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Original Research

Sweetener Purchases in Chile before and after Implementing a Policy for Food Labeling, Marketing, and Sales in Schools

Natalia Rebolledo [1], Maxime Bercholz [2], Linda Adair [1,2], Camila Corvalán [3], Shu Wen Ng [1,2], Lindsey Smith Taillie [1,2,*]

[1] *Department of Nutrition, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA;* [2] *Carolina Population Center, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA;* [3] *Institute of Nutrition and Food Technology (INTA), University of Chile, Macul, Chile*

A B S T R A C T

Background: Chile's landmark food labeling and advertising policy led to major reductions in sugar purchases. However, it is unclear whether this led to increases in the purchases of nonnutritive sweeteners (NNS).

Objectives: The objective of this study was to assess the changes in NNS and caloric-sweetened (CS) products purchased after the law's first phase.

Methods: Longitudinal data on food and beverage purchases from 2,381 households collected from January 1, 2015 to December 31, 2017, were linked to nutritional information and categorized into added sweetener groups (unsweetened, NNS-only, CS-only, or NNS with CS). Logistic random-effects models and fixed-effects models were used to compare the percentage of households purchasing products and the mean volume purchased by sweetener category to a counterfactual based on pre-regulation trends.

Results: Compared with the counterfactual, the percentage of households purchasing any NNS beverages (NNS-only or NNS with CS) increased by 4.2 percentage points (pp) (95% CI: 2.8, 5.7; $P < 0.01$). This increase was driven by households purchasing NNS-only beverages (12.1 pp, 95% CI: 10.0, 14.2; $P < 0.01$). The purchased volume of beverages with any NNS increased by 25.4 mL/person/d (95% CI: 20.1, 30.7; $P < 0.01$) or 26.5%. Relative to the counterfactual, there were declines of -5.9 pp in households purchasing CS-only beverages (95% CI: −7.0, −4.7; $P < 0.01$). Regarding the types of sweeteners purchased, we found significant increases in the amounts of sucralose, aspartame, acesulfame K, and steviol glycosides purchased from beverages. Among foods, differences were minimal.

Conclusions: The first phase of Chile's law was associated with an increase in the purchases of beverages containing NNS and decreases in beverages containing CS, but virtually no changes in foods.

Keywords: nonnutritive sweeteners, sweetening agents, non-caloric sweeteners, artificial sweeteners, low-calorie sweeteners, sugar, food labeling, front-of-package labels, Latin America

Introduction

Front-of-package nutrient warning labels (FOPWL) are a recommended strategy by the World Health Organization (WHO) and the Pan American Health Organization to prevent obesity and noncommunicable diseases [1, 2]. FOPWL can help consumers identify foods high in nutrients of concern, such as sugars, sodium, and saturated fats, and discourage their consumption. Chile was the first country to implement this type of policy in June 2016, along with other policies such as restrictions on marketing directed at children aged <14 y and prohibition of school sales of foods and beverages with FOPWL [3]. Worldwide, several countries have implemented or are implementing similar labeling policies, including Mexico, Uruguay, Peru, Brazil, Colombia, and Argentina [4–9].

Most countries with a FOPWL policy have included a warning on sugars to cut sugar consumption and incentivize reformulation. However, as of 2022, only the Mexican and Argentinian

Abbreviations: CS, caloric sweeteners; FOPWL, front-of-package nutrient warning labels; NFP, nutrition facts panel; NNS, nonnutritive sweeteners.

* Corresponding author. *E-mail address:* taillie@unc.edu (L.S. Taillie).

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policies included a warning on sugars and a separate label on nonnutritive sweeteners (NNSs). Thus, one central question is whether regulations that do not require FOPWL for NNS lead to a reduction in added sugars and a concomitant increase in NNS purchases.

