making.

6.2.5 Online data availability

Digital retail has changed how consumers interact with the food environment.[51] While online grocery stores are now a key source of food and beverage purchases worldwide, nutrition policies originally designed for in-store settings have not been fully implemented in online environments.[51] For example, despite the rise in online beverage purchasing and Codex Alimentarius recommendations for clear and transparent labelling both in-store and online,[258,259] few regions (e.g., Chile, the European Union, and the UK) require nutrition information to be displayed in both settings (although enforcement mechanisms are unclear).[260,261]

While not a primary objective, this thesis found gaps in nutrition labelling in online retail settings. For instance, convenience store websites did not list product availability, while food delivery platforms did not display nutrient labels at the time of data collection (neither as text nor images). Similarly, studies of online retailers in Canada and the US found nutrition facts labels for only 40-70% of products,[322,323] with additional navigation, such as scrolling or separate clicks, often required to access content.[322–324] As a result, consumers may not see complete product information when shopping online, limiting informed decisions about product comparisons or nutrient intakes.[322,323]

The findings of this dissertation suggest the need to strengthen policies for the digital food retail environment. While Canada and the US held consultations with stakeholders in 2022 and 2023 to develop guidance for online nutrition labelling, no policies have been implemented to date.[263,264] Policy approaches include mandating online nutrient labels that are easy to access, require minimal navigation, and include zoomable, legible images.[263,264] Online visibility may be particularly relevant for FOPLs, which aim to influence both brand and consumer behaviour, as their effectiveness may be reduced if consumers do not see them prior to purchasing. While few studies have specifically examined the use of nutrition information when shopping online, emerging experimental studies indicate that displaying FOPLs on grocery store websites or mobile app contexts is associated with healthier food purchases (e.g., less sugar, salt, or fat),[325,326] reinforcing the importance of labelling strategies in the online environment. Beyond labelling, online retail environments may offer opportunities to support healthier purchasing, including filters based on nutrient content, personalized recommendations for dietary preferences or health goals, and marketing strategies that prioritize lower-sugar options (e.g., ranking healthier options higher in searches, suggesting healthier alternatives, and limiting price promotions on high-sugar products).[322,323] Together, these comprehensive approaches may best support consumers in making healthier purchases online.

Increasing the availability of online product information may also benefit researchers monitoring the food environment. Beyond missing product information, this thesis found that some grocery

stores only displayed nutrition information as images, with limited technology currently available to accurately convert this content into text. Although supplementary data collection from brand websites may have helped address this limitation, standardized text-based nutrition information or improvements in image-to-text extraction would enhance the ability to effectively monitor the food supply. Overall, as online grocery shopping continues to rise,[28] integrating digital retail into nutrition policy will be increasingly important to support informed consumer decisions, maximize policy impact, and accurately monitor and improve the healthfulness of food environments worldwide.

6.3 Methodological considerations for monitoring

A primary contribution of this dissertation was the development of a branded beverage composition database to examine nutritional characteristics of the beverage supply across six countries using a standardized web scraping process. However, challenges associated with web scraping, such as data availability and accuracy, highlight the need to consider alternative and/or complementary data collection tools for future monitoring efforts.

6.3.1 Web scraping for data collection

Standardized protocols to systematically monitor food and beverage composition and nutritional labelling across countries have been developed by organizations such as INFORMAS.[327] These recommended methods have typically relied on in-store data collection to populate food composition databases, including photographing products or manually recording label information.[327] However, these methods require considerable resources, including time and money, leading to infrequent data collection from a limited number of retailers and geographic scope, ultimately reducing beverage coverage and the ability to detect changes over time.[196] Alternatively, collecting data from online food retailers via web scraping has emerged as a valuable alternative to develop and maintain branded food databases due to its efficiency and scalability across retailers and countries.[196] This feature is particularly valuable for cross-country analyses, where standardized

data collection methods are required for comparability. Additionally, web scraping can capture brand- and product-level information, rather than averaged nutrient values used in many existing food composition databases,[328] allowing researchers to monitor (re)formulation at the level where changes occur.

Despite the benefits of web scraping, methodological challenges remain. One of the main limitations of web scraping is the lack of available data.[198] For example, not every product available in-store may be listed online, and nutrition information may be incomplete or missing.[198] Additionally, some retailers (e.g., smaller, independent, or ethnic stores) may lack online platforms for web scraping, which may lead to underrepresentation of certain market segments and limit generalizability. Retailers may also implement measures such as CAPTCHAs or anti-bot detection that limit scraping, further reducing data availability. Even when data are available online, accuracy is not guaranteed, as information may not be up to date or error-free.

Furthermore, substantial resources for data cleaning and management are required after web scraping, including cleaning heterogeneous product details (e.g., inconsistent brand name spelling), standardizing units across countries (e.g., metric versus imperial measurements), harmonizing languages (e.g., removing accents and translating ingredients), addressing missing information (e.g., obtaining 'per 100mL' sugar concentrations from 'per serving' values), and deduplicating products (e.g., identifying and grouping beverages based on shared characteristics). These steps require technical expertise and can increase the time needed to process web-scraped datasets.

6.3.2 Alternative data collection approaches

Beyond traditional in-store audits and web scraping, crowdsourcing is increasingly used to collect food composition data.[196] Consumers can scan and upload product information to websites (e.g., Open Food Facts)[329] or mobile applications (e.g., FoodSwitch),[330] which may allow for more frequent

updates, reduced costs, and improved coverage, particularly for niche or regional products (depending on the users).[196] However, crowdsourcing may be limited by issues of data quality and duplication, which require cross-checking.[196] Another approach involves obtaining data from manufacturers through industry partnerships.[202] While this approach can improve data accuracy, manufacturers may not voluntarily provide complete nutrition information (e.g., only 15% of products in the Netherland's database list serving sizes),[202] or update content after products are (re)formulated or discontinued.[331] Alternatively, the Access to Nutrition Initiative, an independent organization that evaluates corporate nutrition practices, contacts food and beverage manufacturers to verify product information.[332] While this approach can strengthen the accuracy of web scraped or crowdsourced data, it depends on manufacturer cooperation and can be resource-intensive. Governments can also mandate the reporting of product composition, with precedents in other sectors, such as mandatory reporting for tobacco and vaping products in Canada.[333] Within the food environment, data on product composition are stored in large barcode-linked databases, such as those managed by major grocery store chains and national GS1 organizations,[334] although such information may not always be up to date or fully reflect (re)formulation.[196] Nevertheless, the potential benefits of mandating the reporting of product composition data should be considered against trade-offs, including industry burden.

Given the limitations of individual data collection methods, hybrid models that combine multiple approaches may provide the most comprehensive way of monitoring the food environment. For instance, Slovenia's Composition and Labeling Information System collects data from web scraping, crowdsourcing, and manufacturers.[196] Additionally, cross-country collaboration can accelerate initial database development by leveraging shared infrastructure and improve the comparability of products through standardized data collection methods. Examples of collaborative approaches include partnerships between Slovenia and Ireland,[335] as well as multi-country initiatives, such as FoodSwitch and Food Label Information & Price, which originated in Australia and Canada, respectively, and are now offered in nearly 20 countries combined.[330,336] Harmonizing data collection methods across countries would strengthen global monitoring efforts, underscoring the need for

organizations like INFORMAS to update best-practices to reflect modern technology-based approaches. While implementation may be limited in settings where online retail is still emerging, combining data collection methods where possible will improve the availability and accuracy of food composition databases, improving their ability to track (re)formulation and inform the development of effective nutrition policies.

6.4 Strengths & limitations

This dissertation examined beverage composition and nutrition labelling across six countries with diverse policy environments (e.g., mandatory, voluntary, and no national-level sugar-related policies). The use of standardized data collection and analytical approaches enabled more comparable cross-country assessment of sugar concentrations, sweetener presence, and serving size labelling practices. The thesis also included branded, product-level information, such as sugar concentrations, ingredient lists, and serving sizes, rather than averaged data from nutrient databases, to better examine associations with (re)formulation. While the data used in this thesis may be less precise than information from laboratory analyses of beverages, comprehensive coverage was prioritized and resulted in scraping nearly 20,000 unique beverages. Data were collected from a variety of store types (i.e., grocery store, food delivery, and brand websites) using automated and manual methods, and included products from leading brands across countries based on market share. As such, the dataset provided a valuable cross-sectional representation of the beverage supply. Together, these methodological strengths enabled the thesis to address several gaps in the literature by providing cross-country evidence on beverage composition across diverse policy environments, extending research on (re)formulation beyond sugar reduction to include LNCS presence, and contributing to the limited evidence comparing serving size formats and amounts across countries. The dataset also provides a baseline for future research examining changes in beverage composition and labelling over time, including potential changes following Canada's FOPL introduction, which occurred shortly after the current data were collected.[293]

However, the cross-sectional design limits the ability to draw causal conclusions about the impact of these policies on (re)formulation. The studies did not compare beverage composition before and after policy implementation or account for other drivers of beverage composition, such as prior regulatory actions, brand positioning, and consumer demand.[166] While this thesis does not provide direct evidence of (re)formulation, lower sugar concentrations in countries with threshold-based policies and country-specific clustering around the UK SSB tax and Chilean FOPL thresholds are consistent with evidence of (re)formulation. This pattern was less evident for other policies, including the Mexican FOPL, UK FOPL, and Chilean SSB tax. Nevertheless, these findings align with previous pre-post studies showing (re)formulation following implementation of the UK SSB tax and Chilean FOPL, despite differences in study design.[175,207,240,245]

Several methodological considerations should be taken into account when interpreting the findings of this thesis. Although including six countries with diverse policy environments strengthened the cross-country scope, the findings may not be generalizable to regions with different policy, market, or consumer contexts. Concentrations or labelling of LNCS were not examined, which limits the ability to fully characterize patterns of LNCS use and their health implications. This thesis did not adjust for multiple comparisons because sugar-related policies are complex interventions that may have varied effects across outcomes. Such adjustment is like testing a universal null hypothesis of no effect across all outcomes, which may be inappropriate when evaluating broad interventions with heterogeneous effects.[337] Furthermore, water drinks were included as a broad category, including plain bottled water without sugars or LNCS. Alternatively, water could have been excluded to avoid its potential influence on overall sugar concentrations; however, differences across countries were also observed across other beverage categories, suggesting that these patterns were not driven by water alone.

