Self-reported decreases in the purchases of selected unhealthy foods resulting from the implementation of warning labels in Mexican youth and adult population

Alejandra Contreras-Manzano[1,2], Christine M. White[3], Claudia Nieto[1], Kathia L. Quevedo[1], Jorge Vargas-Meza[1,4], David Hammond[3], James F. Thrasher[5], Simón Barquera[1] and Alejandra Jáuregui[1*]

Abstract

Background Front-of-package nutritional warning labels (WLs) are designed to facilitate identification and selection of healthier food choices. We assessed self-reported changes in purchasing different types of unhealthy foods due to WLs in Mexico and the association between the self-reported reductions in purchases of sugary beverages and intake of water and sugar-sweetened beverages.

Methods Data came from 14 to 17 year old youth ($n = 1,696$) and adults ≥ 18 ($n = 7,775$) who participated in the Mexican arm of the 2020–2021 International Food Policy Study, an annual repeat cross-sectional online survey. Participants self-reported whether the WLs had influenced them to purchase less of each of nine unhealthy food categories due to WLs. Among adults, a 23-item Beverage Frequency Questionnaire was used derive past 7-day intake of water and sugary beverages analyzed to determine the relationship between self-reported reductions in purchasing sugary drinks due to the WLs. Multilevel mixed-effects logistic regression models were fitted to estimate the percentage of participants who self-reported reducing purchases within each food group, and overall. Sociodemographic characteristics associated with this reduction were investigated as well.

Results Overall, 44.8% of adults and 38.7% of youth reported buying less of unhealthy food categories due to the implementation of WL, with the largest proportion reporting decreased purchases of cola, regular and diet soda. A greater impact of WLs on the reported purchase of unhealthy foods was observed among the following socio-demographic characteristics: females, individuals who self-identified as indigenous, those who were overweight, individuals with lower educational levels, those with higher nutrition knowledge, households with children, and those with a significant role in household food purchases. In addition, adults who reported higher water intake and lower consumption of sugary beverages were more likely to report reduced purchases of sugary drinks due to the WLs. Adults who reported greater water intake and lower sugary beverages intake were significantly more likely to report buying fewer sugary drinks due to the WLs.

*Correspondence:
Alejandra Jáuregui
alejandra.jauregui@insp.mx

Full list of author information is available at the end of the article

Conclusion Our findings suggest that implementation of WLs has reduced perceived purchases of unhealthy foods in Mexico. These results underscore the potential positive impact of the labeling policy particularly in subpopulations with lower levels of education and among indigenous adults.

Keywords Warning labels, Food purchasing behavior, Nutrition labeling, Food policy, Sugar sweetened beverages

Background

Front-of-pack nutrition labeling (FoPL) provides simple, easy to find information about nutrients to promote healthier dietary habits and, thereby, reduce diet-related non-communicable chronic diseases [1, 2]. Various FoPL systems have been introduced in different countries, aiming to enhance consumer decision-making capacity when comparing and purchasing foods with better nutritional profiles [3–6]. These FoPL systems include warning labels (WLs), which identify products that contain excessive amounts of nutrients that may be harmful to health [7, 8]. However, given that WLs have only been recently implemented, to date, scarce evidence exists on their real-life impacts.

In Mexico, WLs were implemented in October 2020 as a public health policy [9] in response to the increasing demand for processed and ultra-processed food products, including sugary drinks, and the prevalence of overweight, obesity, diabetes, and other diet-related non-communicable diseases in the country, with important economic and health repercussions [10]. Mexican WLs consist of black octagon-shaped warnings prominently displayed on the front of packaged foods to help people identify products that have "excess" levels of five nutrients of concern: calories, added sugars, saturated fat, trans fat, and sodium [9]. As part of the policy, two precautionary disclaimers are also displayed as black rectangles on the front of packages are also included to discourage child consumption of products with caffeine ('Contains caffeine, avoid in children') or non-sugar sweeteners ('Contains sweeteners, not recommended in children') [9]. Experimental and qualitative studies conducted with various FoPL systems consistently demonstrate that WLs are the best understood by Mexican consumers from different backgrounds, including low education and low-income groups [11–14].

Processed and ultra-processed products, such as sugary drinks, fruit nectars, savory snacks, and cakes, have a high density of calories and nutrients of concern (i.e., saturated fat, trans fat, sugar, sodium) linked with the development of non-communicable diseases [15]. However, consumers in general are often unaware of the risks and consequences of choosing products with poor nutritional quality; consequently, decisions are usually made based on taste, smell, texture, and/or marketing [16]. A review of experimental studies found that WLs may discourage consumers from purchasing products with excess levels of critical nutrients, including sugary drinks [17].

Few 'real-world' studies have evaluated the impact of WLs or other FoPLs on the purchasing behavior of consumers [18, 19]. A study of Chilean households reported that after the introduction of black octagon WLs, among purchases of products with WLs, overall calories, calories from sugar, calories from saturated fat and sodium purchased decreased by -49.4 kcal, -20.7 kcal, -6.2 kcal and −96.6 mg per capita/day respectively. Larger absolute reductions in sugar were found for beverages, whereas foods had larger absolute reductions in sodium and saturated fat [18]. Additionally, the volume of purchases of beverages with "high in" WLs in Chile decreased by 22.8 mL/capita/day post-regulation, when compared to the expected purchases based on pre-regulation trends [19]. For both, more highly educated households had a greater reduction in perceived purchases of beverages with WLs compared to households with lower levels of education. These results are consistent with a study conducted among Chilean parents, where 49.5% reported having stopped buying certain foods due to the presence of a WLs [20]. A lower probability of food purchase pattern change was observed in families that did not consider the WLs an important tool, did not understand the WLs, and did not regularly read nutritional labels prior to law implementation [20].

Evaluations of the Chilean WLs policy suggest that it has reduced consumption of unhealthy food and that differential effects across population groups are important to assess. To date, no studies have evaluated changes in purchasing behavior following WLs implementation in Mexico. Therefore, this study aimed to analyze the perceived self-reported decreases in purchases of unhealthy foods due to WLs in Mexico, and secondly, to investigate associations between the self-reported reductions in purchasing sugary beverages and the past 7-day consumption of water and sugar-sweetened beverages. This second aim provides a behavioral outcome to assess that is independent of and may therefore reduce concerns about attribution bias that may be present when examining only self-reported reductions in consumption due to the WLs.

Methods

Study design

The current study used data from the Mexican arm of the 2020 and 2021 International Food Policy Study (IFPS). The IFPS is an annual repeated cross-sectional online survey of children (10–13 years), youth (14–17 years)

and adults (≥18 years) from multiple countries, including Mexico. Detailed methods on the IFPS can be found elsewhere [21, 22]. Data were collected in November-December in both 2020 and 2021, one month and over one year after the after the enactment of the Mexican WLs, respectively. Surveys for all age groups asked participants to report the usefulness of WLs, with only those aged 14 or older asked whether the WLs had caused them to change their food purchasing behavior. Hence, we only analyze data from those aged 14 or older.

Sample & Recruitment

Participants were primarily recruited through Nielsen's Consumer Insights Global Panel and their partner panels. Additionally, an oversample of adult respondents with lower educational attainment recruited through Qualtrics and their partner panels in 2021. In prior waves, recruitment through Nielsen and their partners yielded a sample with higher educational attainment than observed in the general population, thus the oversample was recruited in 2021 to obtain a sample that more closely resembles the national education distribution. Participants were recruited using both probability and non-probability sampling methods. Eligible participants were adults 18 to 100 years of age and youth aged 14–17 years residing in Mexico.

For the adult survey, email invitations with unique survey access links were sent to a random sample of panelists in Mexico after targeting for demographics; panelists known to be ineligible were not invited. Potential respondents were screened for eligibility and quota requirements based on age and sex. In 2021, respondents recruited as part of the low education oversample also had to report having a high school-level education or less. After screening, all potential respondents were provided with information about the study and were asked to provide consent before participating.

For the youth survey, parents/ guardians were provided information about the study and asked for permission for their child to participate. Only one child per household was invited to participate. The child was subsequently screened directly to confirm eligibility based on age. Eligible children were provided with information about the study and were asked to provide consent before participating. The youth's parent/ guardian and adult respondents received remuneration in accordance with their panel's usual incentive structure (e.g., points-based, or monetary rewards that can be redeemed for e-gift cards, catalog items, cash, donations and/or chances to win monthly prizes).