NNS are food additives that are commonly used as the primary substitute for sugars in reformulation because they provide a sweet taste, but they only contribute a few calories when added to foods or beverages [10, 11]. According to systematic reviews and meta-analyses, replacing sugar intake with NNS has been associated with reductions in body weight, body mass index, and fasting blood glucose among individuals with obesity [12–14]. However, some scholars have expressed concerns regarding the potential health harms associated with NNS intake. For example, recent experimental studies have suggested that NNS intake could also be associated with reductions in insulin sensitivity in adults [15–17] and alterations in the gut microbiota, which could lead to glucose intolerance [18]. Additionally, some cohort studies have reported that the intake of NNS or NNS-sweetened beverages is positively associated with weight gain and increased body mass index [19]. However, it is difficult to disentangle these associations from potential confounders or reverse causation.

After implementation of the Chilean policy, purchases of "high-in" products declined, along with calories and total sugars from those purchases [20, 21]. Additionally, there was a decrease in the proportion of "high-in sugar" products in the food supply because of reformulation [22], and the prevalence of NNS in packaged products increased [23]. However, we do not know whether there were similar changes in NNS purchases or how purchases of products combining caloric sweeteners (CS) and NNSs have changed after the policy.

The Chilean law provides a unique opportunity to understand how FOPWL policies affect purchases of sweeteners because it was the first law of its kind and because Chile is one of the only countries in the world to require reporting of NNS amounts on food labels. We aimed to estimate the differences in the percentage of households purchasing unsweetened, calorically sweetened, and NNS-sweetened products after implementing the first phase of the law.

Methods

Participants

This study used longitudinal data on household food and beverage purchases from a panel of households located in urban areas of Chile with more than 20,000 inhabitants. The data were collected from 1 January, 2015, to 31 December, 2017, by Kantar WorldPanel Chile (for more information on Kantar, please contact Maria Paz Roman at http://kantar.worldpanel.com). The analytic sample included 2,381 unique households, with a mean follow-up period of 35 mo, providing 67,890 household-month observations (Supplemental Figure 1).

Enumerators visited households weekly to collect information on food and beverage purchases by scanning barcodes, collection of receipts, household pantry inventories, and product packaging checks. Data collected on each purchase included volume (mL) or weight (g), barcode, price per unit, retail channel, brand, package size, and date. Data were aggregated and analyzed at the household-monthly level.

For these analyses, all data collected between 1 January, 2015, and 30 June, 2016, were defined as the pre-implementation of phase 1 of the law, and all data collected between 1 July, 2016, and 31 December, 2017, as the postimplementation of phase 1 of the law.

Ethics

The ethics committee of the Institute of Nutrition and Food Technology of the University of Chile approved this study. This study was exempt from review by the University of North Carolina, Chapel Hill Institutional Review Board because the study used secondary, de-identified data.

The Chilean law

The implementation of the Chilean Food Labeling and Advertising Law (hereinafter, "the law") began in June 2016 (phase 1). The law requires packaged foods and beverages with added sugar, sodium, or saturated fat and exceeding set thresholds for these nutrients or overall calorie content to carry FOPWL with the words "high in" calories, sugars, saturated fats, or sodium [3]. The foods and beverages subject to the law are also subject to restrictions in the use of child-directed marketing techniques. They are also prohibited from sale on school grounds. The law was implemented in 3 phases, with increasingly restrictive nutrient thresholds for solid and liquid products implemented in June 2018 (phase 2) and June 2019 (phase 3) (Supplemental Table 1). In phase 1, the sugars limits were 22.5 g per 100 g of solid foods or 6 g per 100 mL of liquids.

Chilean nutrition facts panel (NFP) data

The NFP database contained nutrition information for packaged foods and beverages in the Chilean food supply. These data were obtained from photographs of products collected in Santiago in 2015, 2016, and 2017 [24]. NFP data were linked to household food and beverage purchases at the product level and reviewed by a team of dietitians [20, 21]. We linked purchases to the 2015-2016 NFP for the pre-law period and the 2017 NFP for the post-law period.

NNS types

The NFP data included the amounts of 8 NNS in packaged foods because in Chile, it is mandatory to declare the added amounts of acesulfame K, aspartame, cyclamate, saccharin, sucralose, steviol glycosides, alitame, and neotame [25]. Alitame and neotame were excluded from the analyses because they were not commonly used in packaged products [23, 26].