This dissertation is also subject to limitations associated with web scraping, including data availability and accuracy. For example, not all products available in stores are listed online, and

online information may be incomplete, inaccurate, or outdated. Technological and resource barriers prevented the capture of labels as images and their conversion into text (e.g., Walmart), and sugar was the only nutrient captured by the manual scrape. A limited number of retailers were scraped and certain types (e.g., independent or ethnic food stores) were not captured, potentially underrepresenting niche- or region-specific products. Using data from one timepoint limits insight into product turnover, including seasonally-marketed, new, and discontinued products, and may not fully capture the dynamic nature of the beverage supply.[247] Although few studies have compared products in-store versus online, an evaluation of UK supermarkets reported that product availability across sources was similar, with 85% of items matched with nearly identical nutritional information.[257] These findings support the use of web scraping data to determine product availability, composition, and labelling practices.

Another limitation of this thesis was the lack of sales or consumption data. All beverages were equally weighted in analyses, regardless of market share or consumption frequency. Consequently, the findings reflect beverages available at the time of data collection, rather than those most often consumed, and prevents determining whether availability of lower-sugar beverages leads to meaningful decreases in population-level sugar intake. Similarly, the absence of dietary intake data limits the ability to examine how beverage composition relates to consumption patterns or health outcomes. In addition, this thesis did not examine consumer interpretation or behavioural responses to beverage composition or nutrition labelling, limiting understanding of how consumers perceive and use this information in real-world consumption or purchase decisions.

6.5 Future directions

The findings of this dissertation highlight several important areas for future research to better understand how sugar-related policies shape the composition and nutritional labelling of the beverage supply and, ultimately, population health.

6.5.1 Expanding the scope of data collection

Firstly, this dissertation focused on pre-packaged beverages available within the consumer nutrition environment. While these products are a primary source of dietary sugar, they represent a single component of the broader food environment. In line with best-practices developed by INFORMAS, future iterations of this work could expand the beverage composition database to include pre-packaged foods.[327] For instance, as FOPLs also apply to food and some countries have introduced taxes on food high in nutrients of concern,[210] examining (re)formulation patterns across both food and beverage categories could help further strengthen understanding of policy effectiveness. Linking product-level data across countries would also enable more comprehensive analyses of how multi-national brands respond to different policy environments through product (re)formulation and nutrition labelling.

Secondly, future analyses should consider overall product healthfulness, rather than single nutrients alone. Collecting full nutrition label information, such as energy, protein, fats, fibre, and micronutrients, would enable foods and beverages to be evaluated using nutrient profiling systems (e.g., HSR), providing a more comprehensive measure of nutritional quality.[338,339] However, nutritional composition alone may not fully capture product healthfulness. Indicators of food processing, such as additives, could also be incorporated, as sugar-related policies targeting single nutrients may encourage ingredient substitution without necessarily improving overall product healthfulness (e.g., LNCS substitution in response to sugar-related policies).[16,207] Overall, these findings highlight the value of considering multiple dimensions of product healthfulness, including both nutrient composition and food processing, when evaluating the impact of sugar-related policies on (re)formulation.

Thirdly, it is essential to expand the temporal scope of data collection. This dissertation, like many studies in the field, relied on cross-sectional data.[139,244,248,251] While findings provided insight into the

beverage market at one timepoint, they cannot determine changes over time or evaluate the effectiveness of sugar-related policies. Longitudinal data collection is therefore essential to better understand the impact of sugar-related policies on beverage composition and nutrition labelling. For instance, repeated measures would allow researchers to identify changes in product composition before and after policies have been implemented or updated, including timing of brand responses, sustainability of (re)formulation efforts, and shifts in ingredient use (e.g., increased presence of LNCS). As such, data from this thesis can be used as a baseline for future analyses across the six countries, including before Canada's FOPL implementation in 2026 and the UK's lowering of SSB tax thresholds in 2028.[175,293]

Fourthly, future research could expand data collection to the out-of-home sector, including restaurants, cafes, and fast-food outlets. In these settings, products are often high in nutrients of concern, yet are not often subject to FOPLs or SSB taxes, as these policies target pre-packaged retail items.[191,210] As such, incorporating these sectors would provide a more comprehensive depiction of consumer exposure to sweeteners and help determine if existing policies should be expanded to additional retail environments. Examining serving sizes across sectors may also improve understanding of sweetener exposure and inform the development of more consistent serving sizes. For example, Australia's Industry Guide to Voluntary Serving Size Reduction, developed in partnership with government, public health groups, and the food industry, recommends a maximum serving size of 450mL for chilled SSBs served in the out-of-home sector, highlighting the potential to inform single-serve beverage requirements in retail settings.[340] Additionally, future research should examine how product availability varies across neighbourhoods and income levels, as differences in food environments and cost can lead to unequal access to healthier product options.[341]

Lastly, future research is needed to explore the associations between sugar-related policies and product composition in low- and middle-income countries.[342] The beverage market is expanding in these countries,[2] and many have adopted sugar-related policies with designs different from both one another and those in upper-middle and high-income countries.[209,210] For instance, the

proportion of countries taxing 100% juices ranges from 20% in Europe to 27% in the Western Pacific, 47% in America, 62% in Africa, and 75% in South-East Asia.[255] Understanding how policy design influences product composition, industry responses, and consumer behaviours in regions with diverse regulatory and market contexts can further develop policies that better support population health.[342] The Food Label Information Program originally developed in Canada has demonstrated the feasibility of expanding branded food composition databases into regions such as Latin America, Africa, and Southeast Asia.[336] Moving forward, developing globally-applicable monitoring systems that capture diverse food environments across countries would better inform effective policy implementation.

6.5.2 Determining real-world consumer behaviour

This dissertation examined associations between sugar-related policies and multiple dimensions of the consumer nutrition environment, including the composition and nutrition labelling of pre-packaged beverages.[83] However, the effectiveness of these policies partly depends on how consumers respond to changes in the food environment, which may be influenced by individual-level factors, such as nutrition knowledge, preferences, and perceptions.[138,299] Research examining both environmental and individual-level determinants of behaviour could help clarify how policy-driven changes to the consumer nutrition environment translate into changes in purchasing behaviours, dietary intake, and health outcomes. While studies have demonstrated that certain FOPL and serving size formats can support consumer understanding of product healthfulness,[138,299] limited evidence exists on consumer interpretation and use of this information in the real world, including online settings. Future research could therefore examine whether sugar-related policies influence purchases and consumption of (re)formulated products, including whether consumers prefer lower-sugar or LNCS-containing options, or compensate for reduced sugar content by consuming greater quantities of these products or other high-sugar foods and beverages. To better characterize the consumer nutrition environment, future work could also assess how nutrition and

health claims, along with price and promotion strategies, influence consumer healthfulness perceptions[327] and purchasing behaviour of (re)formulated products.[327]

Integrating food composition data with sales and dietary intake data could help account for consumer behaviour. Researchers could then identify which products contribute most to population-level sugar intake and examine how (re)formulation may influence purchase and consumption.[247] For instance, beverages (re)formulated with less sugar may have greater impacts on public health if they account for a larger share of total sales. The beverage composition database in this thesis could be linked with data from the International Food Policy Study, which includes measures of purchase and consumption behaviours across the same six countries.[219] Linking these datasets by country and year would allow researchers to examine whether changes in the food supply, including decreased sugar content or increased availability of low/no-sugar products, are associated with changes in self-reported intake. Incorporating indicators of food processing into these analyses could further improve understanding of how sugar-related policies shape overall dietary patterns.[195,327] Future research could also leverage the development of digital tools designed to more accurately record consumption patterns, including food tracking applications and image capture systems.[343]

6.5.3 Leveraging advances in artificial intelligence

Advances in artificial intelligence may transform future approaches to monitoring the food environment, including data collection and management. Automated scraping systems may be developed to better support large-scale and frequent data collection by adapting to different retailer website structures and evading bot detection (although such blocks may also improve over time).[344,345] In turn, these advances may support more consistent data capture across countries and retailers.

Tools such as optical character recognition are currently being used to extract data from product images, including nutrition facts tables, reducing the need for manual data entry.[198] While these systems may still be imperfect and costly to implement, developments in artificial intelligence may improve the accuracy of extraction and ultimately enhance data availability. Likewise, language processing of ingredient lists, marketing claims, and FOPLs may assist with classifying beverages based on nutritional composition, detecting additives, and standardizing terminology across countries with different languages, ultimately improving comparability and data accuracy.

Machine learning is also currently used to link products across datasets and timepoints using identifiers such as barcodes and retailer-specific codes, supporting tracking of (re)formulation and product turnover over time.[198] However, barcodes may not always be listed online or correspond with (re)formulation efforts, as new barcodes may be provided without composition changes or remain constant despite significant changes.[196] Future models incorporating product descriptions or images may support product matching, particularly when product names or beverage varieties differ across countries (e.g., branding is aligned for Pepsi Max in Canada and Pepsi Zero Sugar in Australia).[346,347] These approaches may facilitate analyses combining food composition and sales, price, and dietary intake data to more comprehensively examine associations between policy, the food environment, and consumer behaviour.

