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Beverage consumption among adults in Newfoundland and Labrador, Canada prior to the implementation of a sugar-sweetened beverage tax

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Abstract

Background Lawmakers in Newfoundland and Labrador (NL) recently passed Canada's first sugar-sweetened beverage (SSB) tax. SSB tax evaluations rely on detailed understandings of beverage consumption patterns prior to policy implementation, but there is no recent literature about such patterns among NL residents during the pre-tax period.

Methods We recruited a convenience sample of NL adults ages 19 and older and measured participant characteristics via online surveys and beverage intake via previously-validated, semi-quantitative beverage frequency questionnaires. We generated inverse probability weights of sample selection using the Canadian Census as a representative reference sample. We described the weighted prevalence and intake among consumers of taxable SSBs (e.g., regular pop), non-taxable SSBs (e.g., sweetened milk), diet (non-nutritive sweetened) beverages and unsweetened beverages (including 100% juice). We explored weighted bivariate associations between consumption of beverages and sociodemographic characteristics identified as potential correlates of SSB intake.

Results The sample ($n = 1233$) was 65% female, 57% between ages 30–59 years, and nearly all (94%) white. More than half (57.3%) consumed taxable SSBs weekly, and 23.2% consumed non-taxable SSBs weekly. The most-consumed (highest volume) taxable SSB was regular pop (weighted mean (SD) 2.3 (3.5) L/week); the most-consumed non-taxable SSB was sweetened, flavoured milk (mean (SD) 1.2 (2.0) L/week). We found independent differences in consumption patterns (prevalence, mean intake among consumers) across each beverage category. People who were younger, had fewer years of education, reported income below the poverty threshold, or reported experiencing food insecurity had a higher prevalence and mean intake among consumers of taxable SSBs. People with fewer years of education or those who reported experiencing food insecurity had a lower prevalence and mean intake among consumers of unsweetened beverages.

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Conclusions Our findings align with prior studies of socioeconomic position and SSB consumption in Canada, which collectively demonstrate that, on average, those with less education and income consume more SSBs and fewer unsweetened beverages. This research provides necessary understanding of social patterning of beverage consumption in NL prior to tax implementation. Post-tax evaluations of this policy should investigate potential impacts of the tax on diet and health equity, as well as potential beverage substitutions towards other beverage categories.

Keywords Sugar-sweetened beverage tax, Health equity, Canada

Background

Overconsumption of free or added sugars, defined as those added to any foods or beverages and those present in honey, syrup, and fruit juice, is associated with long term chronic health risks including cardiovascular disease, type 2 diabetes, and obesity [1]. Less than half of all Canadians meet the World Health Organization recommendation to consume fewer than 10% of total daily calories from free or added sugars, and only 5.4% meet the conditional recommendation for optimal nutrition to consume fewer than 5% of total daily calories from these sugars [2]. Sugar-sweetened beverages (SSBs) are the leading source of free or added sugars in the Canadian diet [3] and are thus a target for public health intervention.

Health taxes are a leading method to reduce SSB consumption and improve diet quality [4]. These taxes exist in more than 100 countries and are associated with decreases in purchasing and consumption, which, along with other policies focused on packaging, marketing, and availability, comprise a critical suite of public health interventions designed to reduce diet-related chronic diseases [4]. There is no current national SSB tax in Canada, but in 2022, Newfoundland and Labrador (NL) became the first province to introduce its own excise-type SSB tax. While the taxation policy was introduced through the provincial government's Department of Finance, the policy is promoted as an initiative to support health as the NL population has high incidences of both overweight (35.7%) and obesity (42.2%) [5], a large chronic disease burden [5], and highest per capita health care costs of all ten provinces in Canada. The NL SSB tax was introduced along with a public health messaging campaign titled "Rethink Your Drink" which aimed to promote water and other non-sugar-sweetened beverage options as the drink of choice [5]. The NL policy is an excise tax of \$0.20/litre imposed on SSB wholesalers based on their sales volume to retailers in the province; this tax is intended to be passed on fully from wholesalers to retailers, who receive no remittance with the expectation of passing the tax on to the consumer [5]. The policy applies to all ready-to-drink sugar-sweetened soft drinks (i.e. soda/pop), bottled/canned or dispensed; and sugar-sweetened concentrated drink products (i.e. frozen concentrated fruit drinks, powders, and flavoured

syrops). Beverages prepared at point-of-service with added sugar (e.g., blended coffee drinks) are not considered taxable; chocolate milk and 100% fruit juice are excluded from the policy [5].

The NL SSB tax is the first of its kind in Canada and data collection to assess its impact is ongoing. Still, baseline research on the target population, including their pre-tax beverage consumption patterns, is needed. In a recent review on SSB reduction policies, Krieger and colleagues (2021) specifically highlight the need for an initial understanding of the target population and the characteristics associated with beverage consumption as a way to guide subsequent implementation and evaluation research [6]. However, there is no data on SSB consumption in NL since the most recent Canadian Community Health Survey in 2015 (CCHS-2015), and therefore no understanding of beverage consumption in the immediate period leading up to the new tax [7]. Results from the CCHS-2015 indicated Canadians consumed, on average, more than 200mL of SSBs per day, with people in NL exceeding the national average by about 15% [7]. Therefore, the purpose of this study was to measure beverage consumption among adults in NL, and to explore associations between social and demographic characteristics and beverage consumption patterns, prior to SSB tax implementation.