Food group categorization and added sweetener status

Each food and beverage purchased was categorized into food groups (Supplemental Table 2). We excluded salty snacks, candy, and dried nuts because of inconsistent data collection by Kantar over time. We also excluded vegetable oils, baby food, and formula because they were not NNS sources [27]. We categorized foods and beverages into 4 mutually exclusive groups based on added sweeteners using the ingredient list of each product and specific search terms as follows (Supplemental Table 3): *1*)

unsweetened if they did not contain any added sweetener, *2*) calorically sweetened (CS) only if they included any ingredient considered added sugar according to the law, *3*) NNS-only if they included NNS, but no added sugars, and *4*) NNS and CS if they contained both types of sweeteners as added ingredients. We also created an alternate category called "any NNS," which included NNS-only products and products with both added NNS and CS.

Outcomes

We analyzed foods and beverages separately because the law had different cut-points for solids and liquids. Our primary outcomes were the percentages of households purchasing any products in each added sweetener category (unsweetened, CS only, NNS-only, CS and NNS, and any NNS). The secondary outcomes were the volume of foods (grams/person/day) and beverages (milliliters/person/day) purchased by sweetener category and NNS type.

Covariates

As in previous evaluations of Chile's law [20, 21], covariates included household characteristics such as the head of household's educational level (less than high school, high school, and more than high school), household assets index (continuous variable based on the number of rooms, bathrooms, and cars), and household composition (a set of discrete variables treated as continuous variables, each with the number of people in the following age categories: children 0–1 y, children 2–5 y, children 6–13 y, adolescents 14–18 y, female adults >18 y, and male adults >18 y). Monthly region-level unemployment rates from the Chilean National Institute of Statistics were included as a contextual measure [28]. We included indicator variables for each calendar month [1-12] to adjust for seasonality and a linear time trend (monthly intervals). In random-effects models, we included the region as a covariate because temperatures vary greatly by region in Chile, and there could be regional differences in the purchases of certain products, particularly beverages.

Statistical analyses

All statistical analyses were conducted using Stata 16 (College Station). We preregistered the analysis plan on September 30, 2021, in the Open Science Framework (https://osf.io/uc74w). We defined statistical significance at $P < 0.05$.

Descriptive and unadjusted analyses

We examined the sociodemographic characteristics of households participating in Kantar WorldPanel Chile from 2015 to 2017. We also compared the unadjusted mean volume of foods and beverages purchased by added sweetener category using ordinary least squares to obtain clustered standard errors.

Adjusted analyses

Because the Chilean policy was implemented nationally, we used a pre-post quasi-experimental modeling approach to study the law's impact. Similar to previous evaluations [20, 21], we constructed a counterfactual (a hypothetical scenario) to understand what the post-policy purchases may have looked like if the policy had not been implemented. Our specifications included a binary variable for the policy period (pre vs. post) and its interaction with the linear time trend (to allow for both level and trend changes). We constructed the counterfactuals by predicting purchases in the post-policy period based on pre-policy trends. Consistent with previous evaluations, we included 18 months of data before and after the policy was implemented [20, 21].

We estimated the absolute and relative differences between the predicted value and the counterfactual in the post-policy period for all counterfactuals. 95% confidence intervals (95% CI) and *P* values for the absolute differences were derived using standard errors obtained by the Delta method.

Noting that the policy could influence decisions on whether to purchase specific products and the amount, we predicted counterfactual for the proportion of buyers and mean purchases.

Counterfactual proportion of buyers

We used random-effects logit models to estimate the differences in the proportion of buyers in the post-policy period. We used our models to compare the non-counterfactual predicted proportion of buyers by added sweetener category in the post-policy period to their counterfactuals (evaluated holding the policy indicator to its pre-policy value).

Counterfactual mean volume purchased

We used fixed-effects models to estimate the mean differences in the volumes of products purchased by the sweetener category. We compared the mean volume purchased in the post-policy period to the counterfactual. We also conducted these analyses for the quantity purchased by NNS type.

Sensitivity analyses

Because a large proportion of monthly purchases did not include any NNS products, we repeated our counterfactual analyses of purchased volumes, excluding household-month observations with a purchase volume of zero for the outcome in question.

