



Effects of front-of-package caffeine and sweetener disclaimers in Mexico: cross-sectional results from the 2020 International Food Policy Study

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Abstract

Objective: Front-of-package warning labels introduced in Mexico in 2020 included disclaimers that caution against allowing children to consume products with non-sugary sweeteners and caffeine. We examined the awareness and use of the disclaimers among Mexican adults and youth 1 month after the regulation was implemented. We also investigated their impact on the perceived healthfulness of industrialised beverages designed for children.

Design: Data on the awareness and use of the disclaimers were analysed. Two between-subjects experiments examined the effect of a sweetener disclaimer (Experiment 1, youth and adults) or a caffeine disclaimer (Experiment 2, only adults) on the perceived healthfulness of industrialised beverages. Interactions between experimental conditions and demographic characteristics were tested.

Setting: Online survey in 2020.

Participants: Mexican adults (≥ 18 years, n 2108) and youth (10–17 years, n 1790).

Results: Most participants ($>80\%$) had seen the disclaimers at least rarely, and over 60% used them sometimes or frequently. The sweetener disclaimer led to a lower perceived healthfulness of a fruit drink (adults: 2.74 ± 1.44 ; youth: 2.04 ± 0.96) compared with the no-disclaimer condition (adults: 3.17 ± 1.54 ; youth: 2.32 ± 0.96) (t 's: >4.0 , P values: <0.001). This effect was larger among older adults and male youth. The caffeine disclaimer did not affect adult's perceived healthfulness of a caffeinated drink ($t = 0.861$, P value = 0.3894).

Conclusions: There were high awareness and use of the sweeteners and caffeine disclaimers shortly after the warning labels were implemented. The sweetener disclaimer appears to be helping consumers modify their perceptions regarding industrialised beverages for children. Findings may help decision-makers improve the regulation and better target communication strategies.

Keywords
Warning labelling
Sugar-sweetened beverages
Healthfulness perception
Caffeine
Non-sugary sweeteners

Childhood obesity and poor dietary habits are pressing matters in Mexico and elsewhere. The prevalence of overweight and obesity in school-age children in Mexico is 35.6%, one of the highest rates globally and in Mexican history⁽¹⁾. One of the most important factors associated with this public health problem is the increasing shift in consumption of energy-dense, ultra-processed foods

high in sugar, salt and fat⁽²⁾. In Mexico, 26% of the calories in the diet of adults come from ultra-processed foods; meanwhile, the caloric share of these products among children reaches 34–38% of the total intake⁽³⁾. Soft drinks significantly contribute to energy intake in Mexico, with an average consumption of around 150 l/person annually⁽⁴⁾.

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Fig. 1 Mexican warning label system for packaged foods and beverages approved in 2020

Front-of-package labelling is a public health strategy designed to inform consumers and promote healthier choices⁽⁵⁾. In October 2020, a new front-of-package warning labelling system was implemented in Mexico⁽⁶⁾. Warning labels were initially introduced in Chile in 2016⁽⁷⁾. They informed the Mexican regulations, which consist of octagon-shaped black warnings to draw consumers' attention to 'excess(es) in' five nutrients of concern in packaged foods: calories, added sugars, saturated fat, trans fat and Na⁽⁶⁾. The Mexican regulation required additional elements compared with Chile, including precautionary disclaimers displayed as black rectangles on the front of packs to discourage child consumption of products with caffeine ('Contains caffeine, avoid in children') or non-sugary sweeteners ('Contains sweeteners, not recommended in children') (Fig. 1). A similar labelling system promoting disclaimers for caffeine and sweeteners was also implemented in Argentina in 2022; however, the results of this change are not yet known⁽⁸⁾.

Non-sugary sweeteners (hereafter, sweeteners) are increasingly prevalent in the food supply, and their consumption has increased in the past decade⁽⁹⁾. However, sweeteners have significant public health consequences. These sugar substitutes promote several physiological mechanisms contributing to adverse metabolic effects, including altered sweetness perceptions that lead to greater caloric intake⁽¹⁰⁾. Furthermore, consumption of non-caloric sweeteners increases gut microbiota dysbiosis and disrupts glucose homeostasis, which may lead to increased insulin resistance, hyperinsulinaemic response and increased adiposity^(10–13). Recent evidence also suggests a possible link between some types of sweeteners, particularly aspartame and acesulfame-K, and cancer⁽¹⁴⁾. International health organisations and national health and nutrition associations recommend that parents be advised about the risk of sweeteners in children's diets and discourage their use⁽¹⁵⁾. Despite this, it was found that sweeteners were used to replace sugars after warning labels were introduced in Chile to circumvent the application of sugar warnings on products making the sweeteners prevalent in products marketed to children and increasing the risk of exceeding the acceptable daily intake of some sweeteners in

paediatric populations⁽¹⁶⁾. Therefore, sweeteners were included in the Mexican warning label system to prevent manufacturers from reformulating their products in ways that circumvent the sugar warning as occurred in Chile.