The surveys were conducted in Spanish. The cooperation rate for adults was 9.2% and 16.1% for 2020 and 2021 and for youth 3.4% and 7.4% respectively. Participants who answered "don't know" or "refuse to answer"

in any of the measures of interest were excluded from final analyses (*n*=323). A subsample of 7,775 adults (*n*=3,900 in 2020 and *n*=3,875 in 2021), and 1,638 youths aged 14 to 17 years (*n*=851 in 2020 and *n*=787 in 2021) were included in the current analyses after excluding respondents with missing data (*n*=307). Some additional analyses were completed with an additional 1,622 adult respondents recruited in 2021 as part of the low-education level oversample. (Additional Fig. 1)

The study was reviewed by and received ethics clearance through a University of Waterloo Research Ethics Committee, the Institutional Review Board at the University of South Carolina (only 2021 survey), and the Research Ethics Committee at the Instituto Nacional de Salud Pública in Mexico.

Self-reported changes in unhealthy food purchases

Participants reported perceived changes in their food purchases of nine different food categories where WLs were common: cola (Coca-Cola, Pepsi, etc.), soda (Sprite, Orange Crush, etc.), diet soda (Coca-cola Zero, Pepsi de Dieta, etc.), sweetened fruit drinks (lemonade, iced tea, SunnyD, fruit punch/cocktail, etc.), candy or chocolate bars, snacks such as chips, desserts such as cakes, cookies and ice cream, and sugary cereals. Emerging research suggests that 100% fruit juice may similarly amplify the risk of mortality as observed for sugary drinks [23]. Although 100% fruit or vegetable juice is not included in the WLs regulation, fruit beverages are widely consumed in Mexico [24]. Therefore, self-reported changes in the purchases of processed 100% fruit or vegetable juice were also assessed with the intention of incorporating a "comparison group" without WLs in the analysis.

Participants were shown an image of the "excess calories" WLs and asked how often they had seen that type of food label on packages on in stores (Adults: 4,284 in 2020 and 4,172 in 2021. Youth: 904 in 2020 and 829 in 2021). On average, 98.5% of participants reported having ever seeing the WLs and those 10,043 youth and adults were asked for each of the food categories: *"Have the warning labels (black octagons) changed whether you buy the following packaged products for you or your family?"* The response options were: "Buy less", "Buy more", "No change", "Don't know" or "Refuse to answer". Participants were classified as: 0 "No change/Buy more" or 1 "Buy less".

Self-reported usefulness of nutrient-specific warning labels

The self-reported usefulness of each nutrient-specific WLs was assessed by showing participants an image of each of the WLs and asking: *"Which of these stamps, if any, has been most useful to choose healthier foods?"* Respondents could select one of the following WL: "Excess Calories", "Excess Sodium", "Excess Saturated Fat",
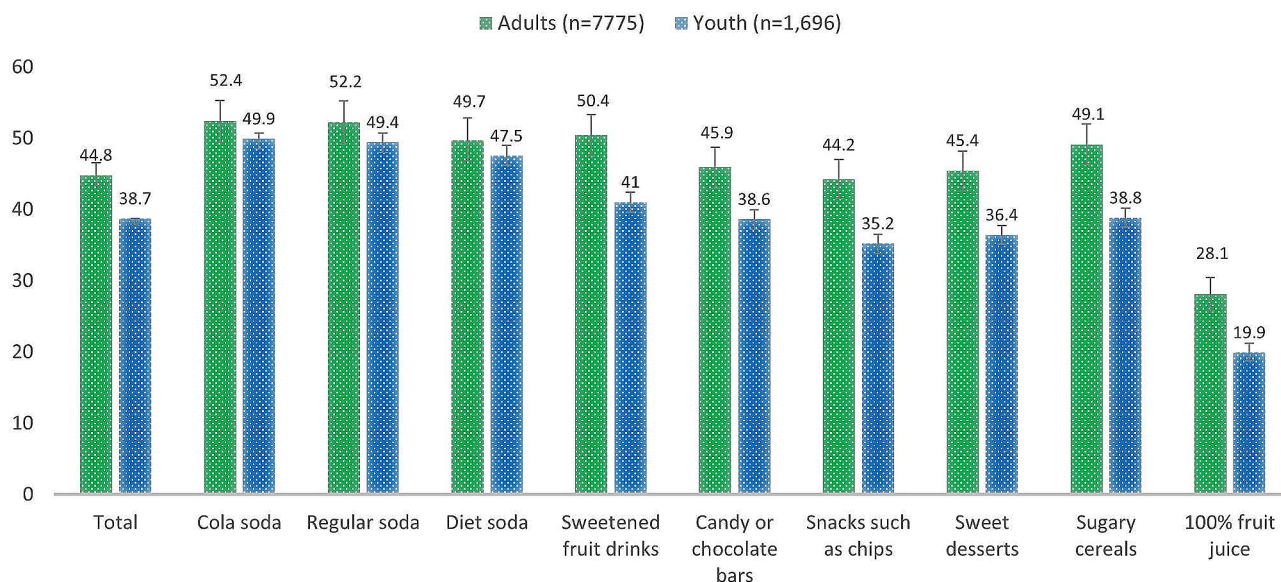
Fig. 1 Adjusted percentage (%) of Mexican adults and youth reporting decreases in food purchases of selected food categories after the enactment of warning labels, International Food Policy Study, 2020 and 2021

Percentage of participants reporting decreases in food purchases derived from logistic regression models adjusted for age, sex, indigeneity, income adequacy and BMI category for adults and youth, and additionally adjusted by educational level, children in the household, nutrition knowledge, role in the food shopping in the household for adults. The overall percentage was derived from a multilevel logistic regression model adjusted by the same covariates and food group categories (diet soda as the reference); individuals were considered the clustering level. The multilevel model did not include 100% fruit juice because this product does not have any warning labels. All percentages were estimated using margins

"Excess Trans Fat", "Excess Sugars", or could select "None of the stamps have been useful", "All of the stamps have been equally useful", "Don't know" or "Refuse to answer".

Beverage intake in adults

Beverage intake among adults was assessed through a Beverage Frequency Questionnaire (BFQ) that queried 23 beverage categories [25]. Participants were asked: *"During the past 7 days, how many drinks did you have in each category below?"* For each category of drink consumed, participants were shown common beverage container sizes and asked to select the usual size of drink consumed, which was subsequently used to estimate the total volume consumed in the last 7 days per beverage category. The BFQ utilized identical brand product examples as the questions in the report on perceived changes in unhealthy purchases. This approach aided in reducing bias in the analyses of beverage intake, as the frame of reference remained consistent across both sets of questions.

The intake of "sugar sweetened beverages" was estimated by summing the estimated volume of regular soda, sweetened fruit drinks, regular flavored waters or vitamin waters with calories, regular sports drinks, regular energy drinks, chocolate milk, coffee/tea with sugar, sweetened specialty coffees/teas, and sweetened smoothies/protein shakes/drinkable yogurt. Water intake was estimated by summing the estimated volume of tap and plain bottled water.

Covariates

Covariates assessed included age, sex at birth (male; female), indigeneity (self-identifying as indigenous or non-Indigenous), self-reported nutrition knowledge (responses recoded as not knowledgeable, somewhat knowledgeable, or knowledgeable). Education level for adults was based on the highest level of formal education completed and recoded as low=basic or less; medium=technical or commercial studies with completed secondary education or less; high=technical or commercial studies with completed high school education or higher.

Perceived income adequacy (*"Thinking about your total monthly income, how difficult or easy is it for you to make ends meet?"*) was assessed with a 5-point Likert scale with responses recoded as "difficult" (very difficult/difficult), "neither easy nor difficult", or "easy" (easy/very easy). BMI was calculated using reported weight and height and categorized according to World Health Organization (WHO) standards for adults and z-scores for age and sex using a WHO macro for youth [26]. Food shopping role for adults was assessed with the question: *"How much of the food shopping do you do in your household?"* with the responses recoded as "Most" or "Some or None".

Statistical analysis

Post-stratification sample weights for the main sample were constructed based on known population totals by age, sex at birth, region, and indigeneity; for the sample

considering the oversample in 2021, sample weights additionally accounted for education. Estimates reported are weighted.

We used two modelling approaches to estimate the self-reported changes in food purchases across survey years and the associated factors with these changes. The first approach involved examining the average change in purchases by combining responses from the eight unhealthy food groups that typically carry WLs, thereby excluding the 100% natural juice group from this general estimation. To estimate the overall self-reported effect of the WLs on reducing unhealthy purchases across various food groups (0=no change/buy more; 1=buy less), we employed a repeated measures (multilevel mixed effects) logistic regression model introducing multiple observations for each respondent, each of which corresponded to the different food group type assessed. We used diet soda as the reference group since it has fewer WLs compared to the other food categories. The individual was considered as the clustering level. The models for youth and adults were adjusted by survey year, sex, age, indigeneity, income adequacy, and BMI category. For adults, the model was further adjusted by education level, children in the household, self-reported nutrition knowledge, and food shopping role.