Methods

Overview

This is a cross-sectional analysis of beverage consumption patterns and sociodemographic characteristics among adults ages 19 years and older residing in NL in August 2022, prior to the implementation of a SSB tax and related public outreach interventions on September 1, 2022. Two recruitment approaches were used to recruit study participants and collect survey data. The research team recruited a convenience sample (e.g. social media advertising, direct email) and administered the survey from Memorial University using an online survey and data collection software (QualtricsXM, Seattle, WA, USA). The research team also used a commercial research company (MQO Research, St. John's, Canada) to administer the same survey to an established consumer research panel on their survey software platform. All study participants provided informed consent prior to

completing the online survey and upon completing the survey, each participant was offered either a \$10 e-gift card or a equivalent honorarium from the commercial consumer research company. Additional details on our sampling strategy are available in the Supplement.

Demographic questionnaire

The demographic questionnaire captured information about participants' age (years), sex at birth (male/female), gender (male, female, non-binary, prefer not to say), education (some/all high school, some post-secondary, Bachelor's or more), employment status (currently vs. not currently working), annual household income, children in home (children under 18 years in home, children 18 years and older in home, no children in home), race and ethnicity (White, Black, East/Southeast Asian, South Asian, Latino/a, Middle Eastern, Indigenous Canadian, other), food security status (secure, marginal, moderate, severe) using the 18-item Household Food Security Survey Module (HFSSM) in the Canadian Income Survey (CIS) and the Canadian Community Health Survey (CCHS) [8, 9], height, and weight.

We report sex assigned at birth because fewer than 1% of respondents indicated a gender identity different than their sex. We categorized age in four categories (<30, 30–44, 45–59, 60+ years) and dichotomized race and ethnicity as White and non-White given extremely low (1–3%) proportions of responses for all non-White options. We categorized respondents' poverty status as either above or below \$50,000/year, which is the mid-point of the Statistics Canada 2022 Market Basket Measure thresholds for reference families in NL [10]. We combined marginal, moderate, and severe food security statuses to represent food insecure. Finally, we used self-reported height and weight to calculate individual body mass index (BMI, kg/m²) and categorized individuals as overweight or obese (BMI ≥ 25 kg/m²) versus not overweight or obese (BMI < 25 kg/m²).

Beverage consumption

Study participants reported their beverage intake during the past seven days using a validated, semi-quantitative beverage frequency questionnaire [11]. The beverage frequency questionnaire has been used extensively in survey-based research to evaluate food policies around the world through the International Food Policy Study [12]. Participants reported how many times in the past week they consumed each of the following beverages, respectively: regular soda/pop, diet soda/pop, 100% fruit juice, sweetened fruit drinks, low/no-calorie fruit drinks, tap water, plain bottled water, flavoured/sweetened water, low/no-calorie flavoured water, regular sports drinks, low/no-calorie sports drinks, regular energy drinks, diet energy drinks, unflavoured milk or milk alternatives,

flavoured/sweetened milk or milk alternatives, coffee, tea, specialty coffee drinks, sweetened smoothies/shakes, and unsweetened smoothies/shakes. Then, for each beverage respectively, participants selected the size of the cup, mug, can, bottle, or carton that corresponded to their usual intake amount, prompted by photographs of beverage containers and sizes in milliliters [11]. We calculated beverage consumption, in milliliters, during the past seven days, multiplying the frequency and volume reported for each beverage [11]. When participants reported less than the smallest size provided (i.e. less than 250 mL), we used a value of 50% of the volumes of the lowest serving size option presented to the participants [11]. Similarly, when participants reported consuming more than the greatest size, we used a value of 125% of the volume of the largest serving size option presented to the participants [11, 13]. For interpretability, we created four beverage categories and summed total intakes, in liters, within these categories:

1. Taxable SSBs (subject to the NL SSB tax): regular soda/pop, juice drinks, regular sports drinks, regular energy drinks, flavoured/sweetened water.
2. Non-taxable (SSBs not subject to the NL SSB tax): specialty coffee drinks, flavoured/sweetened milk, sweetened smoothies/shakes.
3. Diet beverages (sweetened with non-nutritive sweetener): diet soda/pop, diet flavoured water, diet juice drinks, diet sports drinks, diet energy drinks.
4. Unsweetened beverages (no added sugar or non-nutritive sweeteners): plain water, plain unflavoured milk, 100% fruit juice.

Statistical analysis

A trained research assistant reviewed all new survey entries daily to identify and remove duplicitous attempts using strategies identified as the most effective by Storozuk et al. (2020) [14]. Once the research team data and commercial research panel data were combined, we completed quality checks and reviewed the dataset for beverage intakes that would be considered improbable (e.g. excess of normal fluid intakes). We recoded beverage frequency variables as missing when the frequency of beverage consumption per week was greater than 100, a non-number (after hand-recoding write-in responses like "twice per week"), when the total beverage volume consumed per week exceeded 49 L, or when the total volume of water exceeded 36 L [11]. All remaining values of 0 were considered valid and used to categorize individuals as consumers (>0 beverages per week) and non-consumers (0 beverages per week).