Caffeine consumption in children has also been associated with multiple adverse health effects, including sleep disruption, poor decision-making, increased risk-taking, impaired growth and development, high blood pressure, decreased cerebral blood flow, cardiovascular complications, addiction, stress, anxiety and depression^(17,18). There is no safe dose of caffeine for children⁽¹⁸⁾. Furthermore, caffeine in already highly palatable sugary drinks, such as soda drinks, increases their hedonic properties⁽¹⁹⁾, which may promote consumption. The Mexican population highly consumes soft drinks⁽⁴⁾, including infants, toddlers and children⁽²⁰⁾. These drinks are the primary source of added caffeine intake in children and adolescents⁽²¹⁾, justifying the need to prevent youth consumption of soft drinks and associated detrimental health effects. The effect of caffeine on children's health justified the inclusion of this disclaimer in the Mexican warning label system.

To date, several studies have investigated the effects of warning labels on the perceived healthfulness of foods and their potential impact on purchasing decisions⁽²²⁾. However, to our knowledge, no evidence exists on their potential impact due to the novelty of caffeine and sweetener disclaimers. The present study examined the awareness and use of sweetener disclaimers among Mexican youth and adults 1 month after the new warning labels were implemented. We also investigated the potential impact of sweetener and caffeine disclaimers on the perceived healthfulness of industrialised beverages and whether socio-demographic characteristics modified this effect.

Methods

Study design

This article presents results from two online between-subjects experiments embedded in the Mexican arm of the 2020 International Food Policy Study (IFPS). The IFPS is a repeated cross-sectional online survey of youth (10–17 years)

and adults (≥ 18 years) from six and five countries, respectively, including Mexico, to assess the impact of food policies at the national level. Data were collected in November 2020, 1 month after the full implementation of the Mexican warning labels. Using programming in the online survey software, Alchemer, adult participants were randomly assigned to one of a series of controlled experiments, including the two described in this article. Experiment 1 examined the potential impact of a sweetener disclaimer on a sweetened fruit drink on the perceived healthfulness of that type of drink for a child. Experiment 2 examined the potential impact of a caffeine disclaimer of a caffeinated lemon-flavoured soda on the perceived healthfulness of that type of drink for a child. All participants in the youth survey were also asked to complete Experiment 1. Youth were not asked to complete Experiment 2 to accommodate shorter attention spans.

Recruitment

Participants were recruited through the Nielsen Consumer Insights Global Panel and their partners' panels using probability and non-probability sampling methods. Data were collected via self-completed web-based surveys conducted in November–December 2020 with youth (10–17 years) and adults (≥ 18 years). Email invitations with unique survey access links were sent to a random sample of panellists after targeting for demographics; panellists known to be ineligible were not invited. For the adult survey, random samples were drawn from online panels, with quotas for age and sex proportional to the general population. Respondents provided consent before completing the survey. For the youth survey, invitations were sent to adult panellists and those who confirmed they had a child aged 10–17 years in their household were informed about the study and provided consent for their child's participation. Only one child per household was invited. Children were subsequently screened to confirm eligibility, given study information and provided assent before questionnaire commencement. The child's parent/guardian and adult participants received compensation according to their panel's usual incentive structure (e.g. points-based or monetary rewards, chances to win prizes). The survey was conducted in Spanish. The adult and youth studies were reviewed and approved by the University of Waterloo Research Ethics Committee (ORE# 30829 and ORE #41477, respectively) and the National Institute of Public Health of Mexico (CI: 1641 and 1122). A full description of the study methods can be found in the International Food Policy Study Technical Reports^(23,24).