Such advances in artificial intelligence require highly-trained and validated datasets before widespread use.[348,349] Consequently, the development of standardized, open, and validated tools would best support ongoing monitoring of the food environment. For example, codes used to develop both a database for food served by large chains and predict the healthiness of out-of-home food outlets in the UK have been made publicly available.[341] Additionally, as few jurisdictions have implemented policies on the legality of web scraping, researchers should follow current best-practice recommendations, such as ensuring that data collection minimizes disruption to retailer or brand websites (e.g., scrape during off-peak hours).[341,350] Overall, artificial intelligence offers the

potential to strengthen global food environment monitoring, although advances require validated tools and careful consideration of methodological standards.

6.6 Conclusions

In recent decades, the food environment has shifted towards a greater availability of less healthful food and beverages, including SSBs. As a result, an increasing number of countries have implemented policies aimed at improving the consumer nutrition environment, including SSB taxes, FOPLs, and serving size labelling regulations. The findings of this thesis provide novel cross-country evidence on how beverage composition and nutrition labelling practices vary across countries with different sugar-related policy environments. Mandatory policies involving sugar thresholds may incentivize (re)formulation to lower-sugar options and greater LNCS use, suggesting that these approaches may change product composition without necessarily improving overall product healthfulness. The findings also highlight opportunities to standardize the use of 'per 100mL' and 'per serving' formats, as well as serving size labelling requirements for smaller and larger beverage containers, which may improve the comparability and interpretability of nutrition information across beverages. However, the cross-sectional design does not allow causal conclusions to be drawn about the effects of these policies on (re)formulation. While the observed patterns are consistent with policy-related changes in product composition, other factors may also contribute to differences across countries. As such, the branded beverage composition database developed as part of this thesis provides a baseline for ongoing monitoring of the beverage supply across countries, supporting future examinations of sugar-related policies aimed at promoting healthier dietary intakes and reducing the burden of diet-related disease worldwide.

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APPENDICES

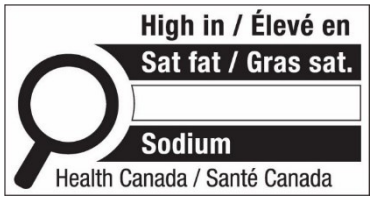
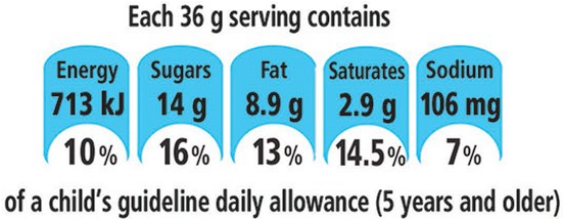
Appendix A – Chapter 1 supplementary material

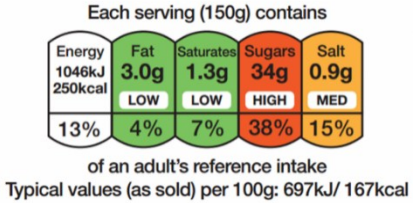
Table A-1. Select examples of sugar-sweetened beverage policies worldwide

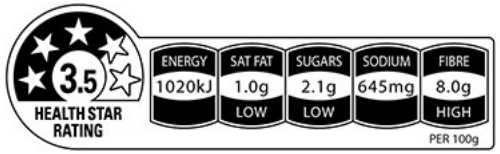
Location	Date implemented	Tax design	Levied on	Taxable products	Exempted products	Tax rate
Berkeley, California, United States[38]	March 2015	*Specific* (volume)	Excise on distributors	Non-alcoholic sweetened drinks (e.g., soda, fruit, energy and sports drinks, and sweetened ice teas and coffees)	Milk products, alcohol, infant formula, and 100% fruit and vegetable juices	US $0.01 per oz
Boulder, Colorado, United States[39,40]	July 2017	Specific (volume)	Excise on distributors	Drinks with at least 5g of added caloric sweeteners per 12oz (e.g., soda, energy, sports, and fruit drinks, and sweetened ice tea and coffee)	Milk products, alcohol, infant formula, 100% fruit and vegetable juices, and meal replacement drinks	US $0.02 per oz
Chile[39,42]	October 2014	*Ad valorem* (based on sugar concentration)	Excise on distributors	Non-alcoholic drinks with added sweeteners	100% fruit juices and dairy products	Less than 6.25g of sugar per 100mL: 10% More than 6.25g of sugar per 100mL: Originally: 13% Updated in 2015: 18%
Cook County, Illinois, United States[43]	August 2017 Repealed October 2017	Specific (volume)	Consumer at point of sale	Sugar- and artificially-sweetened drinks (e.g., soda, energy, and sports drinks, flavoured water, pre-made sweetened coffee and tea with less than 50% milk content,	Milk replacement products, infant formula, 100% fruit and vegetable juices, meal replacement drinks,	US $0.01 per oz

				and sweetened beverages from dispensing machines)	and unsweetened syrup and powder	
Mexico[45]	January 2014	Specific (volume)	Excise on distributors, importers, and manufacturers	Non-alcoholic beverages with added sugar, including reconstituted powdered sugar-sweetened drinks and flavoured/sweetened non-milk dairy products	Milk products (where milk is the primary ingredient) and 100% fruit and vegetable juices	MXN $1 per L; indexed to inflation once cumulative inflation hits 10%
Philadelphia, Pennsylvania, United States[45]	January 2017	Specific (volume)	Excise on distributors, importers, and manufacturers	Bottled drinks, syrups/concentrates for commercial sale, fruit/vegetable drinks with added sugar, mixers, coffee syrups at coffee shops, and diet drinks	Milk products (where milk is the primary ingredient), 100% fruit and vegetable juices, and syrups, concentrates, and powders sold to consumers	US $0.015 per oz; not indexed to inflation
United Kingdom[45]	April 2018	Specific (volume; based on sugar concentration)	Excise on distributors, importers, and manufacturers (exempt producers with under 1 million L per year)	Packaged beverages with at least 5g of added sugar per 100mL in ready to drink form	Drinks with at least 75% milk, dairy or alcohol replacement drinks (under 0.5% alcohol by volume), 100% fruit and vegetable juices, liquid drink flavouring, and powders mixed into liquids served in open containers	At least 5g of sugar per 100mL: £0.18 per L More than 8g of sugar per 100mL: £0.24 per L

Table A-2. Select examples of front-of-package nutrition labelling (FOPL) policies worldwide

Category	Type	Location	Symbol	Date implemented	Sugar threshold
Nutrient-specific	Contains sweeteners	Mexico[98,351]		October 1, 2020 (replacing the previous Guideline Daily Amount labels implemented in 2014)	Inclusion of sweeteners in the ingredient list
	Front-of-package nutrition label	Canada[352]		July 20, 2022 (compliance required as of January 1, 2026)	≥15% Daily Values when reference amount >30mL ≥10% Daily Values when reference amount ≤30mL
	Guideline Daily Amount label	United States[353] (e.g., Nestlé)		Voluntary	Compared against the average diet (90g in adults and 85g in children)

	'High in' label	Chile[354]		June 26, 2016 (Phase 1)	Phase 3 (June 26, 2019): 5g/100mL
		Mexico[351]		October 1, 2020 (replacing the previous Guideline Daily Amount labels implemented in 2014)	Phase 1 (October 1, 2020 – September 30, 2023): ≥10% total energy from free sugars, except beverages with <10kcal/100mL
	Multiple Traffic Light label	United Kingdom[355,356]		Voluntary, government recommended since 2013	Total sugar: Green: ≤2.5g/100ml Amber: >2.5g to ≤11.25g/100ml Red: >12.5% of RIs: >11.25g/100ml >15% of RIs: >13.5g/portion

Summary	Health Star Rating label	Australia[357,358]		June 2014	Rating calculated using baseline and modifying points; each star corresponds to a rating specific to a product category; total sugar is considered in the baseline points
	Nutri-Score	France[359,360]		October 31, 2017	Score calculated by comparing unfavourable (e.g., sugar) and favourable nutritional content; each letter corresponds to a specific range of scores

Appendix B – Chapter 2 supplementary material

Table B-1. Serving size policies for beverage containers with one or more servings across the six countries sampled[a]

	Government mandated for all beverages						**Government mandated when optionally declared**	**Industry norm**		**Brand discretion when optionally declared**	
	Canada[134]			**United States**[136]			**Chile**[133]	**Australia**[141]		**Mexico**[131]	**United Kingdom**[132]
Product category	**Reference amount** (mL)	**Single serving** (mL) (50% to 200% of reference amount)	**Multiple servings** (mL) (>200% of reference amount)	**Reference amount** (mL)	**Single serving** (mL) (≤200% of reference amount)	**Multiple servings** (mL) (>200% of reference amount)	**Single or multiple servings** (mL)	**Single serving** (mL)	**Multiple servings** (mL)	**Single or multiple servings** (mL)	**Single or multiple servings** (mL)
Carbonated and non-carbonated beverages (e.g., energy drinks, iced coffee/tea, soft drinks, sports drinks, water)	375mL	187.5mL to 750mL	375mL	360mL	Container size if ≤720mL Exception: if 200-300% of reference amount (>720-≤1,080mL) and reasonably consumed in one sitting: dual column labels displaying 'per serving' (reference amount) and 'per container'	360mL; number of servings per container	200mL; number of servings per container	Container size if ≤600mL; number of servings per container	250mL for containers >600mL; number of servings per container	Brand discretion; number of servings per container	Brand discretion; number of servings per container

Juices, nectars, fruit drinks	250mL	125mL to 500mL	250mL	240mL	Container size if ≤480mL Exception: if 200-300% of reference amount (>480-≤720mL) and reasonably consumed in one sitting: dual column labels displaying 'per serving' (reference amount) and 'per container'	240mL; number of servings per container	200mL; number of servings per container	Container size if ≤600mL; number of servings per container	250mL for containers >600mL; number of servings per container	Brand discretion; number of servings per container	Brand discretion; number of servings per container
Milk-based drinks (e.g., milkshakes)	250mL	125mL to 500mL	250mL	240mL	Container size if ≤480mL Exception: if 200-300% of reference amount (>480-≤720mL) and reasonably consumed in one sitting: dual column labels displaying 'per serving' (reference amount) and 'per container'	240mL; number of servings per container	200mL; number of servings per container	Container size if ≤600mL; number of servings per container	250mL for containers >600mL; number of servings per container	Brand discretion; number of servings per container	Brand discretion; number of servings per container

[a] Nutrient declaration formats 'per 100mL' are not included in the table. Government-mandated reference amounts are shown for select beverage serving sizes in Canada and the United States[135]. Reference amounts represent the quantity of beverage typically consumed in a single eating instance and are used to establish a single serving of pre-packaged beverages. Serving size declarations

are optional in Chile, but government mandates 200mL when included on non-alcoholic, pre-packaged beverages. Serving sizes in Australia are based on industry norms and depend on container sizes. Mexico and the United Kingdom allow brands to optionally include and determine serving sizes on beverages.