We compared the demographic composition of our study sample to representative estimates of the contemporaneous adult population in NL using the 2021

Canadian Census Public Use Micro File, the 2021 Canadian Community Health Survey, and the 2021 Canadian Income Survey. Then, we weighted each study participant based on the inverse of their predicted probability of being selected into the study sample, thereby generating a pseudo-population with distributions of demographic

Table 1 Demographic characteristics of study sample before implementation of a sugar-sweetened beverage tax in Newfoundland and Labrador ($n = 1233$)

Characteristic	Study Sample		Representative Estimates, (%) ²
	Non-missing sample size, n (%) ¹	n (%)	
Age group			
19–29 years	1233 (100%)	237 (19.2%)	11.8%
30–44 years		308 (25.0%)	21.0%
45–59 years		397 (32.2%)	28.4%
60+ years		291 (23.6%)	38.7%
Sex assigned at birth			
Female	1225 (99.3%)	799 (65.2%)	51.6%
Male		426 (34.8%)	48.4%
Education			
Some/all high school	1223 (100%)	193 (15.8%)	56.4%
Some post-secondary		541 (44.2%)	27.0%
Bachelor's or more		489 (40.0%)	16.9%
Employment status			
Currently working	1217 (99.5%)	715 (58.7%)	47.1%
Not currently working		502 (41.3%)	52.9%
Poverty status³			
Below poverty threshold	1117 (91.3%)	370 (33.1%)	30.6%
Above poverty threshold		747 (66.9%)	69.4%
Food security status⁴			
Food secure	1187 (96.3%)	728 (61.3%)	77.5%
Not food secure		459 (38.7%)	22.5%
Race/Ethnicity⁵			
White	1215 (99.3%)	1140 (93.8%)	90.4%
Non-white		75 (6.2%)	9.6%
Overweight/obesity status⁶			
Overweight/obese	1064 (87.0%)	757 (71.1%)	74.9%
Not overweight/obese		307 (28.9%)	25.1%

¹Total sample size within the specific measured characteristic without missing data; proportion of total study sample $n = 1233$

²Sources: 2021 Canadian Census (age, sex, education, employment, poverty status, race/ethnicity); 2021 Canadian Income Survey (food security status); 2021 Canadian Community Health Survey (overweight/obesity status). Additional notes on methodology are available in the supplement

³Based on self-reported annual income and Statistics Canada 2022 Market Basket Measure thresholds for reference families in Newfoundland and Labrador

⁴Calculated using Statistics Canada Household Food Security Survey Module; food insecure includes marginal (9%), moderate (19%), and severe (12%) food insecurity

⁵All self-reported non-white categories collapsed due to very small cell sizes; include 2.3% Indigenous, 1.5% East/Southeast Asian, 1% Black, and < 1% each South Asian, Latino/a, Middle Eastern, or those who reported “other”

⁶Based on BMI calculated from self-reported height and weight; respondents with BMI ≥ 25 kg/m² considered to have overweight or obesity

characteristics similar to a representative sample of adults in NL at the same time as our study [15–17] (Supplement).

We summarized unweighted and weighted means and standard deviations, frequencies, and proportions of all demographic and beverage intake data. Then, we calculated the frequency and proportion (unweighted and weighted) of the study population who reported any consumption within each beverage category, and the weekly mean and standard deviation (unweighted and weighted) of consumption within each beverage category among those who reported any consumption. Finally, we explore bivariate associations between sociodemographic characteristics and beverage consumption in two parts: first, within each sociodemographic variable, we analyzed associations in the prevalence of weekly consumption (any versus none) for each beverage category using weighted Pearson χ^2 tests; second, we analyzed mean (95% CI) differences in the average weekly consumption, in liters, of each beverage category, among those who reported any consumption, using weighted Wilcoxon rank-sum tests for sociodemographic variables with two groups and weighted Kruskal-Wallis tests for those with more than two groups. For all tests, we set an a priori $\alpha = 0.05$ threshold for statistical significance. The results from these tests are unadjusted and should be interpreted cautiously and used for generating, rather than confirming, relevant hypotheses. We conducted all analyses using R statistical software 4.2.2 (R Foundation for Statistical Computing, Vienna, Austria). We conducted two sensitivity analyses. First, we excluded questions related to coffee or tea made at home due to limited data on the type or amount of sweetener individuals added to these beverages. Excluding these beverages from our analyses reduced the overall estimates of total weekly beverage intake, but made no impact on any comparisons of beverage consumption by demographic characteristics (results not shown). We further excluded 100% juice from the “Unsweetened beverages” category and re-ran all analyses, likewise noting limited impacts on any findings (results not shown). We therefore exclude all questions related to coffee or tea made at home, and retain 100% juice within the “Unsweetened beverages” category.

Results

Sample characteristics

The study sample ($n = 1233$) was 65.2% female, over half (57.2%) were between 30 and 59 years old, and nearly all (93.8%) were white (Table 1). Most (84.2%) had some post-secondary or more education, and 58.7% were currently working. Two-thirds of the sample had annual household income above the poverty threshold, 61.3% were food secure, and most (71.7%) lived without children in the home. The majority (71.1%) of the study

population were classified as overweight or obesity. Our study sample was overall younger and more educated, with a higher proportion of females and people currently employed, compared to the general NL population. Nearly half (48.3%) of the study sample was recruited through the commercial panel.

Beverage consumption, overall

Study participants had the highest prevalence of weekly consumption of unsweetened beverages (86.3%), and the lowest prevalence of non-taxable SSB consumption (weighted 23.2%) (Table 2). More than half (weighted 57.3%) consumed taxable SSBs weekly, and just under half (weighted 47.7%) consumed diet beverages weekly. Participants consumed on average approximately 9.1 L of unsweetened beverages per week, the majority of which came from plain water. The most-consumed taxable SSB was regular pop, at a weighted mean (SD) 2.3 (3.5) L/week; diet pop was the most-consumed diet beverage at a mean (SD) 2.7 (4.4) L/week). The most-consumed

non-taxable SSB was sugar-sweetened flavoured milk at a weighted mean (SD) 1.2 (2.0) L/week.