For Mexico, a total of 135 508 (adults: 81 234; youth: 54 274) email invitations were sent to a random sample of panellists. The American Association for Public Opinion Research cooperation rate #2 was 86.1% for youth and 49.8% for adults, calculated as the percentage of participants who completed the survey and were retained

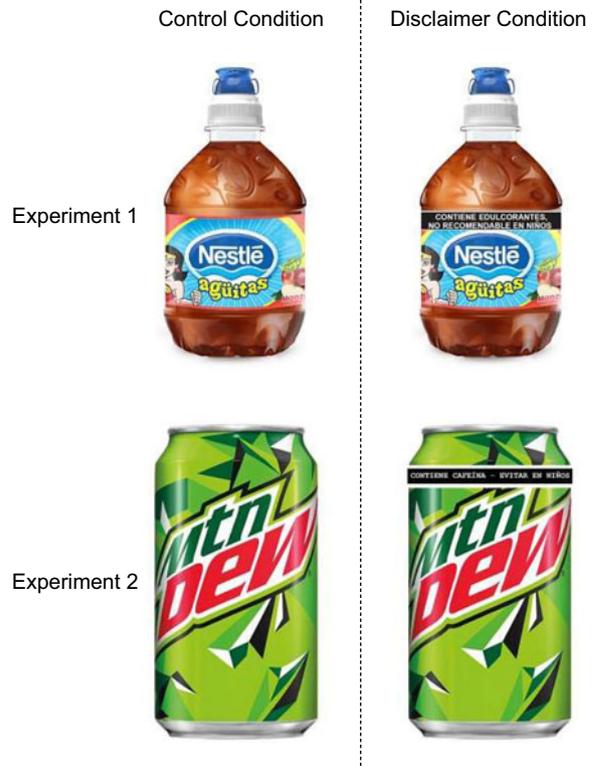


Fig. 2 Images with front-of-package labels displayed during experimental tasks. Experiment 1 = sweetener experiment. Experiment 2 = caffeine experiment. Note: each participant was only shown one image, corresponding to their assigned condition (control or disclaimer)

in the sample (adults: 4284; youth: 1823) out of that eligible who accessed the survey link (adults: 8708; youth: 2118)⁽²⁵⁾.

Measures

Disclaimer awareness and use

Youth and adult participants were asked: 'How often have you seen this type of food label on packages or in stores?', along with an image of the sweetener disclaimer. Response options were (1) Never, (2) Rarely, (3) Sometimes, (4) Often, (5) All the time, (6) Don't know and (7) Refuse to answer. All participants choosing options 2–5 were further asked: 'How often do you use this type of food label when deciding to buy a food product?', with the same response options as the previous question.

Experiments embedded in the survey

To test the effect of disclaimers, we used beverage images of real drink packages containing sweeteners or caffeine, correspondingly, and digitally altered to display the disclaimers (as applicable). The caffeine disclaimer and the sweetener disclaimer were displayed at the top front of the container, as stipulated in the Mexican regulation (Fig. 2). The regulation indicates that these disclaimers should be included when the food or beverage contains



added caffeine or sweeteners, as tested products. We only tested the effect of these disclaimers because we did not want to test the complete warning label system.

Participants' allocation and intervention

Experiment 1. Participants were randomised to view on-screen one of two images (4.5 cm × 9 cm) of a sweetened fruit drink (*agüitas*) with differing labelling: no disclaimer (control) or the disclaimer 'CONTIENE EDULCORANTES, NO RECOMENDABLE EN NIÑOS' label (Fig. 2, Panel A).

Experiment 2. Participants assigned to the caffeine experiment were randomised to view on-screen one of two images of a lemon-flavoured soda with differing labelling: no disclaimer (control) or 'CONTIENE CAFÉINA – EVITAR EN NIÑOS' label (Fig. 2, Panel B). The image used corresponded to a soda that is not common to people in Mexico.

Outcomes

In both experiments, adult participants were asked, 'In your opinion, how unhealthy or healthy is this type of drink for a child?', along with an image of the control drink or a sweetener or caffeine disclaimer. The adult survey contained nine response options: (1) Very unhealthy, (2) Unhealthy, (3) A little unhealthy, (4) Neither unhealthy nor healthy, (5) A little healthy, (6) Healthy, (7) Very healthy, (8) Don't know and (9) Refuse to answer.

Meanwhile, for Experiment 1 the youth were asked, 'Is this type of drink unhealthy or healthy?', along with an image of the control drink or a sweetener disclaimer. The youth survey included seven response options: (1) Very unhealthy, (2) A little unhealthy, (3) A little healthy, (4) Healthy, (5) Very healthy, (6) Don't know and (7) Refuse to answer. Responses were analysed as continuous data, excluding those who answered, 'Don't know' or 'Refuse to answer'.