Exploratory analyses

Given that CS and NNS intake is particularly discouraged in children [29, 30], we repeated the analyses for changes in the volume of our primary and secondary outcomes in a subsample of households with children younger than 14 y (n = 1,490 households and 38,153 household-months). We selected 14 y as the age cut-point based on the definition of children by the Chilean law [3].

Results

Sociodemographic characteristics

From 2015 to 2017, the percentage of households with lower educational levels decreased, whereas those with higher educational levels increased (Table 1). We also observed a slight decrease in the percentage of households in the Santiago Region.

Unadjusted results

Beverages

Before the law, the percentage of households who purchased beverages with any NNS was 89.8%. Most households purchased beverages with a combination of NNS and CS (81.1%), followed

TABLE 1
Sociodemographic characteristics of the Kantar WorldPanel analytical sample from 2015 to 2017

	2015	2016	2017
No. of households	2,099	2,076	2,099
No. of HH-month observations	22,896	22,881	22,113
Head of HH education, *n* (%)			
<High school	652 (31%)	584 (28%)	575 (27%)
High school	793 (38%)	820 (39%)	815 (39%)
College or greater	654 (31%)	672 (32%)	709 (34%)
Household assets index, *n* (%)			
Low	788 (38%)	750 (36%)	781 (37%)
Middle	635 (30%)	648 (31%)	649 (31%)
High	676 (32%)	678 (33%)	669 (32%)
Region, *n* (%)			
Santiago	915 (44%)	905 (44%)	877 (42%)
Valparaiso	225 (11%)	222 (11%)	258 (12%)
Central South	240 (11%)	243 (12%)	244 (12%)
Bio-Bio	230 (11%)	221 (11%)	238 (11%)
South	248 (12%)	250 (12%)	258 (12%)
North	241 (11%)	235 (11%)	224 (11%)
Household composition, mean ± SD			
Children 0–1 y	0.12 ± 0.35	0.08 ± 0.28	0.03 ± 0.19
Children 2–5 y	0.34 ± 0.58	0.33 ± 0.57	0.34 ± 0.58
Children 6–13 y	0.53 ± 0.72	0.53 ± 0.71	0.54 ± 0.72
Children, female, age 14–18 y	0.18 ± 0.44	0.17 ± 0.41	0.16 ± 0.39
Children, male, age 14–18 y	0.17 ± 0.41	0.17 ± 0.41	0.18 ± 0.43
Women, >18 y	1.53 ± 0.73	1.55 ± 0.76	1.60 ± 0.80
Men, >18 y	1.21 ± 0.78	1.22 ± 0.81	1.28 ± 0.84
Monthly regional unemployment rate, mean ± SD	6.3 ± 1.0	6.5 ± 1.2	6.7 ± 1.1

by NNS-only (51.4%). After the law, the percentage of households who purchased beverages sweetened with any NNS increased by 2.8 percentage points (pp from now on, $P < 0.01$), respectively (Supplemental Table 4). Before the law, most households purchased unsweetened and CS-only beverages (87.2% and 92.9%, respectively).

Foods

Before the law, the percentage of households who purchased foods with any NNS was 85.4%. Most households purchased foods with a combination of NNS and CS (82.8%), whereas only 23.8% of households purchased NNS-only foods. After the law, we observed an increase of 3.9 pp in the percentage of households purchasing foods sweetened with any NNS (Supplemental Table 4). Before the law, 99.2% of households purchased unsweetened foods. Interestingly, before the law, purchases of CS-only foods were nearly universal (99.8% of households, respectively).

Adjusted analyses

Proportion of buyers

Compared with the counterfactual, the proportion of households purchasing beverages containing any NNS increased by 4.2 pp (95% CI: 2.8, 5.7; $P < 0.01$) or a relative increase of 4.8% (Table 2). This difference was driven primarily by the increase in households purchasing NNS-only beverages (12.1 pp or a relative increase of 23.1%; 95% CI: 10.0, 14.2; $P < 0.01$), followed by beverages containing NNS and CS (4.6 pp or a relative increase of 5.9%; 95% CI: 2.8, 6.4; $P < 0.01$). The proportion of households purchasing unsweetened beverages decreased by 2.0 pp (95% CI: −3.3, −0.6; $P < 0.01$) or a relative reduction of 2.2%. The proportion of households purchasing CS-only beverages decreased by 5.9 pp (95% CI: −7.0, −4.7; $P < 0.01$) or a relative reduction of 6.4%.