Beverage consumption and demographic characteristics

The weekly prevalence of consuming taxable SSBs was independently associated with age, education, employment, income, and food security (Table 3). Younger (19–29 years) people had a 75.6% weighted prevalence of weekly consumption of taxable SSBs, compared to 65.3%, 48.9%, and 43.9% among those ages 30–44, 45–59, and 60+, respectively ($p < 0.001$). People with fewer years of education had a higher weighted prevalence of weekly taxable SSB consumption (60.2% some/all high school, 57.1% some post-secondary, 53.8% Bachelor's or more, $p = 0.003$), as did those who were currently working (60.7% vs. 53.2% among those not working, $p = 0.008$). People living below the poverty threshold had a higher weighted prevalence of weekly taxable SSB consumption (62.8% vs. 55.1% living above, $p = 0.011$), and those who reported experienced food insecurity also had a higher

Table 2 Weekly beverage consumption among adults ages 19 years and older before implementation of a sugar-sweetened beverage tax in Newfoundland and Labrador

Beverage	Proportion of study sample who reported any weekly consumption, n (%)	Weighted proportion ¹	Weekly consumption, liters, among those who reported any consumption, mean (SD)	Weighted mean (SD) ¹
Sugar-sweetened beverages subject to tax²	696 (56.4%)	57.3%	2.6 (3.4)	3.0 (4.0)
Regular soda/pop	547 (47.2%)	49.6%	2.1 (3.1)	2.3 (3.5)
Sugar-sweetened juice drinks	226 (19.5%)	19.1%	0.9 (1.2)	1.0 (1.4)
Sugar-sweetened sports drink	148 (12.8%)	14.1%	1.4 (1.4)	1.5 (1.9)
Sugar-sweetened flavoured water	94 (8.1%)	8.2%	1.8 (2.4)	2.2 (2.9)
Sugar-sweetened energy drinks	67 (5.8%)	5.9%	1.5 (1.9)	1.3 (1.6)
Sugar-sweetened beverages not subject to tax³	286 (23.2%)	22.0%	1.3 (1.9)	1.4 (1.9)
Blended, sugar-sweetened coffee drink	157 (13.5%)	12.7%	1.0 (9.4)	1.1 (1.4)
Sugar-sweetened, flavoured milk	116 (10.0%)	10.5%	1.4 (2.5)	1.2 (2.0)
Sugar-sweetened smoothies	69 (6.0%)	5.8%	1.0 (1.3)	0.9 (1.1)
Diet beverages⁴	606 (49.1%)	47.7%	3.1 (3.8)	3.6 (5.1)
Diet soda/pop	471 (40.6%)	39.8%	2.5 (3.5)	2.7 (4.4)
Diet, flavoured water	141 (12.2%)	11.2%	2.5 (3.2)	3.4 (5.0)
Diet juice drinks	100 (8.6%)	7.6%	1.0 (1.1)	1.0 (1.2)
Diet sports drink	83 (7.2%)	6.9%	1.8 (1.9)	1.8 (1.9)
Diet energy drinks	47 (4.1%)	4.3%	1.5 (1.5)	1.3 (1.4)
Unsweetened beverages⁵	1096 (88.9%)	86.3%	9.2 (7.4)	9.1 (8.1)
Plain water (tap)	791 (68.6%)	63.1%	8.6 (7.4)	8.4 (7.8)
Plain water (bottle)	498 (43.0%)	44.0%	4.2 (4.6)	4.7 (6.0)
Plain, unflavoured milk (all fat types)	424 (36.6%)	36.2%	1.5 (1.7)	1.6 (2.4)
100% Fruit Juice	473 (40.8%)	41.9%	0.9 (1.1)	0.9 (0.9)

¹Inverse probability weights calculated for each study participant using 2021 Canadian Census. See supplement for additional methodological details for calculating these weights

²Includes ready-to-drink beverages and prepared dispensed beverages that contain added sugars (e.g. sugar, fructose, glucose, glucose-fructose, sucrose, honey, molasses, syrups etc.), including sugar-sweetened soda/pop, fountain drinks, juice drinks, sweetened waters, sports drinks, energy drinks, iced teas, and lemonades. Does not include beverages made at point-of-service

³Includes sweetened milks and point-of-service smoothies and blended coffee drinks made on site

⁴Includes all beverages containing non-nutritive (non-caloric) sweeteners and no caloric sweeteners

⁵Includes all beverages with no added sugars or sweeteners and 100% fruit juice which contains free but not added sugars

Table 3 Unadjusted associations between select demographic characteristics and prevalence weekly beverage consumption among adults ages 19 years and older before implementation of a sugar-sweetened beverage tax in Newfoundland and Labrador ($n = 1233$)