Covariates

Demographic information included sex (male; female), age (youth: 10–13, 14–17 years; adults: 18–29, 30–39, 40–49, 50–59 or 60 years and over), ethnicity (Indigenous *v.* Non-indigenous), frequency of using a nutrition facts table (Never/Rarely, Sometimes, Often/All the time) and self-reported weight (in kg) and height (in cm). Participants were also queried about their nutrition knowledge because it is one of the first mechanisms (cognitive) by which front-of-pack labels may function to influence purchasing behaviour⁽⁵⁾. Adults were asked, 'How would you rate your nutrition knowledge?' Response options for adult participants were recoded as 'Not at all or A little knowledgeable,' 'Somewhat knowledgeable' and 'Very or Extremely knowledgeable'. Youth were asked, 'How much do you know about healthy eating and nutrition' and asked to answer on a scale ranging from 0 (Nothing) to 10 (A lot). Perceived income adequacy was measured with the following question for adults and child parents/guardians: 'Thinking about your total

monthly income, how difficult or easy is it for you to make ends meet?' (Response options recoded as 'Very difficult/Difficult'; 'Neither easy nor difficult'; 'Easy/Very easy')⁽²⁶⁾. Adult participants were asked about their education level, which was recoded as 'Low' (i.e. completed secondary school or less), 'Medium' (i.e. some post-secondary qualifications) or 'High' (i.e. university degree or higher) according to country-specific criteria related to the highest level of formal education attained. Their household shopping role was measured with the following question: 'Do you do most of the food shopping in your household?' ('Most of the shopping'; 'Share equally'; 'Share some of the shopping'; 'None'). Adults were also asked, 'Do you have any children (including step-children or adopted children)?' (Response options were 'Yes', 'No', 'Don't know', 'Refuse to answer'). Finally, youth and adult participants were asked about their agreement with the following statement: 'Boys and girls should not consume foods or drinks with sweeteners (sugar substitutes)' with response options recorded as: (1) Strongly agree, (2) Agree, (3) Neither agree nor disagree, (4) Disagree, (5) Strongly disagree, (6) Don't know and (7) Refuse to answer. Using self-reported weight and height, BMI categories were estimated according to WHO criteria for adults (kg/m²): underweight (<18.5 kg/m²) normal weight (18.5–24.9 kg/m²), overweight (25.0–29.9 kg/m²) and obesity (≥30 kg/m²) and using the WHO macro for youth (BMI for age Z-scores)⁽²⁷⁾. Further details on the IFPS study methods are available elsewhere^(23,24).

Statistical analysis

The IFPS study sample size was powered to examine differences in nutritional outcomes between countries over time and not for each task within the survey. Post-hoc analyses indicated that with a sample size of 500 participants in each experimental condition (control *v.* caffeine or sweetener experiments) and a SD of 1.5, this study had an estimated 84% power to detect a 0.25 mean difference on the 7-point Likert scale. Data analysis was performed using STATA 17.

Of the 4284 participants who completed the adult survey, 1085 were assigned to Experiment 1 (caffeine experiment) and 1098 to Experiment 2 (sweetener experiment); the remaining 2101 were assigned to other experiments not discussed in this article. Between 1.7% and 5.1% of adult participants were excluded due to missing data in the outcome (Experiment 1: *n* 18; Experiment 2: *n* 56) or a technical glitch in Experiment 1 that resulted in them being shown both conditions (control and legend) (*n* 1), leaving 2108 adult participants for main analyses (Experiment 1: 1067; Experiment 2: 1041). Of the 1823 participants who completed the youth survey, 1.8% were excluded due to missing data in Experiment 1 (*n* 29) or a technical glitch that resulted in them seeing both conditions (*n* 4); thus, the final sample size for youth was 1790. Demographic characteristics, awareness and use of the disclaimers and perceived

healthfulness of sweeteners were described using proportions and means, correspondingly, along with 95 % CI.

Differences between experimental groups for the covariates were tested using Chi-squared tests for categorical variables and *t*-tests for continuous variables. For Experiment 1, differences between experimental conditions were observed in the belief that children should not consume foods or drinks with sweeteners among adults and in the percentage of participants self-identifying as indigenous among youth. For Experiment 2 (only among adults), differences between experimental conditions were observed in the distribution of self-reported nutrition knowledge categories.