Table B-2. Grocery and convenience store selection, across countries

Country	Store type	Store name	Region	City
Australia[a]	Grocery	Coles	New South Wales	Newcastle
			Queensland	Gold Coast
			Victoria	Melbourne
			Western Australia	Perth
		Independent Grocers Alliance (IGA)	New South Wales	Newcastle
			Queensland	Brisbane
			Victoria	Melbourne
			Western Australia	Perth
		Woolworths	New South Wales	Sydney
			Queensland	Brisbane
			Victoria	Geelong
			Western Australia	Perth
	Convenience	7-Eleven (via Door Dash)	New South Wales	Sydney
			Victoria	Melbourne
		Couchfood	New South Wales	Sydney
			Victoria	Melbourne
		Foodary (via Uber Eats)	New South Wales	Sydney
			Victoria	Geelong
Canada	Grocery	Loblaws	British Columbia	Vancouver
			Newfoundland and Labrador[a]	St. John's
			Ontario	Ottawa
			Quebec	Montreal
		Sobeys	British Columbia	Vancouver
			Newfoundland and Labrador[a]	St. John's
			Ontario	Toronto
			Quebec	Quebec City
		Walmart[b]	British Columbia	Surrey
			Newfoundland and Labrador[a]	St. John's
			Ontario	Toronto
			Quebec	Lasalle
	Convenience	7-Eleven (via Skip the dishes)	British Columbia	Vancouver
			Ontario	Toronto
		Circle K (via Skip the dishes)	British Columbia	Vancouver
		Couche-Tard (via Door Dash)	Quebec	Montreal
		Petro-Canada (via Skip the dishes)	British Columbia	Vancouver
			Ontario	Toronto
Chile[a]	Grocery	Lider (Walmart)[b]	Biobío	Los Ángeles
			Maule	Talca
			Metropolitan	Santiago
			Valparaíso	Valparaíso
		Santa Isabel	Biobío	Los Ángeles
			Maule	Curicó
			Metropolitan	Santiago
			Valparaíso	Viña del Mar
		Unimarc	Biobío	Concepción
			Maule	Talca
			Metropolitan	Maipú
			Valparaíso	Viña del Mar

	Convenience	OXXO (via Rappi)	Metropolitan	Santiago
			Valparaíso	Viña del Mar
		Pronto Copec (via Rappi)	Valparaíso	Valparaíso
		Punto Copec (via Rappi)	Metropolitan	Santiago
		UPA (via Rappi)	Metropolitan	Santiago
			Metropolitan	Santiago
Mexico[a]	Grocery	Soriana	Ciudad de México	Ciudad de México
			Jalisco	Zapopan
			México	Nezahualcóyotl
			Veracruz	Veracruz
		Tienda Chedraui	Ciudad de México	Ciudad de México
			Jalisco	Zapopan
			México	Ecatepec
			Veracruz	Xalapa-Enríquez
		Walmart[b]	Ciudad de México	Ciudad de México
			Jalisco	Guadalajara
			México	Ecatepec
			Veracruz	Veracruz
	Convenience	7-Eleven (via Rappi)	Ciudad de México	Ciudad de México
			México	Ecatepec
		Círculo CCK (Circle K) (via Uber Eats)	Ciudad de México	Ciudad de México
			México	Naucalpan De Juárez
		OXXO (via Rappi)	Coahuila	Monclova
			México	Toluca
United Kingdom[a]	Grocery	ASDA	East of England	East Suffolk
			London	Barnet
			North West	Manchester
			South East	Milton Keynes
		Tesco	East of England	Bedfordshire
			London	Barnet
			North West	Liverpool
			South East	Buckinghamshire
		Sainsbury's	East of England	East Suffolk
			London	Barnet
			North West	Manchester
			South East	Buckinghamshire
	Convenience	Little Waitrose (via Uber Eats)	East of England	Bedfordshire
			London	Ickenham
		Morrisons Daily (via Uber Eats)	London	Croydon
			South East	Buckinghamshire
		Nisa (via Uber Eats)	East of England	Hertfordshire
			London	Barnet
United States	Grocery	Kroger	California	Los Angeles
			Illinois	Chicago
			Texas	Houston
			Washington	Seattle
		Target	California	San Diego
			Florida	Jacksonville
			Pennsylvania	Philadelphia[a]
			Texas	Houston
		Walmart[b]	California	San Diego
			Florida	Miami
			Pennsylvania	Philadelphia[a]
			Texas	Houston

	Convenience	7-Eleven (via Door Dash)	California	San Diego
			Pennsylvania	Philadelphia[a]
		Circle K (via Door Dash)	California	Berkeley
			Florida	Tampa
		Wawa (via Door Dash)	Florida	Jacksonville
			Pennsylvania	Philadelphia[a]

[a] Jurisdictions with mandatory or voluntary sugary drink taxes and/or front-of-package nutrition labels.
[b] Stores could not be scraped due to technical limitations.

Appendix C – Chapter 3 supplementary material

Table C-1. Summary of sugar-sweetened beverage tax and front-of-package nutrition label policies across the countries studied at the time of data collection (2023-2025)

Country	Presence of national sugar-sweetened beverage tax				Presence of national front-of-package nutrition label			
	No	Yes – voluntary	Yes – Mandatory	Sugar handling	No	Yes – voluntary	Yes – Mandatory	Sugar handling
Australia	X					X[141] (2014)		Summary score, with added sugar reducing the overall rating
Canada	X[a]				X[b]			
Chile			X[210] (2014)	Threshold-based: taxed if <6.25g/100mL (10%) and ≥6.25g/100mL (18%)			X[262] (2016)	Black octagonal warning: 'High in sugar' (>5g total sugar/100mL)
Mexico			X[210] (2014)	Flat rate: 1peso/L			X[131] (2020)	Black octagonal warning: 'Excess sugar' (≥10% of total energy from free sugars)
United Kingdom			X[210] (2018)	Threshold-based: taxed if 5-8g/100mL (£0.18/L) and ≥8 g/100mL (£0.24/L)		X[132] (2013)		Traffic light: ≤2.5g/100mL (green); >2.5 to 11.25g (yellow); >11.25g/100mL (red) for >12.5% of reference intakes; and >13.5g/portion for >15% of reference intakes (red)
United States	X[c]				X			

[a] The province of Newfoundland & Labrador implemented a flat-rate tax of $0.20/L between September 2022 and July 2025.[71]

[b] The current study was conducted prior to full implementation of front-of-package nutrition labels in Canada.[293]

[c] Sub-national taxes have been implemented in select jurisdictions. The current study included data from the state of Philadelphia, which implemented a flat-rate tax of $0.015/oz of sugar- and low/no-calorie-sweetened beverages in 2017.[361]

Table C-2. Linear regression model investigating mean sugar concentration (g/100mL) of non-alcoholic, pre-packaged beverages, excluding dairy & alternatives drinks, by country, beverage category, and store type (N=12,292)

	Mean mL (St dev) (St error)	Adjusted mean mL (St error)	Parameter estimate (β)	(95% CI)[a]	*p* value
Country					
Chile	4.1 (4.1) (0.1)	4.2 (0.1)	Reference	-	-
United Kingdom	4.4 (3.9) (0.1)	4.1 (0.1)	-0.08	(-0.4, 0.24)	0.639
Mexico	4.6 (4.3) (0.1)	5.3 (0.1)	1.12	(0.76, 1.48)	<0.001
United States	5.3 (4.9) (0.1)	5.4 (0.1)	1.17	(0.88, 1.46)	<0.001
Australia	6.0 (4.9) (0.1)	5.6 (0.1)	1.41	(1.06, 1.77)	<0.001
Canada	6.2 (4.6) (0.1)	6.1 (0.1)	1.85	(1.53, 2.17)	<0.001
Category					
Water drink	1.1 (2.2) (0.1)	1.1 (0.1)	Reference	-	-
Sports drink	3.4 (2.8) (0.1)	3.2 (0.2)	2.12	(1.75, 2.49)	<0.001
Low/no-alcohol drink	4.2 (3.9) (0.2)	4.6 (0.3)	3.46	(2.91, 4.01)	<0.001
Energy drink	4.3 (5.1) (0.2)	4.5 (0.1)	3.36	(3.02, 3.7)	<0.001
Carbonated/mixer drink	5.6 (5.2) (0.1)	5.6 (0.1)	4.50	(4.26, 4.73)	<0.001
Coffee drink	5.9 (3.4) (0.2)	6.0 (0.2)	4.90	(4.48, 5.32)	<0.001
Juice/juice drink	6.9 (4.1) (0.1)	6.8 (0.1)	5.75	(5.52, 5.97)	<0.001