Age group	SSBs subject to the tax ¹				SSBs not subject to the tax ²				Diet beverages ³				Unsweetened beverages ⁴			
	n (%)	wt. % ⁵	p ⁶	n (%)	wt. % ⁵	p ⁶	n (%)	wt. % ⁵	n (%)	wt. % ⁵	p ⁶	n (%)	wt. % ⁵	p ⁶	n (%)	wt. % ⁵
19–29 years	172 (72.6%)	75.6%	<0.001	83 (35.0%)	32.9%	<0.001	112 (47.3%)	45.7%	0.289	0.029	0.029	220 (92.8%)	91.1%	0.029	220 (92.8%)	91.1%
30–44 years	200 (64.9%)	65.3%		94 (30.5%)	29.3%		159 (51.6%)	51.6%				275 (89.3%)	86.4%		275 (89.3%)	86.4%
45–59 years	198 (49.9%)	48.9%		72 (18.1%)	16.6%		203 (51.1%)	48.6%				348 (87.7%)	82.8%		348 (87.7%)	82.8%
60+ years	126 (43.3%)	43.9%		37 (12.7%)	12.1%		132 (45.4%)	44.3%				253 (86.9%)	86.3%		253 (86.9%)	86.3%
Sex assigned at birth																
Female	432 (54.1%)	55.7%	0.221	208 (26.0%)	23.9%	0.034	423 (52.9%)	50.9%	0.003	0.008	0.008	723 (90.5%)	88.2%	0.008	723 (90.5%)	88.2%
Male	256 (60.1%)	59.3%		76 (17.8%)	18.7%		180 (42.3%)	42.3%				366 (85.9%)	82.8%		366 (85.9%)	82.8%
Education																
Some/all high school	118 (61.1%)	60.2%	0.003	39 (20.2%)	19.2%	<0.001	84 (43.5%)	43.7%	0.055	<0.001	<0.001	154 (79.8%)	79.5%	<0.001	154 (79.8%)	79.5%
Some post-secondary	309 (57.1%)	57.1%		102 (18.9%)	18.9%		265 (49.0%)	49%				471 (87.1%)	87.1%		471 (87.1%)	87.1%
Bachelor's or more	263 (53.8%)	53.8%		143 (29.2%)	29.2%		254 (51.9%)	51.9%				465 (95.1%)	95.1%		465 (95.1%)	95.1%
Employment status																
Currently working	423 (59.2%)	60.7%	0.008	185 (25.9%)	25.0%	0.003	376 (52.6%)	51.8%	0.002	<0.001	<0.001	653 (91.3%)	90.2%	<0.001	653 (91.3%)	90.2%
Not currently working	263 (52.4%)	53.2%		96 (19.1%)	18.1%		225 (44.8%)	43.2%				431 (85.9%)	81.9%		431 (85.9%)	81.9%
Poverty status⁷																
Below poverty threshold	225 (60.8%)	62.8%	0.011	89.0 (24.1%)	22.8%	0.939	168 (45.4%)	43.2%	0.017	<0.001	<0.001	306 (82.7%)	80.8%	<0.001	306 (82.7%)	80.8%
Above poverty threshold	411 (55.0%)	55.1%		179 (24.0%)	23.0%		384 (51.4%)	50.4%				690 (92.4%)	90.7%		690 (92.4%)	90.7%
Food security status⁸																
Food secure	374 (51.2%)	51.3%	<0.001	163 (22.3%)	20.9%	0.462	367 (50.3%)	50.4%	0.067	0.033	0.033	656 (89.9%)	88.1%	0.033	656 (89.9%)	88.1%
Not food secure	311 (63.7%)	63.5%		117 (24.0%)	22.6%		235 (48.2%)	45.1%				427 (87.5%)	83.8%		427 (87.5%)	83.8%
Overweight/obesity status⁹																
Overweight/obese	427 (56.3%)	56.8%	0.508	160 (21.1%)	18.6%	0.014	406 (53.6%)	52.4%	<0.001	<0.001	<0.001	671 (88.5%)	85.2%	<0.001	671 (88.5%)	85.2%
Not overweight/obese	176 (57.5%)	59.0%		74 (24.2%)	25.3%		107 (35.0%)	32.4%				275 (89.9%)	87.9%		275 (89.9%)	87.9%

¹Includes ready-to-drink beverages and prepared dispensed beverages that contain added sugars (e.g. sugar, fructose, glucose, glucose-fructose, sucrose, honey, molasses, syrups etc.), including sugar-sweetened soda/pop, fountain drinks, juice drinks, sweetened waters, sports drinks, energy drinks, iced teas, and lemonades. Does not include beverages made at point-of-service

²Includes sweetened milks and point-of-service smoothies and blended coffee drinks made on site

³Includes all beverages containing non-nutritive (non-caloric) sweeteners and no caloric sweeteners

⁴Includes all beverages with no added sugars or sweeteners and 100% fruit juice which contains free but not added sugars

⁵Inverse probability weights calculated for each study participant using 2021 Canadian Census. See supplement for additional methodological details for calculating these weights

⁶Unadjusted p -value from weighted Pearson's chi-squared test of group differences

⁷Based on self-reported annual income and Statistics Canada 2022 Market Basket Measure thresholds for reference families in Newfoundland and Labrador

⁸Calculated using Statistics Canada Household Food Security Survey Module; food insecure includes marginal (9%), moderate (19%), and severe (12%) food insecurity

⁹Based on BMI calculated from self-reported height and weight; respondents with BMI ≥ 25 kg/m² considered to have overweight or obesity

weighted prevalence of weekly taxable SSB consumption (63.5% vs. 51.3% food secure, $p < 0.001$).

In general, the weekly prevalence of consuming non-taxable SSBs was inversely associated with age, higher among females (23.9% vs. 18.7%, $p = 0.034$), positively associated with education (19.2% some/all high school, 18.9% some post-secondary, 29.2% Bachelor's or more, $p < 0.001$), and higher among those currently working (25.0% vs. 18.1% not working, $p = 0.003$) and those who did not have overweight or obesity (25.3% vs. 18.6% with overweight or obesity, $p = 0.014$). The weekly prevalence of consuming diet beverages was higher among females (50.9% vs. 42.3%, $p = 0.003$), those currently employed (51.8% vs. 43.2% not currently employed, $p = 0.002$), those living above the poverty threshold (50.4% vs. 43.2%, $p = 0.017$), and lower among those without overweight or obesity (32.4% vs. 52.4%, $p < 0.001$). The weekly prevalence of consuming unsweetened beverages was independently associated with all of our measured demographic characteristics except for weight status, and was higher among younger people, females, individuals with more education, those working, individuals living above the poverty threshold, and those with food security.