The second approach involved estimating changes in purchases individually for each of the nine unhealthy food groups, including 100% natural juice. For this analysis, we employed separate logistic regression models for each of the nine food products, including 100% fruit juice, to estimate the factors associated with self-reported reductions in purchases, while adjusting for the same covariates as in the previous models.

Additionally, we fitted a multilevel mixed-effects logistic regression model for self-reported reduction in purchasing sugary drinks (cola, soda and sweetened fruit drinks), with quintiles of past 7-day water intake and of past 7-day sugary drink intake (reported intake of regular soda, sweetened fruit drinks, regular flavored waters or vitamin waters with calories, regular sports drinks, and regular energy drinks derived from the BFQ) as the independent variable; same covariates described previously were used to adjust the model. Interactions were not tested. To analyze differences in the self-reported usefulness of each nutrient-specific WLs we estimated separate logistic regression models for adults and youth.

Secondary analyses used the same statistical approach after including the 2021 oversample of participants with low education. The individual was considered as the clustering level. Statistical significance was set with a *p* value of 0.05. Analyzes were performed in Stata 14.0v.

Results

Participants characteristics were somewhat consistent across study years. The mean age for youth was 15.4 years and 40.7 years for adults. The male proportion was 50.6% for youth and 48.1% for adults; indigeneity was 22.6% in youth and 19.2% adults; the percentage of participants with high income adequacy was 20.8% in youth and 16.5% in adults. Around 5% of youth and 15.1% of adults had obesity. Half of adults had children in their household, 73.4% had an important food shopping role in the household. However, differences between study years were observed in the distribution of income adequacy, BMI, education level, and nutrition knowledge categories among adults. (Table 1) The analysis considering the oversample of individuals with low education in 2021 had a higher percentage of participants with a low education level (74.6%), or an important role in food shopping within the household (68.2%), and a lower percentage with perceived nutrition knowledge (9.4%) or a BMI<25 (32.6%), compared to the main survey sample for 2021 (Additional File 1).

Figure 1 shows the adjusted percentage of adults and youth reporting that the WLs had led them to buy less of each of the studied food categories and overall. On average, 44.8% of adults and 38.7% of youth self-reported that the WLs had led them to buy less of the food categories overall. Sugary beverages, such as cola, soda, diet soda, and sweetened fruit drinks had the largest self-reported decreases among adults (50.4–52.4%) and youth (41.0-49.9%). Meanwhile, 100% fruit juice, a product free of WL, had the smallest self-reported decreases among youth (19.9%) and adults (28.1%). Additional file 2 shows the adjusted percentage of participants who self-reported buying less of each food group and overall, in adults and youth by study year. No differences were observed between 2020 and 2021 in the percentage of participants reporting buying less food products overall and across food categories; except for 100% fruit juice, where the decrease in purchases was lower in 2021 (26.7%) compared to 2020 (29.6%, *p*<0.05). Secondary analyses including the oversample of low education adults in 2021 showed a slightly higher percentage of participants reporting that the WLs had led them to buy less unhealthy food products overall (48.8%) in comparison to the main sample, and a higher percentage of participants reporting that the WLs had led them to buy less candy or chocolate bars in 2021 (50.9%) compared to 2020 (47.6%) (Additional file 2).

Figure 2 shows the odds ratio of reporting that the WLs had led them to purchase fewer sugary drinks across quintiles of sugary beverage or water intake among adults. Participants classified in the highest quintile of intake of sugary drinks had lower odds of reporting to buy less sugary drinks (OR: 0.09, *p*<0.05) compared to

Table 1 Sociodemographic characteristics of youth and adult participants, International Food Policy Study, 2020 and 2021

	Youth (14–17 y)			Adults (^{3}18 y)		
	2020	2021	Both	2020	2021	Both
n sample	891	805	1,696	3,900	3,875	7,775
	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
Age (years)*	**15.3 (15.2, 15.4)**	**15.5 (15.4, 15.6)**	15.4 (15.3, 15.4)	40.5 (39.9, 41.1)	40.9 (40.3, 41.6)	40.7 (40.3, 41.2)
Sex						
Female	49.4 (45.4, 53.4)	49.3 (45.1, 53.5)	49.4 (46.5, 52.2)	51.8 (49.9, 53.7)	52.0 (50.2, 53.8)	51.9 (50.6, 53.2)
Male	50.6 (46.6, 54.6)	50.7 (46.5, 54.9)	50.6 (47.7, 53.5)	48.2 (46.3, 50.0)	47.9 (46.1, 49.8)	48.1 (46.7, 49.4)
Indigeneity						
No	79.1 (74.8, 82.9)	75.4 (70.8, 79.5)	77.4 (74.3, 80.2)	80.8 (79.1, 82.4)	80.8 (79.1, 82.3)	80.7 (79.6, 81.9)
Yes	20.9 (17.1, 25.2)	24.6 (20.5, 29.2)	22.6 (19.8, 25.7)	19.2 (17.6, 20.9)	19.2 (17.7, 20.9)	19.2 (18.1, 20.4)
Income adequacy						
Easy	38.9 (34.9, 43.0)	21.5 (18.4, 25.1)	20.8 (18.6, 23.2)	13.7 (12.6, 15.0)	**19.4 (18.0, 20.8)**	16.5 (15.6, 17.5)
Neither	38.6 (34.9, 42.5)	38.9 (34.9, 43.0)	38.8 (36.0, 41.6)	36.1 (34.3, 37.9)	**40.8 (39.0, 42.7)**	38.4 (37.2, 39.7)
Difficult	41.2 (37.2, 45.3)	39.5 (35.4, 43.7)	40.4 (37.6, 43.4)	50.2 (48.3, 52.1)	**39.8 (37.9, 41.7)**	44.9 (43.6, 46.3)
BMI category‡						
Underweight/Normal weight	53.5 (49.5, 57.5)	55.0 (50.8, 59.2)	54.2 (51.3, 57.1)	38.0 (36.2, 39.8)	**41.1 (39.3, 43.0)**	39.6 (38.3, 40.8)
Overweight	22.1 (19.0, 25.5)	19.1 (16.1, 22.6)	20.7 (18.5, 23.1)	31.9 (30.2, 33.8)	30.6 (28.9, 32.3)	31.2 (30.0, 32.5)
Obesity	4.4 (3.1, 6.2)	4.9 (3.5, 6.9)	4.6 (3.6, 5.9)	15.3 (13.9, 16.8)	**14.8 (13.5, 16.2)**	15.1 (14.1, 16.1)
Missing	20.0 (16.9, 23.6)	20.9 (17.7, 24.4)	20.5 (18.2, 22.9)	14.7 (13.4, 16.1)	**13.4 (12.1, 14.7)**	14.0 (13.1, 15.0)
Education level						
Low				21.4 (19.9, 23.0)	**19.1 (17.7, 20.5)**	20.2 (19.2, 21.3)
Medium				13.6 (12.2, 14.9)	**14.2 (12.9, 15.6)**	13.8 (12.9, 14.8)
High				65.0 (63.2, 66.8)	**66.8 (64.9, 68.5)**	65.9 (64.6, 67.1)
Children in the household						
No				51.2 (49.3, 53.1)	50.4 (48.5, 52.3)	50.8 (49.5, 52.1)
Yes				48.7 (46.8, 50.6)	49.6 (47.7, 51.4)	49.2 (47.8, 50.5)
Food shopping role						
Most				73.6 (72.0, 75.2)	73.2 (71.6, 74.8)	73.4 (72.2, 74.6)
Some or None				26.4 (24.7, 28.0)	26.7 (25.1, 28.4)	26.5 (25.4, 27.7)
Nutrition knowledge						
Not knowledgeable				31.4 (29.7, 33.1)	**33.9 (32.2, 35.7)**	32.7 (31.4, 33.9)
Somewhat				55.5 (53.6, 57.4)	**50.8 (48.9, 52.7)**	53.2 (51.8, 54.5)
Knowledgeable				13.1 (11.8, 14.5)	**15.2 (13.9, 16.6)**	14.2 (13.2, 15.1)

*Means. **Bold numbers** indicate *p* value < 0.05 among study years ‡For adults, BMI was categorized as < 25 (Underweight or Normal weight), 25–29 (Overweight), and ≥ 30 (Obesity). For youth, BMI z-score was categorized as ≤ 1 (Severe thinness/Thinness/Normal), > 1 to ≤ 2 (Overweight), or > 2 (Obesity)

those classified in the lowest quintile. Conversely, those classified in the highest quintile of water consumption had higher odds of reporting to buy less sugary drinks (OR: 4.80, *p* < 0.05) compared to those in the lowest quintile of water consumption. The analysis of the oversample with a low education level yielded similar results (Additional Fig. 2).