Store type					
Grocery store	5.0 (4.5) (0.1)	5.0 (0.0)	Reference	-	-
Brand website	5.5 (4.8) (0.1)	5.4 (0.1)	0.38	(0.23, 0.54)	<0.001

[a] CI=confidence interval

Table C-3. Distribution of non-alcoholic, pre-packaged beverages according to the United Kingdom's front-of-package sugar label, by country (N=15,640)

	Total sugar ≤2.5g/100mL (green label)	**Total sugar >2.5 to ≤11.25g/100mL** (yellow label)	**Total sugar >11.25g/100mL** (red label)
Overall	34.6%	55.4%	10.0%
n=15,640	n=5,408	n=8,669	n=1,563
Country			
United Kingdom n=2,598	33.5% n=871	62.5% n=1,623	4.0% n=104
Chile	37.0%	57.7%	5.4%
n=1,242	n=459	n=716	n=67
Australia	30.2%	63.3%	6.5%
n=1,728	n=522	n=1,094	n=112
Mexico	33.9%	56.5%	9.6%
n=1,588	n=539	n=897	n=152
Canada	25.8%	63.7%	10.5%
n=2,643	n=682	n=1,683	n=278
United States	40.0%	45.5%	14.6%
n=5,841	n=2,335	n=2,656	n=850

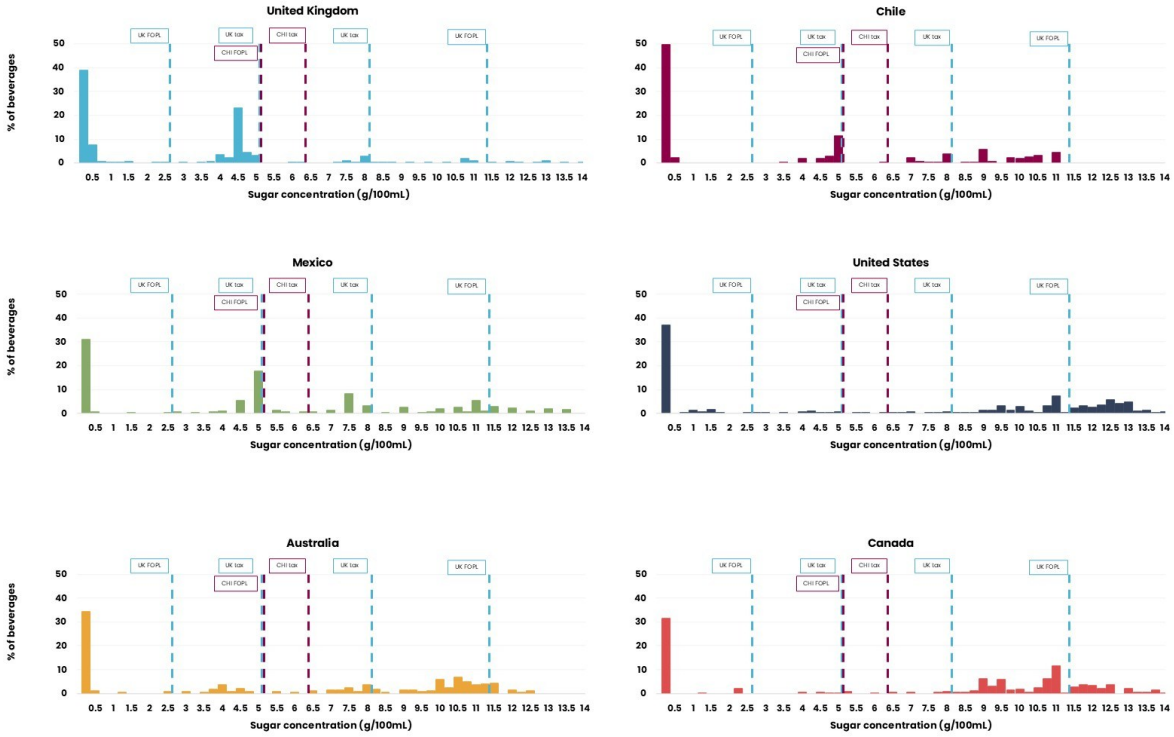
Table C-4. Distribution of non-alcoholic, pre-packaged beverages according to the United Kingdom's sugar-sweetened beverage tax, by country (N=15,640)

	Overall			Not exempt from tax[a]			Exempt from tax[a]		
	Total sugar <5g/100mL (untaxed)	**Total sugar ≥5 to <8g/100mL** (lower tax threshold)	**Total sugar ≥8g/100mL** (higher tax threshold)	**Total sugar <5g/100mL** (untaxed)	**Total sugar ≥5 to <8g/100mL** (lower tax threshold)	**Total sugar ≥8g/100mL** (higher tax threshold)	**Total sugar <5g/100mL** (untaxed)	**Total sugar ≥5 to <8g/100mL** (lower tax threshold)	**Total sugar ≥8g/100mL** (higher tax threshold)
Overall	54.6%	14.5%	30.9%	53.9%	11.8%	34.3%	57.3%	24.4%	18.4%
n=15,640	n=8,543	n=2,271	n=4,826	n=6,626	n=1,455	n=4,211	n=1,917	n=816	n=615
Country									
Chile	72.3%	8.8%	18.9%	70.6%	7.4%	22.0%	78.1%	13.2%	8.7%
n=1,242	n=898	n=109	n=235	n=674	n=71	n=210	n=224	n=38	n=25
United Kingdom n=2,598	68.6% n=1,781	8.8% n=228	22.7% n=589	70.1% n=1,472	6.9% n=144	23.1% n=484	62.1% n=309	16.9% n=84	21.1% n=105
Mexico	57.1%	18.2%	24.8%	56.2%	18.3%	25.6%	58.9%	18.1%	23.1%
n=1,588	n=906	n=289	n=393	n=597	n=194	n=272	n=309	n=95	n=121
United States n=5,841	51.4% n=3,000	16.3% n=953	32.3% n=1,888	51.2% n=2,537	13.4% n=663	35.4% n=1,754	52.2% n=463	32.7% n=290	15.1% n=134
Australia	46.0%	15.9%	38.1%	42.1%	12.0%	45.9%	56.9%	26.5%	16.6%
n=1,728	n=795	n=274	n=659	n=535	n=153	n=583	n=260	n=121	n=76
Canada	44.0%	15.8%	40.2%	41.6%	11.8%	46.6%	50.7%	27.1%	22.2%
n=2,643	n=1,163	n=418	n=1,062	n=811	n=230	n=908	n=352	n=188	n=154

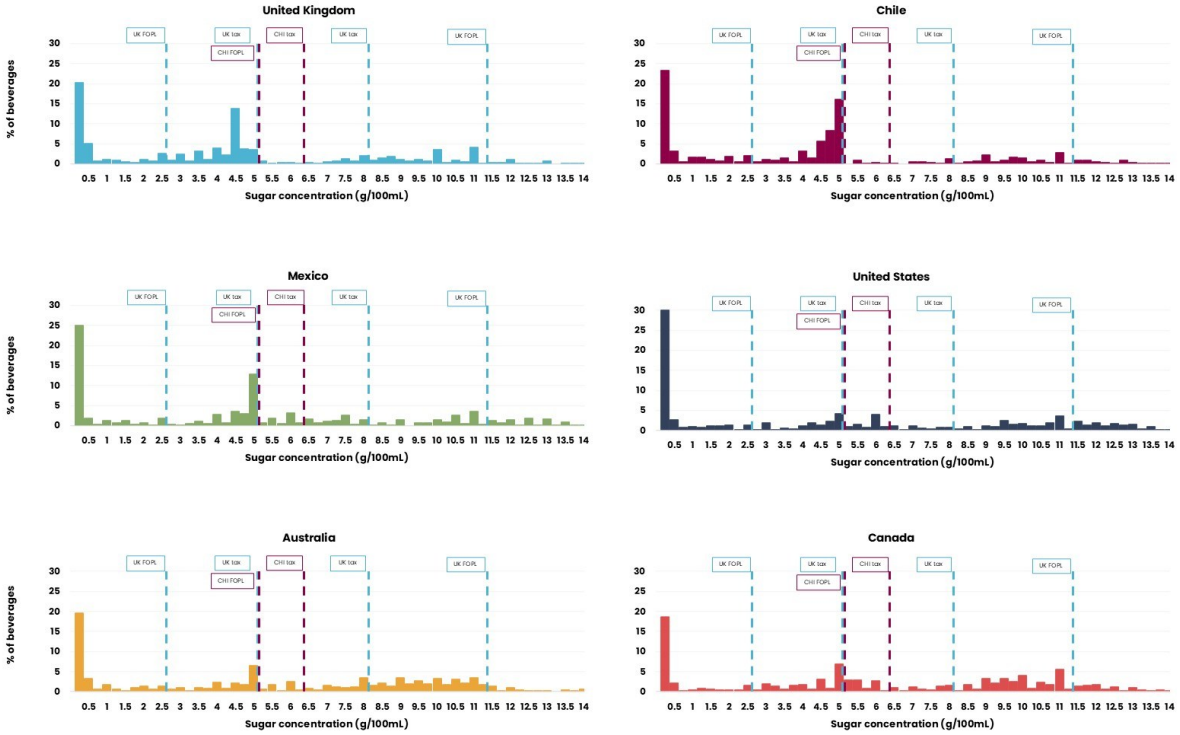
[a] Exempt: dairy & alternatives drinks category only. Not exempt: all categories other than dairy & alternatives drinks.