The proportion of households purchasing any NNS foods decreased by 2.1 pp (95% CI: −3.1, −1.1; $P < 0.01$) or a relative reduction of 2.3% compared with the counterfactual. Underlying this decrease were reductions in the proportion of households purchasing NNS-only foods (−5.0 pp or a relative reduction of 17.3%; 95% CI: −7.1, −3.0; $P < 0.01$) and NNS and CS foods (−1.7 pp or a relative reduction of 1.9%; 95% CI: −2.8, −0.6; $P < 0.01$).

Volume purchased

The results for the mean volume purchased by the sweetener categories mirrored the results for the percentages of buyers, except for foods containing both NNS and CS.

When compared with the counterfactual, the volume of beverages containing any NNS increased by 25.4 mL/person/d (95% CI: 20.1, 30.7; $P < 0.01$) or 26.5% (Table 3). Most of the increase occurred in beverages with both NNS and CS, followed by NNS-only beverages. The volume of beverages containing NNS and CS increased by 17.3 mL/person/d (95% CI: 13.0, 21.6; $P < 0.01$) or 28.8%, whereas the volume of NNS-only beverages increased by 8.2 mL/person/d (95% CI: 4.9, 11.4; $P < 0.01$) or 22.7%. The volume of unsweetened beverages decreased by 31.3 mL/person/d (95% CI: −39.8, −22.8; $P < 0.01$) or 17.2%, and CS-only beverage purchases decreased by 11.1 mL/person/d (95% CI: −17.6, −4.7; $P < 0.01$) or 7.8%. For the total volume of beverage purchases, the mean decreased by 17.1 mL/person/d (95% CI: −29.7, −4.5; $P = 0.01$) or 4.1%.

The differences for food purchases were statistically significant but extremely small in magnitude. The purchased volume of foods containing any NNS decreased by 1.0 g/person/d (95% CI: −1.8, −0.2; $P = 0.02$) or 4.8%. Changes in the volume of NNS-only food purchases and foods containing both NNS and CS were minimal and inconsequential (<1g). The volume purchased of unsweetened foods decreased by 2.8 g/person/d (95% CI: −4.7, −1.0; $P < 0.01$) or a relative reduction of 4.5%.

Quantities purchased by NNS type

Among beverages, the largest increases were observed for sucralose, aspartame, acesulfame K, and steviol glycosides (Supplemental Table 5). Compared with the counterfactual, sucralose from beverages increased by 3.0 mg/person/d (95% CI: 2.7, 3.4; $P < 0.01$) or 83.6%. Aspartame increased by 2.7 mg/person/d (95% CI: 1.3, 4.0; $P < 0.01$) or 14.5%, and acesulfame

TABLE 2
Mean differences between the observed adjusted postpolicy and estimated adjusted counterfactual postpolicy purchases for the percentage of household buying by sweetener category

	Counterfactual	Predicted	Absolute difference (95% CI)[1]	*P* value	Relative difference
Beverages (% buyers)					
Unsweetened	88.3%	86.3%	−2.0 (−3.3, −0.6)	<0.01	−2.2
CS[2] only	92.0%	86.1%	−5.9 (−7.0, −4.7)	<0.01	−6.4
NNS[3] only	52.4%	64.5%	12.1 (10.0, 14.2)	<0.01	23.1
NNS and CS	78.0%	82.6%	4.6 (2.8, 6.4)	<0.01	5.9
Any NNS	88.0%	92.2%	4.2 (2.8, 5.7)	<0.01	4.8
Foods (% buyers)					
Unsweetened	99.3%	98.7%	−0.6 (−1.0, −0.3)	<0.01	−0.6
CS only	99.8%	99.7%	−0.1 (−0.3, 0.1)	0.24	−0.1
NNS-only	29.2%	24.2%	−5.0 (−7.1, −3.0)	<0.01	−17.3
NNS and CS	89.1%	87.4%	−1.7 (−2.8, −0.6)	<0.01	−1.9
Any NNS	91.3%	89.2%	−2.1 (−3.1, −1.1)	<0.01	−2.3