Table 2 shows the sociodemographic characteristics associated with self-reported changes in food purchases due to the WLs. Among adults, reporting that the WLs had led them to buy less unhealthy food products was positively associated with being female, older age, self-identifying as indigenous, being overweight, low educational level (compared to high), having children in the household, self-reporting higher nutrition knowledge, and having an important role shopping food in the household. Among youth, perceiving to buy fewer food

products due to the implementation of the WLs was negatively associated with age and positively associated with indigeneity and low-income adequacy.

Figure 3 shows the adjusted self-reported usefulness of each nutrient-specific WLs among youth and adults in both survey years. On average, 31.3% (95% CI: 28.6–33.9) of youth and 32.1% (95%CI: 30.9–33.4) of adults self-reported that all the nutrient-specific WLs were equally useful for choosing healthier foods, with the next highest percentage reporting that the "Excess Sugars" warning was most useful (23.3% and 18.2% respectively). Around 15% of youth (95% CI: 13.2–17.4) and adults (95% CI: 15.7–17.7) self-reported that none of the nutrient-specific WLs had been useful. The "Excess sodium" label and the "Excess Trans-fat" label were rated most useful by the lowest proportion of youth (4.3%), and adults (6.3%), respectively. These percentages remained similar
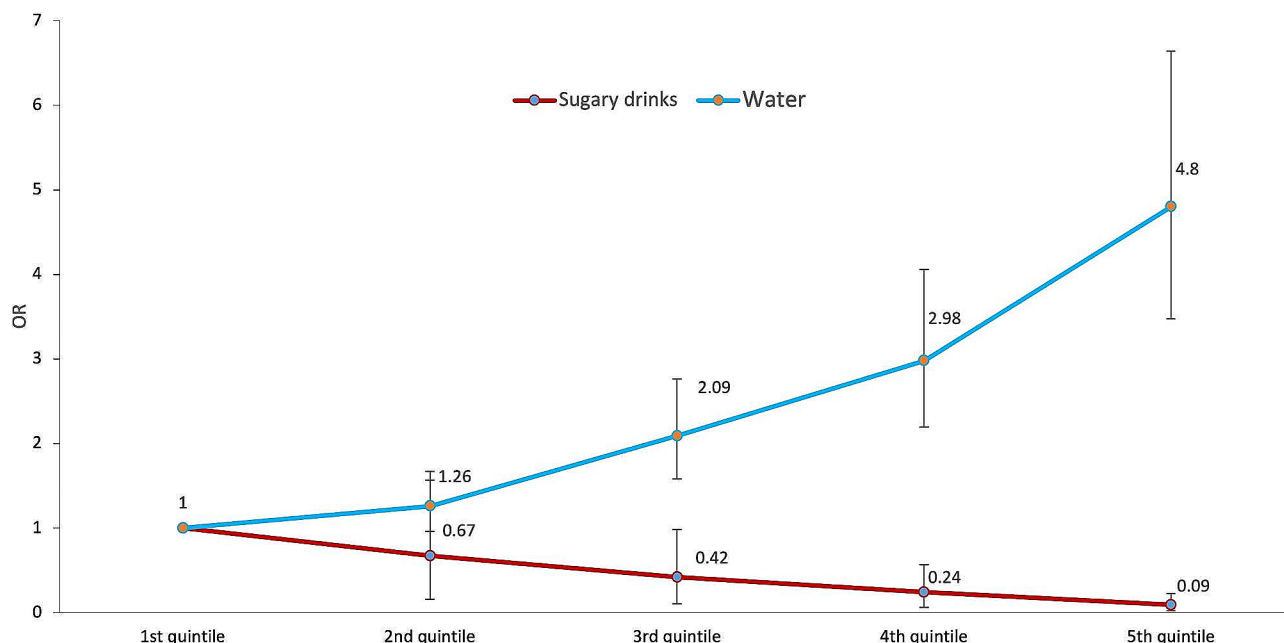
Fig. 2 Odds ratio of self-reported buying less sugary drinks due to the WLs by quintile of past 7-day intake of sugary beverages and water in adults, International Food Policy Study, 2020 and 2021 ($n = 7,071$)
Self-reported purchase change in sugary drink groups included cola, soda, and sweetened fruit drinks. Sugary drink intake was based on the summed volume of regular soda, sweetened fruit drinks, regular flavored waters or vitamin waters with calories, regular sports drinks, and regular energy drinks. Median intake per quintile: Sugary drinks intake (Q1 = 71.4 ml, Q2 = 301.7 ml, Q3 = 540 ml, Q4 = 848 ml, Q5 = 1528 ml), Water intake (Q1 = 0 ml, Q2 = 357 ml, Q3 = 750 ml, Q4 = 1071 ml, Q5 = 1857 ml). Multilevel regression model adjusted by age, sex, indigeneity, educational level, income adequacy, children in the household, nutrition knowledge, role in the food shopping in the household, BMI category and year of the survey

across study years, except for "All have been equally useful" which decreased from 34.1% in 2020 to 29.6% in 2021 ($p < 0.05$) (Additional file 3). Some factors associated with the self-reported usefulness of some WLs among adults were; age with "Excess Calories", "Excess Sugars", "None" and "All", educational level for "Excess calories" and "All", indigeneity for "Excess calories", "Excess Sugars" and "None", and having children in the households for "Excess Sodium", "Excess Sugars", "None" and "All" (Additional file 4).

Discussion

The results of this study show that, one month and one year after the enactment of WLs in Mexico, more than a third of youth and nearly half of adults self-reported that this labeling system had led them to decrease the purchase of various unhealthy food products. Self-reported decreases in purchases of unhealthy food products were associated with various demographic characteristics, including indigeneity, having a lower education (adults), or lower income adequacy (youth). Larger decreases in self-reported purchases of sugary drinks were observed among those with the highest water consumption but not among those with high consumption of sugary drinks. These findings demonstrate a positive impact of the labeling policy, which aims to promote healthier food choices.

Scarce evidence exists regarding the real-life effect of FoPLs on food purchases. In Chile, a pioneering country in the implementation of WLs in 2016, comparisons before and after the implementation of this labeling have shown decreases in the overall purchases of calories, sugar, saturated fat, and sodium in the school setting [18], as well as in the volume of high-sugar beverage purchases [19]. This study adds to the literature by investigating the self-reported effect of WLs on unhealthy food purchases following the implementation of WLs in Mexico, finding that WLs may have led consumers to decrease their purchases of unhealthy food categories with sustained perceived effects at least one year after the introduction of the labels. These results are in line with recent meta-analyses suggesting that food labeling reduces consumer intake of energy, total fat, and other unhealthy dietary options, while increasing the selection of healthier products and vegetable consumption [27, 28]. Similarly, previous research has also shown that following the implementation of WLs in Mexico, increases in the awareness, use and understanding of nutrition labels were observed among Mexican adults and youth [29, 30]. Additionally, our study found that only 15% of the surveyed adults and young individuals considered none of the labels to be useful, indicating that most of the population perceives WLs as a useful tool for decision-making.

Table 2 Adjusted odds ratios for perceiving buying less unhealthy foods due to the warning labels, International Food Policy Study, 2020 and 2021

	Youth (*n* = 1,696)		Adults (*n* = 7,775)	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Survey year				
2020	1.0	Ref.	1.0	Ref.
2021	0.83 (0.62, 1.12)	0.219	0.9 (0.78, 1.04)	0.143
Food group				
Diet soda	1.0	Ref.	1.0	Ref.
Cola	1.33 (1.03, 1.72)	0.031	1.33 (1.19, 1.49)	< 0.001
Soda	1.27 (0.99, 1.62)	0.057	1.3 (1.17, 1.44)	< 0.001
Sweetened fruit drinks	0.53 (0.4, 0.71)	< 0.001	1.07 (0.95, 1.21)	0.237
Candy or chocolate bars	0.43 (0.32, 0.58)	< 0.001	0.67 (0.58, 0.77)	< 0.001
Snacks	0.3 (0.22, 0.4)	< 0.001	0.56 (0.49, 0.64)	< 0.001
Dessert	0.34 (0.26, 0.46)	< 0.001	0.64 (0.56, 0.73)	< 0.001
Sugary cereals	0.44 (0.32, 0.58)	< 0.001	0.94 (0.82, 1.07)	0.340
Age	0.86 (0.75, 0.98)	0.024	1.01 (1, 1.01)	0.024
Sex				
Male	1.0	Ref.	1.0	Ref.
Female	1.27 (0.94, 1.72)	0.117	1.59 (1.37, 1.83)	< 0.001
Indigeneity				
No	1.0	Ref.	1.0	Ref.
Yes	2.47 (1.61, 3.79)	< 0.001	3.15 (2.59, 3.82)	< 0.001
Income adequacy				
Easy	1.0	Ref.	1.0	Ref.
Neither	1.32 (0.91, 1.91)	0.140	0.81 (0.66, 0.99)	0.041
Difficult	1.59 (1.08, 2.34)	0.017	0.87 (0.71, 1.07)	0.199
BMI category[‡]				
Underweight/Normal weight	1.0	Ref.	1.0	Ref.
Overweight	0.75 (0.52, 1.09)	0.130	1.35 (1.14, 1.6)	0.001
Obesity	0.6 (0.31, 1.17)	0.134	1.03 (0.83, 1.28)	0.780
Missing	1.08 (0.73, 1.6)	0.688	1.43 (1.14, 1.78)	0.002
Education level				
High			1.0	Ref.
Medium			1.08 (0.88, 1.34)	0.453
Low			1.64 (1.37, 1.98)	< 0.001
Children in the household				
No			1.0	Ref.
Yes			1.42 (1.23, 1.64)	< 0.001
Shopping role				
Some or none			1.0	Ref.
Most			1.93 (1.64, 2.28)	< 0.001
Nutrition Knowledge				
Not knowledgeable			1.0	Ref.
Somewhat know			2.09 (1.79, 2.45)	< 0.001
Knowledgeable			2.89 (2.29, 3.64)	< 0.001