Figure C-1. Distribution of unique non-alcoholic, pre-packaged beverages by sugar-sweetened beverage tax and front-of-package sugar label thresholds, by country[a,b]

a) All beverages (N=15,640)



b) Carbonated/mixer drink category (N=3,386)



[a] Policy thresholds:
United Kingdom (UK) front-of-package nutrition label (FOPL): ≤2.5g/100mL (green label); >2.5 to ≤11.25g/100mL (yellow label); >11.25g/100mL (red label).
United Kingdom sugar-sweetened beverage (SSB) tax: <5g/100mL (untaxed); ≥5 to <8g/100mL (lower tax threshold); ≥8g/100mL (higher tax threshold).
Chile (CHI) front-of-package nutrition label: ≤5g/100mL (unlabeled); >5g/100mL (labeled).
Chile sugar-sweetened beverage tax: <6.25g/100mL (lower tax threshold); ≥6.25g/100mL (higher tax threshold).

[b] Beverages with sugar concentrations >14g/100mL are not shown (1.1% of all beverages) to assist with visual interpretation.

Table C-5. Distribution of non-alcoholic, pre-packaged beverages according to Chile's front-of-package sugar label, by country (N=15,640)

	Total sugar ≤5g/100mL (unlabeled)	**Total sugar >5g/100mL** (labeled)
Overall n=15,640	56.9% n=8,894	43.1% n=6,746
Country		
Chile n=1,242	76.4% n=949	23.6% n=293
United Kingdom n=2,598	69.7% n=1,811	30.3% n=787
Mexico n=1,588	59.8% n=950	40.2% n=638
United States n=5,841	54.4% n=3,180	45.6% n=2,661
Australia n=1,728	47.6% n=822	52.4% n=906
Canada n=2,643	44.7% n=1,182	55.3% n=1,461

Table C-6. Distribution of non-alcoholic, pre-packaged beverages according to Chile's sugar-sweetened beverage tax thresholds, by country (N=15,640)

	Overall		Not exempt from tax[a]		Exempt from tax[a]	
	Total sugar <6.25g/100mL (lower tax threshold)	**Total sugar ≥6.25g/100mL** (higher tax threshold)	**Total sugar <6.25g/100mL** (lower tax threshold)	**Total sugar ≥6.25g/100mL** (higher tax threshold)	**Total sugar <6.25g/100mL** (lower tax threshold)	**Total sugar ≥6.25g/100mL** (higher tax threshold)
Overall	63.5%	36.5%	60.7%	39.4%	73.8%	26.2%
n=15,640	n=9,926	n=5,714	n=7,455	n=4,837	n=2,471	n=877
Country						
Chile	78.2%	21.8%	74.5%	25.6%	90.6%	9.4%
n=1,242	n=971	n=271	n=711	n=244	n=260	n=27
United	71.6%	28.4%	72.0%	28.1%	69.9%	30.1%
Kingdom	n=1,859	n=739	n=1,511	n=589	n=348	n=150
n=2,598						
Mexico	67.1%	32.9%	66.9%	33.1%	67.4%	32.6%
n=1,588	n=1,065	n=523	n=711	n=352	n=354	n=171
United	62.9%	37.1%	60.2%	39.8%	78.2%	21.8%
States	n=3,675	n=2,166	n=2,981	n=1,973	n=694	n=193
n=5,841						
Canada	54.3%	45.7%	48.7%	51.3%	69.9%	30.1%
n=2,643	n=1,435	n=1,208	n=950	n=999	n=485	n=209
Australia	53.3%	46.7%	46.5%	53.5%	72.2%	27.8%
n=1,728	n=921	n=807	n=591	n=680	n=330	n=127

[a] Exempt: dairy & alternatives drinks category only. Not exempt: all categories other than dairy & alternatives drinks.

Appendix D – Chapter 4 supplementary material

Table D-1. Sweetener descriptors identified from ingredient lists in unique non-alcoholic, pre-packaged beverages from online retailer and brand websites, by country (N=15,994)[a]

	Overall % (n)	Australia % (n)	Canada % (n)	Chile % (n)	Mexico % (n)	United Kingdom % (n)	United States % (n)
Sugars							
Fruit juice concentrate	32.9% (n=5,257)	32.9% (n=693)	33.8% (n=903)	34.1% (n=418)	26.7% (n=417)	44.3% (n=1,146)	28.8% (n=1,680)
Sugar	27.9% (n=4,460)	31.1% (n=655)	35.0% (n=936)	29.9% (n=367)	35.6% (n=557)	33.8% (n=873)	18.4% (n=1,072)
Intrinsic milk sugar	18.4% (n=2,944)	23.4% (n=492)	21.4% (n=572)	21.0% (n=258)	26.5% (n=415)	15.1% (n=391)	14.0% (n=816)
High fructose corn syrup	8.6% (n=1,381)	0.0% (n=0)	0.9% (n=24)	1.1% (n=14)	8.8% (n=138)	0.0% (n=1)	20.6% (n=1,204)
Cane sugar	6.0% (n=964)	4.5% (n=95)	10.3% (n=274)	1.9% (n=23)	0.4% (n=6)	1.8% (n=47)	8.9% (n=519)
Maltodextrin	5.9% (n=945)	4.2% (n=89)	3.3% (n=88)	8.6% (n=106)	10.1% (n=158)	5.3% (n=136)	6.3% (n=368)
Fructose	4.1% (n=662)	1.3% (n=27)	1.7% (n=44)	4.5% (n=55)	18.3% (n=286)	8.3% (n=215)	0.6% (n=35)
Coconut intrinsic	3.4% (n=543)	2.5% (n=52)	3.0% (n=80)	1.7% (n=21)	2.4% (n=38)	4.5% (n=116)	4.0% (n=236)
Glucose-fructose	3.4% (n=536)	0.0% (n=0)	17.7% (n=474)	0.0% (n=0)	0.0% (n=0)	1.1% (n=28)	0.6% (n=34)
Sucrose	3.4% (n=541)	2.8% (n=59)	1.0% (n=27)	2.6% (n=32)	9.3% (n=145)	3.4% (n=87)	3.3% (n=191)
Glucose	2.5% (n=395)	3.4% (n=71)	1.9% (n=51)	1.6% (n=19)	2.9% (n=45)	3.6% (n=92)	2.0% (n=117)
Intrinsic plant milk sugar	1.6% (n=257)	3.2% (n=68)	1.2% (n=33)	0.2% (n=2)	0.5% (n=7)	3.0% (n=78)	1.2% (n=69)
Lactose	1.0% (n=152)	0.0% (n=0)	0.3% (n=9)	0.0% (n=0)	7.5% (n=117)	1.0% (n=26)	0.0% (n=0)
Malt	0.8% (n=134)	1.0% (n=21)	0.8% (n=22)	1.5% (n=18)	0.3% (n=4)	2.6% (n=66)	0.1% (n=3)
Caramel	0.6% (n=97)	0.5% (n=11)	1.2% (n=32)	1.1% (n=13)	0.8% (n=12)	1.0% (n=26)	0.1% (n=3)
Agave	0.4% (n=69)	0.4% (n=8)	0.1% (n=2)	0.0% (n=0)	0.0% (n=0)	0.2% (n=4)	0.9% (n=55)
Honey	0.4% (n=70)	0.5% (n=11)	0.4% (n=11)	0.0% (n=0)	0.1% (n=2)	0.1% (n=2)	0.8% (n=44)

Liquid sugar	0.4% (n=56)	0.0% (n=0)	0.3% (n=9)	0.0% (n=0)	0.0% (n=0)	0.8% (n=20)	0.5% (n=27)
Carob	0.3% (n=41)	0.0% (n=0)	0.2% (n=5)	0.2% (n=2)	0.8% (n=12)	0.5% (n=12)	0.2% (n=10)
Nectar	0.2% (n=29)	0.1% (n=2)	0.1% (n=2)	0.0% (n=0)	0.0% (n=0)	0.1% (n=2)	0.4% (n=23)
Allulose	0.2% (n=27)	0.0% (n=0)	0.0% (n=0)	0.2% (n=2)	0.5% (n=8)	0.0% (n=0)	0.3% (n=17)
Molasses	0.2% (n=29)	0.2% (n=4)	0.4% (n=10)	0.0% (n=0)	0.0% (n=0)	0.2% (n=5)	0.2% (n=10)
Rice syrup	0.1% (n=20)	0.5% (n=11)	0.0% (n=1)	0.0% (n=0)	0.0% (n=0)	0.1% (n=2)	0.1% (n=6)
Coconut sugar	0.1% (n=14)	0.1% (n=2)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.3% (n=7)	0.1% (n=5)
Demerara	0.1% (n=14)	0.1% (n=1)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.5% (n=13)	0.0% (n=0)
Beet sugar	0.1% (n=13)	0.0% (n=0)	0.1% (n=3)	0.0% (n=0)	0.0% (n=0)	0.2% (n=6)	0.1% (n=4)
Invert sugar	0.1% (n=8)	0.0% (n=0)	0.1% (n=2)	0.0% (n=0)	0.1% (n=2)	0.1% (n=2)	0.0% (n=2)
Brown sugar	0.0% (n=7)	0.1% (n=1)	0.0% (n=1)	0.0% (n=0)	0.0% (n=0)	0.0% (n=1)	0.1% (n=4)
Maple syrup	0.0% (n=5)	0.0% (n=0)	0.2% (n=5)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Trehalose	0.0% (n=4)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.2% (n=4)	0.0% (n=0)
Condensed milk	0.0% (n=4)	0.1% (n=1)	0.0% (n=1)	0.0% (n=0)	0.0% (n=0)	0.0% (n=1)	0.0% (n=1)
Isomaltulose	0.0% (n=3)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.1% (n=2)	0.0% (n=1)
Malted milk	0.0% (n=3)	0.0% (n=0)	0.0% (n=0)	0.2% (n=3)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Golden syrup	0.0% (n=2)	0.1% (n=2)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Oat syrup solids	0.0% (n=2)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.1% (n=2)	0.0% (n=0)
Tapioca syrup	0.0% (n=3)	0.1% (n=3)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Overall presence (% yes)[b]	79.8% (n=12,757)	82.2% (n=1,731)	84.8% (n=2,265)	79.3% (n=974)	80.3% (n=1,256)	82.6% (n=2,136)	75.3% (n=4,395)
Non-sugar sweetener							
Sucralose	22.3% (n=3,562)	9.8% (n=207)	8.7% (n=232)	50.4% (n=615)	31.8% (n=497)	31.0% (n=801)	20.7% (n=1,210)
Acesulfame K	19.4% (n=3,098)	11.7% (n=247)	9.3% (n=248)	25.8% (n=317)	30.4% (n=476)	27.9% (n=722)	18.6% (n=1,088)