There were several differences in the weighted average volume of beverages consumed, among those who reported any consumption (Table 4). Notably, there were gradients of beverage intakes associated with education level. Study participants with a Bachelor's degree or more consumed significantly more unsweetened beverages (mean [95% CI] = 9.9 [9.2–10.5] L/week) than was consumed by those with some post-secondary education (9.2 [8.5, 9.8]) and those with some/all high school (7.7 [6.5–8.8]) ($p < 0.001$). Conversely, participants with a Bachelor's degree or more consumed significantly less taxable SSBs (1.8 [1.5–2.1]) than that consumed by those with some post-secondary education (2.9 [2.5–3.3]) and those with some or all high school (3.8 [3.0–4.6]) ($p < 0.001$). Individuals living below the poverty threshold consumed a mean (95% CI) 3.6 (2.9–4.4) L/week of taxable SSBs, compared to 2.5 (2.1–2.9) L/week among those living above the poverty threshold ($p = 0.022$). Similarly, those who reported having food security had a lower mean (95% CI) intake of taxable SSBs (2.4 [2.0–2.8] L/week) compared to that consumed by those who reported experiencing food insecurity (3.5 [2.9–4.2] L/week, $p < 0.001$).

Discussion

In this cross-sectional analysis, we described beverage consumption patterns among weighted, non-probability sample adults living in NL prior to the implementation of Canada's first SSB tax. More than half of study participants regularly consumed taxable SSBs, with an average weekly intake of more than 3 L. We found a variety of independent, unadjusted associations between

sociodemographic characteristics and the prevalence and mean intake of taxable SSBs, non-taxable SSBs, unsweetened beverages, and diet beverages.

Individuals with less education, those living below the poverty threshold, and those experiencing food insecurity had a higher prevalence of regularly consuming taxable SSBs. These characteristics were also associated with decreased prevalence of consuming unsweetened beverages weekly. In general, our findings align with prior national studies of socioeconomic position (SEP) and SSB consumption in Canada, which collectively demonstrate that, on average, those with lower knowledge and material resources consume more SSBs and fewer unsweetened beverages [7, 18]. Researchers have previously observed this sociodemographic patterning of beverage intake, and more broadly, of overall diet quality, with consistent evidence that individuals and communities with lower SEP may have less healthy dietary intake with subsequent increases in chronic health outcomes [19, 20]. The mechanisms to explain this social patterning of diet quality include neighbourhood characteristics of the local food environment, like the availability (or lack thereof) of healthy foods and beverages [21], and the overall cost of healthier versus less healthy diets [22]. High density of corner or convenience stores in NL and low access to full-service grocery stores or supermarkets, particularly in rural areas, may contribute to the increased consumption of SSBs among individuals with lower SEP [23]. There is some evidence to suggest that healthier beverages are more expensive than less healthy beverages in NL [24], and this may additionally contribute to our observed social patterning of beverage consumption; of particular note, many areas of NL were under a boil water advisory during this baseline study and this may further contribute to a decrease in water consumption among those living in affected areas [25]. At the time of this research, upwards of 130 communities in NL had current boil water advisories, affecting an estimated 83,350 people - approximately 15% of the province's population. In future research, we intend to assess the contribution of living in these affected areas to the likelihood of consuming SSBs, and how the SSB tax may have differential impacts based on water quality issues. There is emerging evidence that SSB taxes may be an effective intervention to reduce health inequities by having an outsize impact on the dietary quality of communities with lower socioeconomic status [26, 27]. Future evaluations of Canada's first SSB tax in NL should specifically focus on its potential to improve health equity.

The prevalence of SSB consumption in Canada was estimated to be 56% by a national survey using the same validated beverage frequency questionnaire in 2017, which is consistent with our findings in NL [28]. The total volume of SSBs among Canadian consumers was found

Table 4 Unadjusted associations between select demographic characteristics and weekly beverage consumption (volume) among adults ages 19 years and older who reported any consumption before implementation of a sugar-sweetened beverage tax in Newfoundland and Labrador ($n = 1233$)