Estimates derived from random-effects logit models comparing postpolicy buyers with counterfactual postpolicy buyers based on pre-policy trends. Purchase data obtained from Kantar WorldPanel Chile.
[1] Absolute difference is percentage point difference.
[2] CS, caloric sweetener.
[3] NNS, nonnutritive sweetener.

TABLE 3
Mean differences between the observed adjusted postpolicy and estimated adjusted counterfactual postpolicy purchases for the grams and volume purchased by sweetener category

	Counterfactual	Predicted	Absolute difference (95% CI)	*P* value	Relative difference
Beverages (mL/person/d)					
Unsweetened	182.4	151.1	−31.3 (−39.8, −22.8)	<0.01	−17.2
CS[1] only	142.4	131.3	−11.1 (−17.6, −4.7)	<0.01	−7.8
NNS[2] only	36.0	44.1	8.2 (4.9, 11.4)	<0.01	22.7
NNS and CS	60.1	77.3	17.3 (13.0, 21.6)	<0.01	28.8
Any NNS	96.0	121.5	25.4 (20.1, 30.7)	<0.01	26.5
Overall	420.9	403.8	−17.1 (−29.7, −4.5)	0.01	−4.1
Foods (g/person/d)					
Unsweetened	62.4	59.6	−2.8 (−4.7, −1.0)	<0.01	−4.5
CS only	77.6	79.1	1.5 (−0.8, 3.8)	0.19	1.9
NNS-only	1.4	1.2	−0.2 (−0.4, −0.02)	0.03	−14.1
NNS and CS	20.0	19.2	−0.8 (−1.6, −0.03)	0.04	−4.1
Any NNS	21.4	20.4	−1.0 (−1.8, −0.2)	0.02	−4.8
Overall	161.4	159.1	−2.3 (−6.1, 1.4)	0.22	−1.5

Estimates derived from fixed-effects models comparing postpolicy milliliters or grams purchased with counterfactual postpolicy milliliters or grams purchased based on pre-policy trends. Purchase data obtained from Kantar WorldPanel Chile.
[1] CS, caloric sweetener.
[2] NNS, nonnutritive sweetener.

K increased by 1.3 mg/person/d (95% CI: 0.7, 1.9; $P < 0.01$) or 14.6%. Steviol glycosides increased by 0.4 mg/person/d (95% CI: 0.3, 0.5; $P < 0.01$) or 59.5%.

Among foods, we found increases for sucralose and acesulfame K, whereas cyclamate decreased. Compared with the counterfactual, sucralose from foods increased by 3.1 mg/person/d (95% CI: 1.2, 4.9; $P < 0.01$) or 20.0%, and acesulfame K increased by 0.2 mg/person/d (95% CI: 0.1, 0.3; $P < 0.01$) or 51.1%. Cyclamate decreased by 3.6 mg/person/d (95% CI: −6.8, −0.3; $P = 0.03$) or 88.8%.

Sensitivity analyses

When we restricted the sample to households that had any NNS purchases, we observed slightly different results for the volume purchased for foods and beverages compared with the main analyses. Regarding beverage purchases, the decline observed in CS-only and the increase in NNS-only beverage purchases were no longer statistically significant (Supplemental Table 6). For CS-only beverages, the difference between the predicted and the counterfactual volume purchased was −6.6 (95% CI: −13.3, 0.1) compared with our main analyses estimate of −11.1 (95% CI: −17.6, −4.7). For NNS-only beverages, the difference between the predicted and the counterfactual volume purchased was 5.5 (95% CI: −0.1, 11.1) compared with our main analyses estimate of 8.2 (95% CI: 4.9, 11.4).