Stevia	8.9% (n=1,426)	9.6% (n=202)	4.0% (n=107)	18.6% (n=228)	11.1% (n=173)	6.8% (n=176)	9.3% (n=540)
Aspartame	7.0% (n=1,116)	4.3% (n=90)	4.8% (n=128)	14.1% (n=173)	5.5% (n=86)	11.6% (n=301)	5.8% (n=338)
Monk fruit extract	1.2% (n=186)	0.4% (n=8)	0.7% (n=19)	0.0% (n=0)	0.2% (n=3)	0.0% (n=1)	2.7% (n=155)
Polydextrose	0.5% (n=86)	0.4% (n=8)	0.1% (n=2)	2.0% (n=25)	2.6% (n=40)	0.4% (n=11)	0.0% (n=0)
Saccharin	0.5% (n=78)	0.1% (n=1)	0.0% (n=0)	0.5% (n=6)	0.0% (n=0)	2.4% (n=63)	0.1% (n=8)
Cyclamate	0.5% (n=85)	3.1% (n=65)	0.0% (n=0)	1.0% (n=12)	0.0% (n=0)	0.3% (n=8)	0.0% (n=0)
Neotame	0.3% (n=46)	0.4% (n=8)	0.0% (n=0)	0.0% (n=0)	0.2% (n=3)	0.0% (n=1)	0.6% (n=34)
Neohesperidine dihydrochalcone	0.0% (n=4)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.2% (n=4)	0.0% (n=0)
Thaumatin	0.0% (n=2)	0.0% (n=0)	0.0% (n=0)	0.1% (n=1)	0.0% (n=0)	0.0% (n=1)	0.0% (n=0)
Advantame	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Alitame	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Aspartame acesulfame salt	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Brazzein	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Curculin	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Cweet	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Fructo-oligosaccharide	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Hernandulcin	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Mabinlin	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Miraculin	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Monatin	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Monellin	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Osladin	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Oubli	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0

Pentadin	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Phyllodulcin	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Overall presence (% yes)[b]	36.4% (n=5,821)	24.2% (n=509)	17.2% (n=459)	64.7% (n=795)	44.4% (n=694)	48.8% (n=1,262)	36.0% (n=2,102)
Sugar alcohol							
Erythritol	3.0% (n=473)	9.1% (n=191)	2.3% (n=61)	1.1% (n=14)	1.0% (n=15)	1.6% (n=41)	2.6% (n=151)
Sorbitol	0.1% (n=18)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.9% (n=14)	0.0% (n=0)	0.1% (n=4)
Maltitol	0.0% (n=5)	0.1% (n=2)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.1% (n=2)	0.0% (n=1)
Xylitol	0.0% (n=1)	0.0% (n=0)	0.0% (n=1)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Galactitol	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Hydrogenated starch	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Isomalt	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Lactitol	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Mannitol	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Polyglycitol	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0	0.0% n=0
Overall presence (% yes)[b]	3.1% (n=494)	9.2% (n=193)	2.3% (n=62)	1.1% (n=14)	1.9% (n=29)	1.7% (n=43)	2.6% (n=153)

[a] Sugar descriptors included added and intrinsic sugars. Intrinsic milk/plant milk sugar was identified from nutrition facts tables when total sugar>0g/100mL and ingredient lists did not include any form of sugar. Fruit juice concentrate was identified from juice, whole fruits, and wine.
[b] Overall use may not sum to the individual totals due to products containing multiple sweeteners.

Table D-2. Sweetener descriptors identified from ingredient lists in unique non-alcoholic, pre-packaged beverages from online retailer and brand websites, by category (N=15,994)[a]

	Overall % (n)	Coffee % (n)	Dairy % (n)	Energy % (n)	Juice % (n)	Low/no-alcohol % (n)	Soft drinks % (n)	Sports % (n)	Water % (n)
Sugars									
Fruit juice concentrate	32.9% (n=5,257)	3.6% n=18	7.1% n=246	14.2% n=125	75.7% n=3,717	46.3% n=127	16.7% n=580	8.5% n=59	21.1% n=385
Sugar	27.9% (n=4,460)	63.9% n=322	28.0% n=964	27.6% n=243	25.5% (n=1,253)	44.5% n=122	30.5% (n=1,058)	43.4% n=300	10.9% n=198
Intrinsic milk sugar	18.4% (n=2,944)	75.2% n=379	74.1% (n=2,551)	1.6% n=14	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
High fructose corn syrup	8.6% (n=1,381)	0.0% (n=0)	1.3% (n=45)	3.1% (n=27)	9.1% (n=445)	0.4% (n=1)	22.4% (n=777)	6.2% (n=43)	2.4% (n=43)
Cane sugar	6.0% (n=964)	14.5% (n=73)	8.5% (n=291)	1.1% (n=10)	6.1% (n=298)	2.6% (n=7)	4.8% (n=167)	6.1% (n=42)	4.2% (n=76)
Maltodextrin	5.9% (n=945)	13.9% (n=70)	9.7% (n=335)	20.9% (n=184)	1.0% (n=50)	5.5% (n=15)	0.6% (n=21)	33.1% (n=229)	2.3% (n=41)
Fructose	4.1% (n=662)	0.2% (n=1)	4.6% (n=158)	0.1% (n=1)	3.6% (n=175)	5.8% (n=16)	4.9% (n=168)	3.6% (n=25)	6.5% (n=118)
Coconut intrinsic	3.4% (n=543)	0.8% (n=4)	4.2% (n=146)	5.7% (n=50)	1.4% (n=69)	0.4% (n=1)	0.1% (n=5)	10.1% (n=67)	10.9% (n=198)
Glucose-fructose	3.4% (n=536)	0.0% (n=0)	0.9% (n=30)	3.3% (n=29)	4.6% (n=225)	1.5% (n=4)	6.4% (n=220)	3.2% (n=22)	0.3% (n=6)
Sucrose	3.4% (n=541)	0.4% (n=2)	3.7% (n=128)	14.2% (n=125)	1.3% (n=65)	1.1% (n=3)	3.4% (n=118)	12.6% (n=87)	0.7% (n=13)

Glucose	2.5% (n=395)	0.6% (n=3)	1.5% (n=53)	25.5% (n=225)	1.1% (n=52)	4.0% (n=1)	0.9% (n=32)	2.0% (n=14)	0.3% (n=5)
Intrinsic plant milk sugar	1.6% (n=257)	0.6% (n=3)	7.4% (n=254)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Lactose	1.0% (n=152)	0.2% (n=1)	4.3% (n=148)	0.0% (n=0)	0.0% (n=0)	1.1% (n=3)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Malt	0.8% (n=134)	0.2% (n=1)	0.5% (n=18)	0.0% (n=0)	0.1% (n=4)	29.2% (n=80)	0.8% (n=298)	0.0% (n=0)	0.1% (n=2)
Caramel	0.6% (n=97)	1.8% (n=9)	0.7% (n=25)	0.8% (n=7)	0.1% (n=3)	4.4% (n=12)	1.0% (n=33)	0.4% (n=3)	0.3% (n=5)
Agave	0.4% (n=69)	0.2% (n=1)	0.1% (n=4)	0.1% (n=1)	0.4% (n=20)	2.0% (n=5)	0.6% (n=21)	0.4% (n=3)	0.8% (n=14)
Honey	0.4% (n=70)	0.8% (n=4)	0.1% (n=4)	0.3% (n=3)	1.1% (n=52)	0.7% (n=2)	0.1% (n=4)	0.0% (n=0)	0.1% (n=1)
Liquid sugar	0.4% (n=56)	0.0% (n=0)	1.4% (n=47)	0.0% (n=0)	0.1% (n=5)	0.0% (n=0)	0.0% (n=0)	0.6% (n=4)	0.0% (n=0)
Carob	0.3% (n=41)	0.4% (n=2)	0.8% (n=26)	0.1% (n=1)	0.0% (n=0)	0.7% (n=2)	0.3% (n=10)	0.0% (n=0)	0.0% (n=0)
Nectar	0.2% (n=29)	0.2% (n=1)	0.1% (n=2)	0.0% (n=0)	0.2% (n=10)	0.0% (n=0)	0.0% (n=0)	0.4% (n=3)	0.7% (n=13)
Allulose	0.2% (n=27)	0.2% (n=1)	0.6% (n=22)	0.0% (n=0)	0.0% (n=2)	0.0% (n=0)	0.1% (n=2)	0.0% (n=0)	0.0% (n=0)
Molasses	0.2% (n=29)	0.4% (n=2)	0.0% (n=0)	0.0% (n=0)	0.3% (n=14)	0.0% (n=0)	0.2% (n=8)	0.7% (n=5)	0.0% (n=0)
Rice syrup	0.1% (n=20)	0.0% (n=0)	0.6% (n=20)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Coconut sugar	0.1% (n=14)	0.2% (n=1)	0.3% (n=8)	0.0% (n=0)	0.1% (n=5)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)