Multilevel mixed-effects logistic regression adjusted by food group and the covariates shown in the table. *All food categories were included except 100% fruit or vegetable juice. [‡]For adults, BMI was categorized as < 25 (Underweight or Normal weight), 25–29 (Overweight), and ≥ 30 (Obesity). For youth, BMI z-score was categorized as ≤ 1 (Severe thinness/Thinness/Normal), > 1 to ≤ 2 (Overweight), or > 2 (Obesity)

Data from the National Health and Nutrition Survey (ENSANUT) of Mexico [31] showed a decrease in the percentage of Mexican adults reporting the consumption of sugary beverages three or more days per week, from 86.7% [CI 95%: 83.5, 89.3%] in 2020 to 69.3% [CI 95%: 66.6, 71.8] in 2021 [32]. According to our study results, the impact of the implementation of WLs in Mexico might have contributed to these declines.

Our findings show that the self-reported impact of WLs was similar between 2020 and 2021 with a slightly higher prevalence of self-reported reduced purchases in 2021. This difference may be attributable to the timing
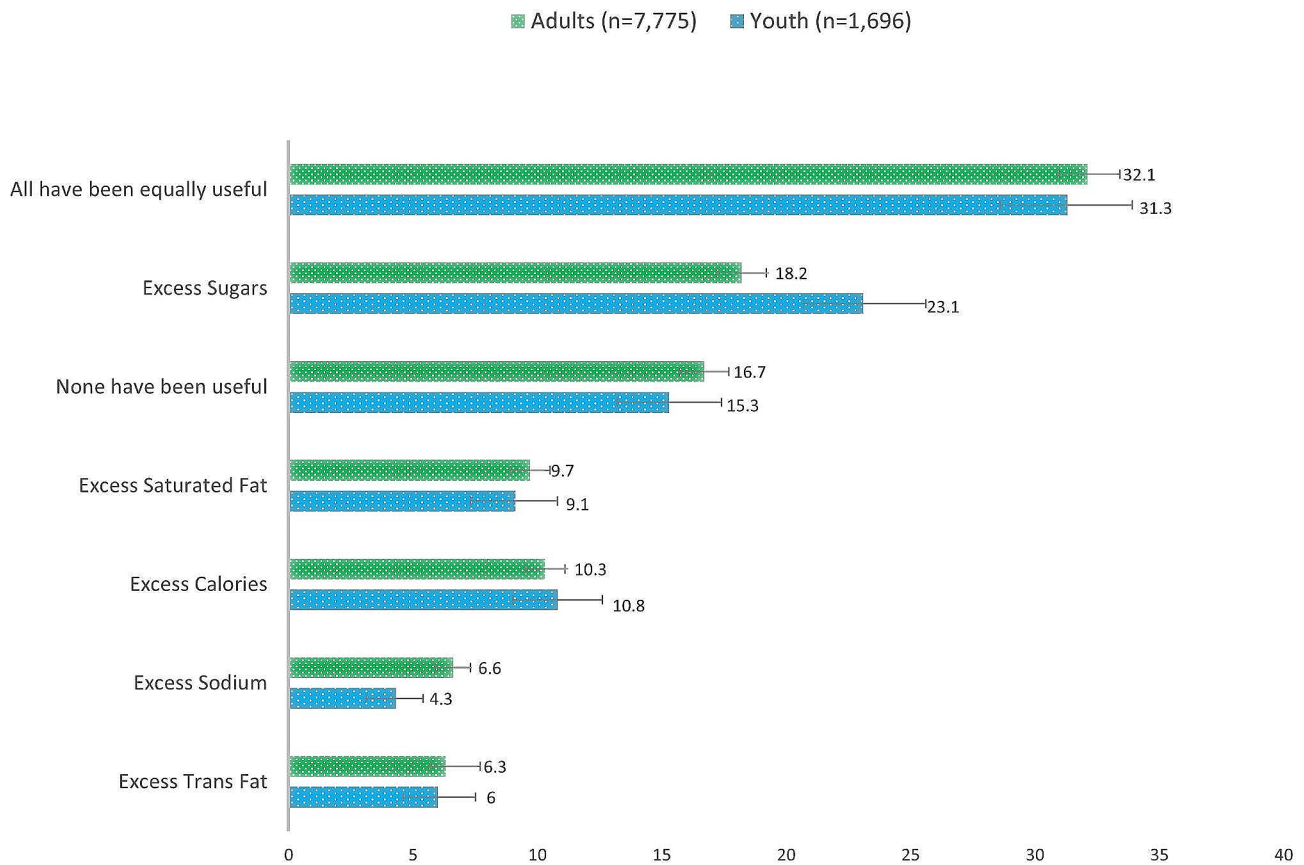
Fig. 3 Adjusted percentage (%) of self-reported usefulness of each nutrient-specific warning labels among Mexican adults and youth. International Food Policy Study, 2020 and 2021

Data derived from a logistic regression model adjusted by age, sex, indigeneity, income adequacy and BMI category for youth and adults, and additionally adjusted by educational level, children in the household, nutrition knowledge, role in the food shopping in the household for adults

of our study. Towards the end of 2020, WLs were newly introduced [33], and not all products were properly labeled, and some items might still have retained the previous labeling system. However, by the end of 2021, the WLs were fully implemented, facilitating their accurate utilization by consumers, and possibly showing a wear-in period of label influence as more products use them and consumers get accustomed to using WLs [34]. Future research should assess the continued impact of the labels over the long term to explore possible wear-out effects of the labels, as has been found for cigarette warning labels, where wear out also varies across sociodemographic groups of people who smoke [35].

In our study, we found that the largest self-reported decreases in unhealthy food purchases among both adults and young people occurred among sugary drinks, with lower self-reported reductions in other food categories such as desserts, snacks, or candies. While some research has suggested that WLs may have more impact in reducing the intake of sugar-sweetened beverages compared to other food categories [19], other research among Mexican children and adults suggests that the

objective understanding of WLs is similar across food categories [36]. Indeed, this larger self-reported effect on sugary drinks may be attributable to Mexico being among the leading consumers of sugar-sweetened beverages globally [37] and sugary drinks being more commonly consumed than the other unhealthy products assessed [32]. According to the ENSANUT 2020 [29], sugary drinks were consumed daily by 90.9% of children aged 5–11 years, 90.7% of adolescents, and 86.7% of adults. Conversely, snacks, desserts, and sugary cereals were only consumed daily by less than 55% of the population. Furthermore, in addition to the traditional WLs indicating excess content of critical nutrients, many sugary drinks in Mexico are also required to display the two rectangle-shaped warning legends related to sweeteners and caffeine content [38]. These additional labels, which are generally less applicable to other food categories, may contribute to changes in the perceived healthiness of cola beverages and artificially sweetened drinks [38, 39]. For example, the perceived impact of WLs on sugary fruit drink purchases was significantly lower than on diet soda purchases among youth (although no difference was

observed among adults) [39]. In line with the former, data from ENSANUT 2021 suggested that one year after the enactment of WLs in Mexico, 21.6% of adults identified excess calories in cola beverages, 82.3% identified excess sugars, 22.4% identified the caffeine warning, and 11.8% identified the sweeteners warning [32]. However, our results also indicate that self-reported decreases in the purchases of sugary drinks were more common among individuals who were in the highest quintile of water consumption, rather than sugary drinks. These findings underscore the importance of directing communication efforts to heavy consumers of sugary drinks to promote changes in the social norms regarding soda consumption in Mexico and complement current front-of-pack labeling and soda tax regulations in the region as well as additional policies aimed at improving the food environment.