Characteristic	SSBs subject to the tax ¹		SSBs not subject to the tax ²		Diet beverages ³		Unsweetened beverages ⁴	
	Wt. mean (95% CI) ⁵	p^6	Wt. mean (95% CI) ⁵	p^6	Wt. mean (95% CI) ⁵	p^6	Wt. mean (95% CI) ⁵	p^6
Age group								
19–29 years	3.0 (2.3, 3.8)	0.007	1.0 (0.7, 1.2)	0.383	2.8 (2.2, 3.4)	0.009	9.2 (8.1, 10.4)	0.678
30–44 years	3.6 (2.8, 4.4)		1.7 (1.2, 2.3)		3.7 (2.9, 4.5)		9.1 (7.9, 10.2)	
45–59 years	3.0 (2.3, 3.6)		1.9 (0.5, 3.3)		3.6 (2.8, 4.4)		9.0 (8.1, 9.9)	
60+ years	1.8 (1.4, 2.3)		1.2 (0.8, 1.7)		2.3 (1.8, 2.8)		8.1 (7.2, 9.0)	
Sex assigned at birth								
Female	2.8 (2.4, 3.3)	0.215	1.5 (1.0, 2.1)	0.440	3.0 (2.6, 3.4)	0.150	9.2 (8.6, 9.9)	0.084
Male	3.2 (2.6, 3.9)		1.3 (1.0, 1.6)		3.5 (2.8, 4.3)		8.3 (7.5, 9.1)	
Education								
Some/all high school	3.8 (3.0, 4.6)	<0.001	1.9 (0.8, 3.0)	0.759	3.50 (2.7, 4.3)	0.262	7.7 (6.5, 8.8)	<0.001
Some post-secondary	2.9 (2.5, 3.3)		1.4 (1.0, 1.8)		3.0 (2.6, 3.4)		9.2 (8.5, 9.8)	
Bachelor's or more	1.8 (1.5, 2.1)		1.2 (1.0, 1.4)		3.0 (2.5, 3.5)		9.9 (9.2, 10.5)	
Employment status								
Currently working	2.8 (2.4, 3.2)	0.577	1.3 (1.0, 1.6)	0.333	3.4 (3.0, 3.8)	0.002	8.9 (8.2, 9.6)	0.978
Not currently working	3.1 (2.4, 3.8)		1.7 (0.7, 2.7)		2.9 (2.2, 3.6)		8.7 (8.0, 9.5)	
Poverty status⁷								
Below poverty threshold	3.6 (2.9, 4.4)	0.022	2.0 (1.0, 3.0)	0.010	3.3 (2.5, 4.2)	0.488	7.9 (7.0, 8.8)	0.001
Above poverty threshold	2.5 (2.1, 2.9)		1.1 (0.9, 1.3)		3.2 (2.8, 3.5)		9.3 (8.7, 10.0)	
Food security status⁸								
Food secure	2.4 (2.0, 2.8)	<0.001	1.4 (0.8, 2.1)	0.402	3.1 (2.6, 3.5)	0.330	9.1 (8.4, 9.8)	0.427
Not food secure	3.5 (2.9, 4.2)		1.5 (1.1, 1.9)		3.4 (2.8, 3.9)		8.7 (7.9, 9.5)	
Overweight/obesity status⁹								
Overweight/obese	3.1 (2.6, 3.6)	0.668	1.5 (1.2, 1.9)	0.426	3.4 (2.9, 3.9)	0.006	8.9 (8.3, 9.5)	0.452
Not overweight/obese	2.9 (2.2, 3.5)		1.7 (0.5, 2.9)		2.2 (1.7, 2.6)		8.6 (7.6, 9.6)	

¹Includes ready-to-drink beverages and prepared dispensed beverages that contain added sugars (e.g. sugar, fructose, glucose, glucose-fructose, sucrose, honey, molasses, syrups etc.), including sugar-sweetened soda/pop, fountain drinks, juice drinks, sweetened waters, sports drinks, energy drinks, iced teas, and lemonades. Does not include beverages made at point-of-service

²Includes sweetened milks and point-of-service smoothies and blended coffee drinks made on site

³Includes all beverages containing non-nutritive (non-caloric) sweeteners and no caloric sweeteners

⁴Includes all beverages with no added sugars or sweeteners and 100% fruit juice which contains free but not added sugars

⁵Inverse probability weights calculated for each study participant using 2021 Canadian Census. See supplement for additional methodological details for calculating these weights

⁶Unadjusted p -value from weighted Wilcoxon rank-sum test (for variables with two groups) or Kruskal-Wallis tests (for those with > 2 groups)

⁷Based on self-reported annual income and Statistics Canada 2022 Market Basket Measure thresholds for reference families in Newfoundland and Labrador

⁸Calculated using Statistics Canada Household Food Security Survey Module; food insecure includes marginal (9%), moderate (19%), and severe (12%) food insecurity

⁹Based on BMI calculated from self-reported height and weight; respondents with BMI ≥ 25 kg/m² considered to have overweight or obesity

to be lower by Vanderlee and coauthors (2.2 L) than our study in NL (3.0 L) which likely reflect the higher intakes of SSB in NL compared to Canada [7, 28]. Notably, our results and those of Vanderlee and colleagues [28] are more closely aligned than estimates of mean beverage intake among Canadians using data from the CCHS-2015 [7]. This is due to two main methodological differences between our study and the Vanderlee et al. study [28] compared to the Jones et al. analysis of CCHS-2015 beverage intake [7]: first, CCHS collects intake data using a 24-hour recall and therefore corresponds to usual *daily* intake, whereas the Beverage Frequency

Questionnaire measures intake across a 7-day period and therefore corresponds to usual *weekly* intake. Interpolating weekly intake from a 24-hour recall may not be valid when assessing episodically consumed beverages like SSBs. Furthermore, the CCHS-2015 analysis included all respondents (including those with values of 0) and therefore corresponds to a population-average intake, whereas our analysis of mean intake is limited to those with any consumption (> 0) and corresponds to the average *among consumers*.

We categorized SSBs in this study as either taxable or non-taxable, since the NL policy covers some but not

all SSBs. For example, the World Health Organization defines any beverage with free or added sugars as an SSB, including 100% fruit juice and sweetened milks [1], but the NL policy does not tax these beverages. On average, study participants consumed about 1.5 L per week of non-taxable SSBs including sweetened milks, blended coffee drinks, and blended smoothies, representing a likely high source of free or added sugars in the diet of NL residents. This baseline understanding of non-taxable SSB consumption is an important contribution to the literature as it may inform future changes to the SSB tax legislation that may capture a broader array of less healthy beverages. Globally, most SSB taxes do not apply to these beverages [4], and this may be for several reasons: first, consumption of sweetened milks may have a modest association with increased adiposity and weight gain, but may also contribute to consumption of vitamin D and calcium (and other micronutrients depending on fortification policies in different jurisdictions), which are both public health nutrients of interest [29]. Second, SSBs prepared at point-of-purchase (e.g. smoothies, specialty coffees) may vary widely in their added sugar content, representing a potential challenge in applying taxes at points of purchase [4], and there is some experimental evidence to suggest that consumption of these beverages increase when they are not targeted by taxes [30]. In this study, consumption of specialty coffees and smoothies was relatively low, compared to the SSBs targeted by the tax. Still, it is critical to monitor substitution effects that may occur when consumers shift their purchasing from taxed to non-taxed SSBs [31, 32].