Demerara	0.1% (n=14)	2.8% (n=14)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Beet sugar	0.1% (n=13)	0.0% (n=0)	0.0% (n=0)	0.7% (n=6)	0.1% (n=5)	0.0% (n=0)	0.1% (n=2)	0.0% (n=0)	0.0% (n=0)
Invert sugar	0.1% (n=8)	0.0% (n=0)	0.1% (n=2)	0.1% (n=1)	0.1% (n=4)	0.0% (n=0)	0.0% (n=1)	0.0% (n=0)	0.0% (n=0)
Brown sugar	0.0% (n=7)	0.2% (n=1)	0.1% (n=2)	0.0% (n=0)	0.1% (n=4)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Maple syrup	0.0% (n=5)	0.0% (n=0)	0.0% (n=1)	0.0% (n=0)	0.0% (n=1)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.2% (n=3)
Trehalose	0.0% (n=4)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.2% (n=4)
Condensed milk	0.0% (n=4)	0.4% (n=2)	0.0% (n=1)	0.0% (n=0)	0.0% (n=1)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Isomaltulose	0.0% (n=3)	0.0% (n=0)	0.1% (n=2)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.1% (n=1)	0.0% (n=0)
Malted milk	0.0% (n=3)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	1.1% (n=3)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Golden syrup	0.0% (n=2)	0.0% (n=0)	0.1% (n=2)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Oat syrup solids	0.0% (n=2)	0.0% (n=0)	0.1% (n=2)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Tapioca syrup	0.0% (n=3)	0.0% (n=0)	0.1% (n=3)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Overall presence (% yes)[b]	79.8% (n=12,757)	89.5% (n=451)	95.3% (n=3,283)	60.9% (n=537)	93.9% (n=4,612)	94.5% (n=259)	66.5% (n=2,304)	77.0% (n=533)	42.6% (n=778)
Non-sugar sweetener									
Sucralose	22.3% (n=3,562)	8.9% (n=45)	13.0% (n=446)	67.5% (n=595)	20.1% (n=987)	4.7% (n=13)	20.9% (n=724)	33.5% (n=232)	28.5% (n=520)

Acesulfame K	19.4% (n=3,098)	6.4% (n=32)	5.4% (n=187)	53.3% (n=470)	10.8% (n=530)	1.5% (n=4)	36.9% (n=1,278)	30.5% (n=211)	21.2% (n=386)
Stevia	8.9% (n=1,426)	1.2% (n=6)	7.0% (n=242)	2.6% (n=23)	11.7% (n=572)	9.5% (n=26)	4.4% (n=152)	15.3% (n=106)	16.4% (n=299)
Aspartame	7.0% (n=1,116)	1.4% (n=7)	0.1% (n=3)	5.9% (n=52)	3.4% (n=169)	1.5% (n=4)	24.3% (n=840)	0.9% (n=6)	1.9% (n=35)
Monk fruit extract	1.2% (n=186)	5.0% (n=25)	2.0% (n=70)	0.1% (n=1)	0.8% (n=38)	0.7% (n=2)	0.1% (n=5)	0.0% (n=0)	2.5% (n=45)
Polydextrose	0.5% (n=86)	0.4% (n=2)	1.0% (n=34)	0.0% (n=0)	0.2% (n=10)	0.0% (n=0)	0.1% (n=4)	0.9% (n=6)	1.6% (n=30)
Saccharin	0.5% (n=78)	0.8% (n=4)	0.0% (n=0)	0.0% (n=0)	0.7% (n=35)	0.0% (n=0)	1.1% (n=39)	0.0% (n=0)	0.0% (n=0)
Cyclamate	0.5% (n=85)	1.4% (n=7)	0.0% (n=0)	0.0% (n=0)	0.1% (n=6)	0.0% (n=0)	1.6% (n=56)	0.0% (n=0)	0.9% (n=16)
Neotame	0.3% (n=46)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.5% (n=26)	0.0% (n=0)	0.3% (n=10)	0.0% (n=0)	0.6% (n=10)
Neohesperidine dihydrochalcone	0.0% (n=4)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.1% (n=4)	0.0% (n=0)	0.0% (n=0)
Thaumatin	0.0% (n=2)	0.0% (n=0)	0.0% (n=0)	0.2% (n=2)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Advantame	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Alitame	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Aspartame acesulfame salt	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Brazzein	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)

Curculin	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Cweet	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Fructo-oligosaccharide	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Hernandulcin	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Mabinlin	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Miraculin	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Monatin	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Monellin	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Osladin	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Oubli	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Pentadin	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Phyllodulcin	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Overall presence (% yes)[b]	36.4% (n=5,821)	18.1% (n=91)	18.4% (n=632)	74.6% (n=658)	33.6% (n=1,649)	15.0% (n=41)	46.9% (n=1,625	49.7% (n=344)	42.8% (n=781)
Sugar alcohol									
Erythritol	3.0% (n=473)	0.8% (n=4)	0.3% (n=11)	14.5% (n=128)	3.5% (n=171)	7.3% (n=20)	0.8% (n=28)	3.8% (n=26)	4.7% (n=85)

Sorbitol	0.1% (n=18)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.3% (n=14)	0.0% (n=0)	0.0% (n=1)	0.0% (n=0)	0.2% (n=3)
Maltitol	0.0% (n=5)	0.0% (n=0)	0.2% (n=5)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Xylitol	0.0% (n=1)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=1)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Galactitol	0.0% n=0	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=1)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Hydrogenated starch	0.0% n=0	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=1)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Isomalt	0.0% n=0	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=1)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Lactitol	0.0% n=0	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=1)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Mannitol	0.0% n=0	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=1)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Polyglycitol	0.0% n=0	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=1)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)	0.0% (n=0)
Overall presence (% yes)[b]	3.1% (n=494)	0.8% (n=4)	0.5% (n=16)	14.5% (n=128)	3.8% (n=186)	7.3% (n=20)	0.8% (n=29)	3.8% (n=26)	4.7% (n=85)

[a] Sugar descriptors included added and intrinsic sugars. Intrinsic milk/plant milk sugar was identified from nutrition facts tables when total sugar>0g/100mL and ingredient lists did not include any form of sugar. Fruit juice concentrate was identified from juice, whole fruits, and wine.

[b] Overall use may not sum to the individual totals due to products containing multiple sweeteners.

Appendix E – Chapter 5 supplementary material

Figure E-1. Examples of nutrition labelling formats for different serving size approaches

A) 'Per serving' for beverages with one serving

Nutrition information	
Serving Size	Per 1 bottle (500mL)
Energy	200kcal
Protein	0g
Total fat	0g
Carbohydrate	50g
Sugars	50g

B) 'Per serving' for beverages with multiple servings

Nutrition information	
Servings Per Container: 4 Serving Size: 250mL	
Energy	100kcal
Protein	0g
Total fat	0g
Carbohydrate	25g
Sugars	25g

C) ‘Per 100mL’ for beverages with multiple servings

Nutrition information	
Servings Per Container: 10	Per 100mL
Energy	40kcal
Protein	0g
Total fat	0g
Carbohydrate	10g
Sugars	10g

D) Both ‘per serving’ and ‘per 100mL’ for beverages with multiple servings

Nutrition information		
Servings Per Container: 4 Serving Size: 250mL		
	Per Serving	Per 100mL
Energy	100kcal	40kcal
Protein	0g	0g
Total fat	0g	0g
Carbohydrate	25g	10g
Sugars	25g	10g

Table E-1. Serving size formats of unique non-alcoholic, pre-packaged beverages from online retailer and brand websites (N=17,965)

	Both % n	'Per 100mL' % n	'Per serving' % n
Overall	31.9% n=5,731	12.0% n=2,155	56.1% n=10,079
Country			
Australia	89.1% n=2,561	6.6% n=191	4.3% n=124
Canada	0.0% n=0	0.5% n=16	99.5% n=3,046
Chile	80.9% n=1,015	4.5% n=56	14.6% n=183
Mexico	18.0% n=336	45.7% n=855	36.4% n=681
United Kingdom	63.5% n=1,808	36.3% n=1,034	0.2% n=5
United States	0.2% n=11	0.1% n=3	99.8% n=6,040
Category			
Coffee	27.1% n=150	13.7% n=76	59.1% n=327
Dairy & alternatives	34.6% n=1,399	19.0% n=768	46.4% n=1,876
Energy drink	35.0% n=339	10.6% n=103	54.3% n=526
Juice/juice drink	32.7% n=1,836	10.1% n=565	57.2% n=3,213
Low/no-alcohol	44.7% n=147	26.1% n=86	29.2% n=96
Carbonated/mixer drink	31.7% n=1,186	9.2% n=345	59.1% n=2,213
Sports drink	19.0% n=142	4.6% n=34	76.4% n=570
Water	27.0% n=532	9.0% n=178	63.9% n=1,258

Table E-23. Mean container size of unique non-alcoholic, pre-packaged beverages from online retailer and brand websites (N=26,552)

	Unadjusted mean (mL)	(St dev) (mL)
Country		
United Kingdom	699.7	534.6
Australia	794.5	638.1
United States	828.9	769.2
Mexico	858.4	792.2
Canada	926.5	812.8
Chile	946.0	752.2
Category		
Energy	409.7	158.7
Low/no alcohol	497.1	206.8
Coffee	563.8	433.5
Sports	683.4	309.8
Soft drinks	799.9	723.8
Water	800.2	755.7
Juice	911.1	746.5
Dairy & alternative	1,011.6	849.7
Store type		
Grocery store only	869.8	757.6
Brand only	806.5	737.1
Convenience store only	715.5	574.4
Grocery store and brand only	808.5	700.3
Grocery and convenience store only	731.5	506.1
Brand and convenience store only	709.3	490.7
All store types	708.0	631.7