Exploratory analyses in a subsample of households with children aged <14 y

The results for households with children younger than 14 y were consistent with the main findings in the overall sample (Supplemental Table 7). One of the notable differences in the magnitude of the results was observed for CS-only beverages. The difference between the predicted and the counterfactual

volume purchased in CS-only beverages was −15.3 (95% CI: −22.2, −8.4), which is a larger decline compared with the main analyses estimate of −11.1 (95% CI: −17.6, −4.7).

Discussion

To our knowledge, this is the first study to examine the changes in purchases of sweetened products after the implementation of the Food Labeling and Advertising Law. After the law, we found an increase in the percentages of households who purchased NNS-only beverages and beverages with both NNSs and CSs, relative to a counterfactual constructed from pre-law trends. At the same time, there was a decrease in the percentage of households who purchased unsweetened and CS-only beverages. Among foods, there were slight declines in the percentage of buyers and mean volume purchased for all sweetener categories relative to the counterfactual.

We observed that after the law, the largest changes occurred in the volume of beverages purchased, whereas there were minimal changes for solid foods. One possible explanation for the changes in beverages is that Phase 1 of the law had different cut-points for solid and liquid products [31]. Specifically, the limits for added sugars were stricter for liquids than for solids [31]. Thus, more beverages were reformulated to avoid the law, given that the major nutrient of concern in these products was added sugars [22, 23]. Previous evaluations focused on food reformulation have shown that the sugar content of beverages decreased [22], whereas the prevalence of NNS use increased from 72.0% to 82.6% after the law [23]. In addition, reformulated beverages that reduced the amounts of sugar below the law's thresholds were more likely to start using NNS after the law [23].

Among packaged foods, we observed that the percentage of households purchasing foods declined after the law, irrespective of the sweetener category, and the grams of foods purchased also declined slightly. It is important to point out that our data only include purchases of packaged foods, and we do not know how purchases of free-weight foods changed after the law, which are usually unsweetened. This is relevant for the Chilean context because most fruit, vegetables, eggs, fish, and shellfish are purchased as free-weight in wet or open markets [32]. In addition, future research should evaluate the changes in food purchases after implementing the subsequent phases of the regulation because the sugar limits became stricter for solids (with smaller changes in the threshold for liquids), which could have incentivized more reformulation from CS to NNS in packaged foods.

Substituting CS with other refined and processed ingredients such as NNSs could be considered mal-substitution [33] because added NNSs are not recommended by international nutrient profile models, such as the Pan American Health Organization Nutrient Profile Model [30]. However, evidence from reformulation after implementing sugar-sweetened beverages (SSB) taxes indicate that replacing sugars with NNS helps to decrease the amounts of sugars purchased from SSBs [34, 35]. It is important to mention that replacing CS with NNS is commonly recommended to reduce weight in people with obesity or for glycemic control in people with diabetes [36, 37]. Nevertheless, recent studies have shown that NNS intake could be associated with decreases in insulin sensitivity [15–17]. Future studies should continue to monitor the long-term health benefits and harms of replacing sugars with NNS.

The sensitivity analyses conducted only on households who purchased NNS before the law showed that there were no changes in the amounts of NNS beverages purchased after the law. However, the amounts of NNS beverages purchased increased in the overall sample. This finding could indicate that the households who purchased NNS before the law did not change their purchasing behavior, whereas households who did not purchase NNS before the law did change their purchasing behavior. In contrast, other households may have been motivated to purchase beverages with added NNS for the first time after the law, which is in line with the changes in the percentage of households who purchased beverages with added NNS after the law. Future research should explore if there were differences in the characteristics of households who changed their purchasing behaviors after the law.

Notably, the prevalence of any NNS purchases was elevated before the law, and more than 80% of Chilean households purchased any NNS products monthly. Compared with the United States, the percentage of households purchasing products containing added sweeteners before the law was similar, particularly among unsweetened, CS-only, and NNS-only foods and beverages, but the percentage of households who purchased NNS and CS products was higher in the Chilean setting [38]. We found that the percentages of buyers of foods and beverages containing both NNS and CS were 82.8% and 81.1%, respectively, whereas those figures stood at 58.4% and 49.4% in the United States.