In our study, adults with lower educational level, youth with lower income adequacy and youth and adults self-identifying as indigenous self-reported a greater reduction in the purchase of unhealthy foods because of the WLs. These population groups have a disproportionate burden of non-communicable diseases and lower access to healthy and nutritious foods [40]. Results of this study suggest that WLs may aid in decreasing health disparities. Indeed, WLs have been proposed as a policy with equitable impacts among consumers of all socioeconomic strata [12, 13, 36] that can have significant impacts even on populations with social inequities, who potentially may benefit more from public strategies that enhance food-related decision-making [27, 28]. Consistent with our findings, other studies have demonstrated that WLs can have a greater influence on food purchasing choices among specific subpopulations [11–13]. Experimental studies have shown that WLs are equally understood by consumers of all backgrounds and promote healthier purchasing intentions [11–13, 17–19, 32, 36]. Our results also show that among adults with low self-reported nutrition knowledge, the perceived impact on unhealthy purchases was lower. This finding underscores the importance of increasing nutritional literacy and raising awareness of health risks associated with excessive consumption of ultra-processed products high in added sugars, saturated fats, or sodium. For example, there is a higher likelihood of developing obesity, diabetes, hypertension, or other chronic diseases associated with poor dietary habits [41].

WLs also led to greater self-reported decreases of unhealthy food purchases among adult women, those with children in the household, and those with overweight. Results suggests that in Mexico women may be more aware and willing to change purchasing decisions due to front-of-pack labeling than men. This is consistent with nationally representative studies showing that Mexican women were more likely to correctly interpret front-of-pack labels [42].

Regarding the BMI category, our study found that the probability of self-reported decreases in unhealthy food purchases was significantly higher for adults with overweight, but not for those with obesity, compared to normal BMI individuals. We believe that this finding is not related to differences in the understanding of WLs, as our model was adjusted for self-reported nutrition knowledge and education level. In this context, in an experiment using data from the 2018 National Health and Nutrition Survey, Sagaceta et al. (2022) [43] demonstrated that, when compared with Guideline Daily Amounts, WLs helped more Mexican adults correctly classify unhealthy food products, yet correct answers showed no variation when stratified by the presence or absence of overweight and obesity [43]. Unpublished analyses by our research team using public data from the 2021 ENSANUT [44], also suggest no differences in self-reported purchases of unhealthy food products with WLs by Mexican adults across BMI categories. More studies are needed to comprehensively understand the relationship between BMI and food purchasing behavior, particularly in the context of the WLs policy.

Finally, in our study, a greater proportion of participants rated the calorie, sugar, or saturated fat WLs as most useful, with the lowest proportion of adults rating the trans-fat WLs as most useful. This could be attributed to the fact that only around 1% of Mexican products are reportedly high in trans-fat, while 48.3, 40.4 and 33.9% of products were reportedly high in calories, sugar, and saturated fat, respectively, and showed the corresponding WLs [38]. Additionally, in Mexico, a law prohibiting the use of trans fats was approved in 2023, which is expected to lead to a decrease in the visibility and utilization of this label among the Mexican population [45].

This is the first study to describe the self-reported changes in unhealthy food purchases due to the implementation of FoPL in Mexico, contributing to the current knowledge on the impacts of front-of-pack labels at the population level. Nonetheless, results should be interpreted considering some limitations, including the non-probabilistic sampling design of the online survey, which prevents the extrapolation of the results to a national level. When comparing the characteristics of the sample in 2020 with those of the national census of 2020 [21, 22], it was observed that there were notably lower levels of overweight and obesity compared to national benchmark estimates. This fact underscores the importance of our subanalyses with the oversample of low educational level, which is more similar to the population of Mexican adults. Secondly, although this study assessed the frequency of beverage consumption, total calorie and critical nutrient intakes were not estimated; therefore, we

were unable to evaluate whether overall dietary patterns were healthier among those who self-reported reducing their purchases of unhealthy products due to the WL. Furthermore, this study did not capture detailed information regarding the specific strategies employed to reduce the purchase of unhealthy foods. For instance, we were unable to determine whether the reduction was due to portion control, decreased frequency of consumption, or substitution with products that had fewer or no WLs. Indeed, evidence from other countries suggests that fruit drinks may have replaced soda as the most consumed sugar-sweetened beverage among children [46]. In Mexico, sugary fruit drinks typically contain WLs for excess calories and sugars, while soda is additionally labeled with warning legends for sweeteners and/or caffeine (cola sodas) [39]. Future analyses should investigate substitution effects to fully understand the impact of WLs.

Although a limitation of our study is that we cannot infer causality due to the cross-sectional nature of the surveys, the results suggest similar behaviors in reducing unhealthy food purchases measured by objective metrics, such as evaluations in other countries that have implemented WLs. Examples include Chile, where a reduction of purchases of sugary beverages and "high in" labeled products was observed [18, 19], or as reported by Araya S et al., measuring changes in shopping carts purchases among Chilean consumers [47]. Additionally, the measures involved perceived self-reported changes in purchasing and beverage intake, which may be subject to recall, attribution, and social desirability biases. However, self-reported changes in food purchasing have been used in other studies to evaluate the performance of nutrition policies [48–50] because they provide insight into individuals' own perceptions and behaviors offering a unique perspective on how WLs may have impacted their daily lives and can capture nuances that objective measures might miss, such as emotional or psychological responses to interventions. The measure used to assess self-reported changes in food purchases and evaluate WLs impact was adapted from another IFPS measure previously used to evaluate the sugar-sweetened beverage tax policy [48]. Acton R, et al., utilizing data from the IFPS 2017–2019, estimated changes in perceived purchases of 14 types of sugary beverages due to the tax, asking, "Has the tax (SSB tax) changed whether you buy the following drinks for you or your family?" In Mexico, "buy less" responses ranged between 32% and 41% for taxed beverages [48], which is aligned with national survey data reporting a 6.3% reduction of taxed beverages puchases in the first year of tax implementation [51]. Subsequent comparisons of the dietary intake showed a decrease of -3.2% at 2 years and −3.7% at 4 years post-implementation [52]. While it's likely that the trend reported by IFPS might be overestimated, it still aligns with the overall direction indicated by other data sources.

Conclusion

In conclusion, our findings suggest that WLs may contribute to a reduction in the unhealthy food and beverages purchases that pose risk to the health of the Mexican population and hold significant potential for promoting healthier decision-making among both Mexican youth and adults. Self-reported decreases in the purchases of unhealthy food products, especially sugary beverages, were more pronounced among subgroups characterized by lower education levels, a low-income adequacy, self-identified indigenous individuals, and those with the highest intakes of water. These results suggest a positive impact of the labeling policy and highlight the opportunity to reinforce the promotion of healthier food choices within subgroups that self-reported fewer changes in their unhealthy food purchases. It is essential to maintain the implementation of this policy in the country and consistently promote its adoption.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12966-024-01609-3.

Additional Fig. 1. Participant Flow Diagram with Sample Size for Adults and Youth in the IFPS Study (2019–2021).

Additional Fig. 2. Odds ratio of perceiving buying less sugary drinks due to the WLs by quintile of the intake of sugary beverages and water in adults including an oversample with a low education level in 2021, International Food Policy Study, 2020 and 2021 (*n* = 8,555). Perceived purchase change in sugary drink groups included cola, soda, and sweetened fruit drinks. Sugary drink intake was based on the summed volume of regular soda, sweetened fruit drinks, regular flavored waters or vitamin waters with calories, regular sports drinks, and regular energy drinks. Median intake per quintile: Sugary drinks intake (Q1 = 71 ml, Q2 = 295 ml, Q3 = 526 ml, Q4 = 832 ml, Q5 = 1529 ml), Water intake (Q1 = 0 ml, Q2 = 357 ml, Q3 = 714 ml, Q4 = 1000 ml, Q5 = 1786 ml). Multilevel regression model adjusted by age, sex, indigeneity, educational level, income adequacy, children in the household, nutrition knowledge, role in the food shopping in the household, BMI category and year of the survey.

Additional file 1. Adjusted percentage of participants reporting that the warning labels had led them to buy less unhealthy foods overall and across food categories. IFPS 2020 and 2021. The mean and 95% CI are reported for age. Bold numbers indicate significant difference between 2020 and main sample in 2021 (*p* < 0.05). *Indicate significant difference between main sample in 2021 and including low-education level oversample. ‡For adults, BMI was categorized as < 25 (Underweight or Normal weight), 25–29 (Overweight), and ≥ 30 (Obesity). For youth, BMI z-score was categorized as ≤ 1 (Severe thinness/Thinness/Normal), > 1 to ≤ 2 (Overweight), or > 2 (Obesity).

Additional file 2. Adjusted percentage of self-reported usefulness of each of the warning label in Mexican, youth and adults in 2020 and 2021. Percentages were obtained from logistic regression models for each food

group and adjusted by year of the survey, sex, age, indigeneity, income adequacy and BMI category for adults and youth, and additionally adjusted by educational level, children in the household, nutrition knowledge, role in the food shopping in the household for adults.**Bold** numbers indicate significant difference between 2020 and 2021 ($p < 0.05$).