One emerging area of SSB tax evaluation is the potential impact of consumers substituting taxed SSBs for beverages with non-nutritive sweeteners (“diet” drinks) [33]. The negative health impacts of SSB consumption are in part mediated by increased caloric intake (overconsumption) and therefore this substitution may have short-term benefits for individuals at higher risk for metabolic disorder, including those with overweight and obesity or type 2 diabetes [34]. In one recent randomized controlled trial, adults with overweight or obesity enrolled in a weight-loss program had similar weight loss when substituting SSBs for diet drinks or water [35], but there is evidence from prospective cohort studies that diet beverage consumption during childhood or adolescence increases risks of overall and central adiposity [36, 37]. Our study was limited to adults, and those with overweight or obesity had a higher weekly prevalence and consumption of diet beverages compared to those without overweight or obesity. Future research should focus on substitution effects, particularly within children and adolescents.

Our findings are the first to describe beverage consumption in NL prior to the implementation of the SSB tax, and provide a necessary baseline understanding for

future estimations of how the tax differentially impacts those living in the province. Collecting beverage consumption data prior to the implementation of the tax and examining social patterns of this consumption is a key step to elucidate potential unintended consequences of the policy and examine its potential to impact dietary health inequalities [26]. For example, our findings collectively suggest an inverse relation between socioeconomic position and taxable SSB consumption in NL, which may lead to a greater reduction of SSB consumption among individuals who are already disproportionately impacted by dietary health inequalities. We also measured non-taxable SSBs, diet, and unsweetened beverages in the pre-implementation period to allow for an examination of post-tax substitution effects. However, our findings should be interpreted cautiously within the context of several limitations. First, our convenience sampling strategy may introduce self-selection bias: individuals with strong opinions about the forthcoming (at the time of the survey participation) SSB tax in NL or those with a greater interest in diet or health may have been more likely to choose to participate. Further, the online nature of the survey may have reduced participation from certain groups with poor access to the internet or data, or challenges accessing or using electronics. Our use of inverse-probability weighting to adjust our sample to more closely reflect a generalizable NL population likely reduces many of these biases. Second, we present unadjusted associations between sociodemographic characteristics and beverage consumption to generate hypotheses, and do not consider our findings confirmatory of any *a priori* hypothesis. We used the NL reference family (4 members) as our threshold for determining poverty status, which may not accurately represent the households of all members in our study. Still, examining these unadjusted associations in the period immediately preceding tax implementation is critical to the design of post-tax evaluations, specifically when considering potential effect measure modifiers of the tax effect. Finally, the data we collected in this study does not assess the level of understanding or adherence of the participants to the Canada Food Guide (CFG-2019) recommendation for water as the drink of choice for Canadians or the Government of NL “Rethink Your Drink” education program. The CFG-2019 does not promote the consumption of any beverage other than water and these recommendations were in existence for 3 years prior to our study. The “Rethink Your Drink” education program was released at the same time the tax was implemented with very little awareness prior to its launch. Therefore, the impact of these positive nutrition education programs on beverage selection is also a contributing factor to individual beverage choice that is not discernible from the impact of the SSB tax as behavior modifying tool. However, our data were

collected prior to this communication campaign. Future research should make use of both dietary intake data as well as available retail sales data to evaluate changes to individual and population-level beverage intake after the tax.

Conclusions

The prevalence of sugar-sweetened beverage consumption in NL prior to the implementation of Canada's first SSB tax was high, with 57.3% of adults reporting weekly consumption of taxable beverages (soda/pop, juice drinks, sweetened waters, sports drinks, energy drinks) and 22.0% reporting weekly consumption of non-taxable (flavoured milks, specialty coffee drinks, smoothies) beverages. There were sociodemographic differences in the prevalence and average consumption of these beverages, with a higher consumption of taxable beverages among young adults, individuals with high school education or less, and those living below the poverty threshold or experiencing food insecurity. Post-tax evaluations of this policy should consider the social patterning of beverage consumption prior to implementation when measuring potential impacts on health inequalities, as well as potential unintended consequences of beverage substitutions towards non-taxed SSBs.

Abbreviations

SSBs	Sugar-sweetened beverages
NL	Newfoundland and Labrador
CFG	Canada food guide
WHO	World health organization
SEP	Socioeconomic position

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Author contributions

D.A.Z.: Methodology, Formal analysis, Writing—Original draft preparation; R.P.: Conceptualization, Methodology, Funding acquisition, Supervision, Project administration, Writing—Review & Editing; Y.Y.: Conceptualization and Methodology, Writing—Review & Editing; J.O'D.: Data collection, Preliminary analysis, Writing—Review & Editing Methodology; S.V.H.: Conceptualization, Methodology, Funding acquisition, Supervision, Project administration, Writing—Review & Editing.

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Data availability

The datasets generated and/or analysed during the current study are not currently publicly available due to data privacy concerns. Requests for access to data can be made directly to the corresponding authors and will be evaluated on a case-by-case basis until the final data set is archived in a repository.

Declarations

Ethics approval and consent to participate

This study protocol was reviewed and approved by the Interdisciplinary Committee on Ethics in Human Research at Memorial University (ICEHR Number 20222081-SC).

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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