We do not know why the NNS purchases were elevated before the law, but 2 possible explanations are the high prevalence of overweight and the wide availability of NNS in the food supply. In 2016, the prevalence of overweight or obesity was 74.2% of Chilean adults [39]. Clinicians and dietitians provide counseling and follow the guidelines developed by the Ministry of Health. Specifically, the guideline for obesity treatment recommends reducing the intake of calories by using tabletop NNS or consuming low-calorie or light foods and beverages [40]. Regarding the Chilean food supply, 37.9% of products contained NNS before the law [23]. In other countries, the prevalence of NNS use in packaged products ranges from 1.4% to 14%, less than half than reported in Chile [41–45]. Future research should explore why Chileans were already high purchasers of NNS before the law.

Our research is important for other countries because, soon after Chile implemented this law, a number of countries have implemented similar policies, and all have included a FOPWL on sugars [4–6, 31]. So far, only Mexico and Argentina have included a FOPWL for NNS (specifically, a label that states that NNS consumption is not recommended for children) [6, 9]. Future research should explore how the prevalence of added sweeteners in food and beverage purchases changed in Mexico and Argentina compared with Chile.

Our study has several limitations. First, the observational nature of our data and the simultaneous implementation of the law nationwide precludes us from drawing causal conclusions. However, we used rigorous quantitative methods to control for secular trends that could influence the results. Second, the purchase data only represent some foods and beverages purchased by Chileans. The Kantar WorldPanel data only included information about packaged foods in specific food categories because we did not have

complete information about free-weight foods. Nevertheless, our data capture most of the sources of NNS in the food supply, given that they are commonly added to packaged foods. Third, we could not untangle the effects of the different policy components (i.e., reformulation, labeling, and marketing restrictions).

Another limitation is the use of purchase data aggregated at the household level. Although using purchase data can provide a reasonable proxy for diet quality, there are some limitations when characterizing the dietary intake of specific nutrients [46, 47]. For example, using purchase data did not allow us to verify the amounts of purchased products that were actually consumed. In addition, because the data were aggregated at the household level, we could not distinguish how the purchased products were shared within the household and whether all household members consumed the same amounts. This may be particularly salient for CS and NNS, given the concerns that relate to children's consumption of CS or NNS [37, 48]. However, the findings of our purchases study for the NNS types align with the findings of dietary intake research [31]. We found that the predicted proportion of households who purchased any NNS after the law was 89.2% for solids and 92.2% for liquids, whereas dietary intake analyses showed that the prevalence of consumption of any NNS was 92.0% in a sample of preschoolers after the law [31]. In addition, in both studies, the amount of sucralose and steviol glycosides purchased or consumed increased significantly after the law. The consistency between different types of data strengthens the evidence of our findings.

The main strength of our study is that we categorized purchased products into sweetener categories using the ingredients list from the NFP data, which was necessary for cross-country evaluations because most countries mandate that ingredients are reported. Future studies evaluating similar policies could search for added sweeteners using the ingredients list and compare their results with our findings.

Conclusions

In conclusion, after implementing the first phase of the Chilean Food Labeling and Advertising Law, we found a decline in purchases of beverages without sweeteners or added sugars, but an increase in the prevalence of nonnutritive sweeteners in beverage purchases. In contrast, small declines were observed for foods. Future research should revisit these findings as the second and third phases of the law were implemented, especially for foods, because sugar limits became stricter for solids.

Author disclosures

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The authors' responsibilities were as follows – NR, LST: designed the research; NR: conducted the research; CC, LST: provided essential materials; NR, MB: analyzed the data; NR, MB, LA, CC, SWN, LST: wrote the paper; NR, CC, LST: had primary responsibility for the final content; and all authors have read and approved the final manuscript.

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Data Availability

Data described in the manuscript and codebook will not and cannot be made available because the Kantar WorldPanel Chile data are proprietary. We are not legally permitted to share the data used for this study, but interested parties can contact Kantar WorldPanel representative Maria Paz Roman (mariapaz.roman@kantar.worldpanel.com) to inquire about accessing this proprietary data. No accession number is needed when requesting data. The analytic code will be made available upon request pending adequate permissions.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cdnut.2022.100016.

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