Additional file 3. Odds ratio of perceiving each warning label most useful for food decision making in Mexican adults and youth in 2020 and 2021.Percentages were obtained from logistic regression models for each WLs and adjusted by year of the survey, sex, age, indigeneity, income adequacy and BMI category for youth and adults, and additionally adjusted by education level, children in the household, nutrition knowledge, and food shopping role in the household for adults.**Bold** numbers indicate significant difference between 2020 and 2021 ($p < 0.05$).

Additional file 4. Odds ratio of perceiving each warning label most useful for choosing healthier foods among Mexican adults and youth, International Food Policy Study, 2020 and 2021.Odds ratios were obtained from logistic regression models.

Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was conducted according to the guidelines laid down in the Declaration of Helsinki. The study was reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#41477 and #30829). Informed consent was obtained from all respondents prior to their participation.
A full description of the study methods can be found in the International Food Policy Study: Technical Reports (2020–2021) at www.foodpolicystudy.com/methods.

Consent for publication
Not applicable.

Competing interests
DH has provided paid expert testimony on behalf of public health authorities in response to legal claims from the food and beverage industry. All remaining authors declare no conflicts of interest.

Author details
[1]Center for Nutrition and Health Research, National Institute of Public Health, Cuernavaca, Mexico
[2]National Council for Humanities, Science and Technology, Mexico City, Mexico
[3]School of Public Health Sciences, University of Waterloo, Waterloo, Canada
[4]El Poder del Consumidor A.C., Mexico City, Mexico
[5]Department of Health Promotion, Education and Behavior, Arnold School of Public Health, University of South Carolina, Columbia, SC, USA

References
1. World Health Organization. Global strategy on diet, physical activity and health Genoa. In: WHO 2002. https://apps.who.int/iris/bitstream/handle/10665/43035/9241592222_eng.pdf?sequence=1
2. Ares G, Antúnez L, Curutchet MR, Giménez A. Warning labels as a policy tool to encourage healthier eating habits. Curr Opin Food Sci. 2023. https://doi.org/10.1016/j.cofs.2023.101011
3. Cabrera LJA. Estudios sobre la influencia del etiquetado frontal en los alimentos sobre el comportamiento de los consumidores en diversos países y en Colombia Breve revisión del estado actual. 2020. https://acta.org.co/acta_sites/alimentoshoy/index.php/hoy/article/view/556/426 Accessed Sept 1st, 2023.
4. UNICEF. Policy brief. Front-of-pack nutrition labelling of foods and beverages 2021. https://www.unicef.org/media/116686/file/Front-of-Pack Nutrition Labelling (FOPNL).pdf Accessed Sept 1st, 2023.
5. Temple NJ. Front-of-package food labels: a narrative review. Appetite. 2020. https://doi.org/10.1016/j.appet.2019.104485
6. Champagne B, Arora M, ElSayed A, Løgstrup S, Naidoo P, Shilton T, Vaca McGhie D, Armstrong-Walenczak K, Berteletti F, Ganesan S, Popkin B. World Heart Federation Policy brief: Front-Of-Pack labelling: unhealthy changes in the global Food System. Glob Heart. 2020. https://doi.org/10.5334/gh.935
7. Organización Panamericana de la Salud. Etiquetado frontal. https://www.paho.org/es/temas/etiquetado-frontal#:~:text=El etiquetado frontal es una,orientar las decisiones de compra Accessed Sept 1st, 2023.
8. Comité de expertos académicos nacionales del etiquetado frontal de alimentos y bebidas no alcohólicas para una mejor salud. A front-of-pack labelling system for food and beverages for Mexico: a strategy of healthy decision-making. Salud Publica Mex. 2018. https://doi.org/10.21149/9615
9. Secretaría de Economía MODIFICACIÓN a la Norma Oficial Mexicana NOM-051-SCFI/SSA1-. 2010, Especificaciones Generales de Etiquetado Para Alimentos y Bebidas No Alcohólicas Preenvasados-Información Comercial y Sanitaria, Publicada el 5 de abril de 2010. https://www.dof.gob.mx/2020/SEECO/NOM_051.pdf Accessed Sept 1st, 2023.
10. Organización Panamericana de la Salud. Alimentos y bebidas ultraprocesados en América Latina: ventas, fuentes, perfiles de nutrientes e implicaciones. https://iris.paho.org/handle/10665.2/51523 Accessed Sept 1st, 2023.
11. Nieto C, Jauregui A, Contreras-Manzano A, Arillo-Santillán E, Barquera S, White C, Hammond D, Trasher J. Int J Behav Nutr Phys Act. 2019. https://doi.org/10.1186/s12966-019-0842-1. Understanding of food labeling systems among White, Latinos, and Mexican population: Data from the International Food Policy Study 2017.
12. Vargas-Meza J, Jáuregui A, Pacheco-Miranda S, Contreras-Manzano A, Barquera S. Front-of-pack nutritional labels: understanding by low- and middle-income Mexican consumers. PLoS ONE. 2019. https://doi.org/10.1371/journal.pone.0225268
13. Jáuregui A, Vargas-Meza J, Nieto C, et al. Impact of front-of-pack nutrition labels on consumer purchasing intentions: a randomized experiment in low- and middle-income Mexican adults. BMC Public Health. 2020;20:463. https://doi.org/10.1186/s12889-020-08549-0
14. Experimental study of front, Hock K, Acton RB, Jáuregui A, Vanderlee L, White CM, Hammond D. -of-package nutrition labels' efficacy on perceived

healthfulness of sugar-sweetened beverages among youth in six countries. Prev Med Rep. 2021;24:101577. https://doi.org/10.1016/j.pmedr.2021.101577

15. Monteiro C, Cannon G, Lawrence M, Costa Louzada ML, Pereira Machado P. Ultra-processed foods, diet quality, and health using the NOVA classification system. FAO. 2019. https://www.fao.org/3/ca5644en/ca5644en.pdf Accessed Sept 1st, 2023.

16. Petty R, Cacioppo JT. The Elaboration Likelihood Model of Persuasion. In Communication and Persuasion; Springer Science and Business Media. 1986. https://doi.org/10.1016/S0065-2601(08)60214-2

17. Taillie LS, Hall MG, Popkin BM, Ng SW, Murukutla N. Experimental studies of front-of-Package nutrient warning labels on Sugar-Sweetened beverages and Ultra-processed foods: a scoping review. Nutrients. 2020. https://doi.org/10.3390/nu12020569

18. Taillie LS, Bercholz M, Popkin B, Reyes M, colchero A, Corvalán C. Changes in food purchases after the Chilean policies on food labelling, marketing, and sales in schools: a before and after study. Lancet Planet Health. 2021. https://doi.org/10.1016/S2542-5196(21)00172-8

19. Taillie LS, Reyes M, Colchero MA, Popkin B, Corvalán C. An evaluation of Chile's Law of Food labeling and advertising on sugar-sweetened beverage purchases from 2015 to 2017: a before-and-after study. PLoS Med. 2020. https://doi.org/10.1371/journal.pmed.1003015

20. Quintiliano S, Dourado D, Gomes Ramires T, Araneda Flores JA, Pinheiro Fernandes AC. Impact of front-of-pack labeling on food purchase pattern in Chile. Nutr Hosp. 2021. https://doi.org/10.20960/nh.03311

21. Hammond D, White Cm R, Vl VL. International Food Policy Study: Technical Report – 2020 Youth Survey. University Of Waterloo. 2021. www.foodpolicystudy.com/methods Accessed Sept 1st, 2023.

22. Hammond D, White Cm R, Vl VL. International Food Policy Study: Technical Report – 2020 Survey (Wave 4). University Of Waterloo. 2022. www.foodpolicystudy.com/Methods Accessed Sept 1st, 2023.

23. Collin LJ, Judd S, Safford M, Vaccarino V, Welsh JA. Association of sugary beverage consumption with mortality risk in US adults: a secondary analysis of data from the REGARDS Study. JAMA Netw Open. 2019. https://doi.org/10.1001/jamanetworkopen.2019.3121

24. Contreras A, Lamadrid H, Guerrero C, Arango A, López Ridaura R, Malik V. Trends in Consumption of Sweet, Unsweetened and alcoholic beverages in Mexican adults: 2006 to 2016. Curr Dev Nutr. 2020. https://doi.org/10.1093/cdn/nzaa051_004

25. Evaluation of the online Beverage Frequency Questionnaire (BFQ), Vanderlee L, Reid JL, White CM, Hobin EP, Acton RB, Jones AC, O'Neill M, Kirkpatrick S, Hammond D. Nutr J. 2018;17(1):73. https://doi.org/10.1186/s12937-018-0380-8

26. World Health Organization (WHO). Chapter 6. Construction of body Mass Index- for-age standards. World Health Organization: Washington, DC, USA,; 2000.

27. Shangguan S, Afshin A, Shulkin M, Ma W, Marsden D, Smith J, et al. A Meta-analysis of food labeling effects on Consumer Diet behaviors and Industry practices. Am J Prev Med. 2019. https://doi.org/10.1016/j.amepre.2018.09.024

28. Cecchini M, Warin L. Impact of food labelling systems on food choices and eating behaviours: a systematic review and meta-analysis of randomized studies. Obes Rev. 2016. https://doi.org/10.1111/obr.12364

29. Hammond D, Acton RB, Rynard VL, et al. Awareness, use and understanding of nutrition labels among children and youth from six countries: findings from the 2019–2020 International Food Policy Study. Int J Behav Nutr Phys Act. 2023. https://doi.org/10.1186/s12966-023-01455-9

30. Acton RB, Rynard VL, Adams J, et al. Awareness, use and understanding of nutrition labels among adults from five countries: findings from the 2018–2020 International Food Policy Study. Appetite. 2023. https://doi.org/10.1016/j.appet.2022.106311

31. Shamah-Levy T, Romero-Martínez M, Barrientos-Gutiérrez T, Cuevas-Nasu L, Bautista-Arredondo S, Colchero MA et al. Encuesta Nacional de Salud y Nutrición 2020 sobre Covid-19. Resultados nacionales. Cuernavaca, México: Instituto Nacional de Salud Pública, 2021. https://ensanut.insp.mx/encuestas/ensanutcontinua2020/informes.php Accessed Sept 1st, 2023.

32. Shamah-Levy T, Romero-Martínez M, Barrientos-Gutiérrez T, Cuevas-Nasu L, Bautista-Arredondo S, Colchero MA, Gaona-Pineda EB, Lazcano-Ponce E, Martínez-Barnetche J, Alpuche-Arana C et al. Encuesta Nacional de Salud y Nutrición 2021 sobre Covid-19. Resultados nacionales. Cuernavaca, México: Instituto Nacional de Salud Pública, 2022. https://ensanut.insp.mx/encuestas/ensanutcontinua2021/informes.php Accessed Sept 1st, 2023.

33. ACUERDO Interinstitucional entre la Secretaría de Economía. la Secretaría de Salud, a través de la Comisión Federal para la Protección contra Riesgos Sanitarios, y la Procuraduría Federal del Consumidor, respecto a las actividades de verificación de la Modificación a la Norma Oficial Mexicana NOM-051-SCFI/SSA1-2010, Especificaciones generales de etiquetado para alimentos y bebidas no alcohólicas preenvasados-Información comercial y sanitaria, publicada el 5 de abril de 2010, que fue publicada el 27 de marzo de 2020. https://www.dof.gob.mx/nota_detalle.php?codigo=5597654&fecha=31/07/2020#gsc.tab=0 Accessed Sept 2nd, 2023.

34. Melo G, Aguilar-Farias N, López Barrera E, Chomalí L, Moz-Christofoletti MA, Salgado JC, Swensson LJ, Caro JC. Structural responses to the obesity epidemic in Latin America: what are the next steps for food and physical activity policies? Lancet Reg Health Am. 2023. https://doi.org/10.1016/j.lana.2023.100486

35. Swayampakala K, Thrasher JF, Yong HH, Nagelhout G, Li L, Borland R, Hammond D, O'Connor RJ, Hardin JW. Over-time impacts of pictorial health warning labels and their differences across smoker subgroups: results from adult smokers in Canada and Australia. Nicotine Tob Res. 2018. https://doi.org/10.1093/ntr/ntx134

36. Contreras-Manzano A, Jáuregui A, Vargas-Meza J, Nieto C, Granich-Armenta A, de Lourdes Alemán Escobar M, et al. Objective understanding of front of pack warning labels among Mexican children of public elementary schools. A randomized experiment. Nutr J. 2022. https://doi.org/10.1186/s12937-022-00791-z

37. Consumer G. & FMCG. Non-alcoholic Beverages. Per capita consumption of carbonated soft drinks in 2019 in the ten most populated countries worldwide (in 8-ounce servings). Statista. 2020. https://www.statista.com/statistics/505794/cds-per-capita-consumption-in-worlds-top-ten-population-countries/ Accessed Sept 2nd, 2023.

38. Contreras-Manzano A, Cruz-Casarrubias C, Munguía A, Jáuregui A, Vargas-Meza J, Nieto C, Tolentino-Mayo L, Barquera S. Evaluation of the Mexican warning label nutrient profile on food products marketed in Mexico in 2016 and 2017: a cross-sectional analysis. PLoS Med. 2022. https://doi.org/10.1371/journal.pmed.1003968

39. Arellano-Gómez LP, Jáuregui A, Nieto C, Contreras-Manzano A, Quevedo KL, White CM, et al. Effects of front-of-package caffeine and sweetener disclaimers in Mexico: cross-sectional results from the 2020 International Food Policy Study. Public Health Nutr. 2023. https://doi.org/10.1017/S1368980023002100

40. Rivera-Dommarco J, Shamah-Levy T, Barrientos-Gutiérrez T, Bautista-Arredondo S, Romero-Martínez M, Pelcastre-Villafuerte B, Torres-Pereda P. The health of mexicans living in localities with less than 100 000 inhabitants. Salud Publica Mex. 2019. https://doi.org/10.21149/10980

41. Lane MM, Davis JA, Beattie S, Gómez-Donoso C, Loughman A, O'Neil A, et al. Ultraprocessed food and chronic noncommunicable diseases: a systematic review and meta-analysis of 43 observational studies. Obes Rev. 2021. https://doi.org/10.1111/obr.13146

42. Tolentino-Mayo L, Sagaceta-Mejía J, Cruz-Casarrubias C, Ríos-Cortázar V, Jauregui A, Barquera S. Comprensión Y uso del etiquetado frontal nutrimental Guías Diarias De Alimentación De alimentos y bebidas industrializados en México. Salud Publica Mex. 2020. https://doi.org/10.21149/11568

43. Sagaceta-Mejía J, Tolentino-Mayo L, Cruz-Casarrubias C, Nieto C, Barquera S. Understanding of front of package nutrition labels: Guideline daily amount and warning labels in mexicans with non-communicable diseases. PLoS ONE. 2022. https://doi.org/10.1371/journal.pone.0269892

44. Instituto Nacional de Salud Pública. Bases de datos y cuestionarios para ENSANUT Continua 2021. https://ensanut.insp.mx/encuestas/ensanutcontinua2021/descargas.php

45. Diario Oficial de la Federación. DECRETO por el que se adiciona un artículo 216 Bis a la Ley General de Salud. 2023. https://dof.gob.mx/nota_detalle.php?codigo=5683777&fecha=24/03/2023#gsc.tab=0 Accessed Sept 1st, 2023.

46. Monteiro LS, Vasconcelos TM, Veiga GV, Pereira RA. Changes in beverage consumption among adolescents from public schools in the first decade of the century XXI. Rev Bras Epidemiol. 2016. https://doi.org/10.1590/1980-5497201600020012

47. Araya S, Noton C, Schwartz D. Identifying food labeling effects on Consumer Behavior. Mark Sci. 2022. https://doi.org/10.1287/mksc.2022.1356

48. Acton RB, Vanderlee L, Adams J, et al. Tax awareness and perceived cost of sugar-sweetened beverages in four countries between 2017 and 2019: findings from the international food policy study. Int J Behav Nutr Phys Act. 2022. https://doi.org/10.1186/s12966-022-01277-1

49. Bopape M, Taillie LS, Swart R. Perceived effect of warning label on parental food purchasing and drivers of food selection among South African parents-An exploratory study. Front Public Health. 2022. https://doi.org/10.3389/fpubh.2022.939937

50. Yeung RMW, Morris J. Food safety risk: consumer perception and purchase behaviour. Br Food J. 2001. https://doi.org/10.1108/00070700110386728

51. Colchero MA, Molina M, Guerrero-López CM. After Mexico implemented a tax, purchases of Sugar-Sweetened beverages decreased and water increased: difference by Place of Residence, Household Composition, and Income Level. J Nutr. 2017. https://doi.org/10.3945/jn.117.251892

52. Batis C, Castellanos-Gutiérrez A, Sánchez-Pimienta TG, Reyes-García A, Colchero MA, Basto-Abreu A, et al. Comparison of Dietary Intake before vs after taxes on Sugar-sweetened beverages and nonessential energy-dense foods in Mexico, 2012 to 2018. JAMA Netw Open. 2023. https://doi.org/10.1001/jamanetworkopen.2023.25191

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.