Differences in the mean perceived healthfulness between experimental conditions were tested using *t*-tests for independent means among the full sample. To account for the unbalanced covariates between experimental conditions, we also used linear regression models introducing the beverage perceived healthfulness as the outcome and the experimental condition as the exposure and were adjusted for the unbalanced variable. These models were run among those with complete information in the outcome and the unbalanced variable (Experiment 1: adults: 1066, youth: 1749; Experiment 2: 1038).

We tested for possible interactions between experimental conditions and demographic characteristics (i.e. sex, age group, income adequacy, ethnicity, education (only for adults), nutrition knowledge, food shopping in the household (only for adults), frequency of using the nutrition facts table, BMI category and the belief that children should not consume foods or drinks with sweeteners). For this purpose, linear regression modeling was used to evaluate the effect of the labels on perceived healthfulness, introducing multiplicative interactions between each demographic variable and experimental condition and adjusting for the unbalanced variable, accordingly. Only significant interactions ($P < 0.05$) were retained. Associations within the demographic variables were presented in cases where demographic \times label interactions were significant.

Results

A total of 3898 (2108 adults and 1790 youth) participants were analysed. Table 1 shows the characteristics of the study participants. In total, 80.7 % of adults and 67.3 % of youth agreed that boys and girls should not consume foods or drinks with sweeteners.

Randomisation successfully created comparable groups for most measures across experimental groups (see online Supplemental Table 1). In total, 1067 adults (control: 531; sweetener disclaimer: 536) and 1790 youth (control: 917; sweetener disclaimer: 873) completed the sweetener

experiment, and 1041 adult participants completed the caffeine experiment (control: 505; caffeine disclaimer: 536).

Disclaimer awareness and use

Over 80 % of youth and adults reported seeing disclaimer-type labels on packages or in the stores at least rarely (Fig. 3), and, among those, around 30 % and 20 % reported that they used the disclaimers sometimes or frequently, respectively, when deciding what to eat or buy. Regarding the use of disclaimers to make buy choices, 67.0 % of adults and 60.4 % of youth participants mentioned using them sometimes, frequently or all the time (Fig. 3).

Experiment 1. Effect of the sweetener disclaimer on the perceived healthfulness of a sweetened fruit drink

Among adults, the sweetener disclaimer led to a lower perceived healthfulness of the sweetened drink for a child. Participants assigned to the no-disclaimer condition reported a higher mean perceived healthfulness of the sweetened fruit drink (3.17 ± 1.54) compared with those assigned to the sweetener disclaimer condition (2.74 ± 1.44 ; $t = 4.66$, P value: < 0.001). The linear regression model adjusting for the belief that children should not consume foods or drinks with sweeteners (unbalanced variable across experimental groups) showed similar differences ($\beta = -0.39$, 95 % CI $(-0.56, -0.21)$; Fig. 4, Panel A). This effect differed across age groups (Fig. 4, Panel B). The sweetener disclaimer was more effective in reducing the perceived product healthfulness for a child among adults aged 60 years and over compared with those aged 18–29 years (interaction $\beta = -1.24$, 95 % CI $(-2.05, -0.44)$). No other differences in sweetener label effects were observed among adults across key demographic characteristics (i.e. sex, income adequacy, ethnicity, education, nutrition knowledge, food shopping in the household, frequency of using the nutrition facts table, BMI category or the belief that children should not consume foods or drinks with sweeteners).

Similar results to the ones from adults were observed among youth. Youth assigned to the no-disclaimer condition reported a higher mean perceived healthfulness of the sweetened fruit drink (2.32 ± 0.96) compared with those assigned to the sweetener disclaimer (2.04 ± 0.96 ; $t = 6.18$, P value: < 0.001). The linear regression model adjusted for ethnicity (unbalanced variable across experimental groups) showed similar differences between experimental conditions ($\beta = -0.28$, 95 % CI $(-0.37, -0.19)$; Fig. 5, Panel A). This effect differed across sex (Fig. 5, Panel B) and the belief that children should not consume foods or drinks with sweeteners (Fig. 5, Panel C). The sweetener disclaimer was more effective in reducing the perceived beverage healthfulness among boys compared with girls (interaction $\beta = -0.24$, 95 % CI $(-0.42, -0.06)$). Meanwhile, the sweetener disclaimer led to a higher mean perceived healthfulness of the drink among

**Table 1** Demographic characteristics of Mexican participants in the 2020 International Food Policy Study

	Adults (n 2108)		Youth (n 1790)	
	n	%	n	%
Sex				
Male	1046	49.6	992	55.4
Female	1062	50.4	798	44.6
Ethnicity				
Non-indigenous	1728	83.6	1529	87.4
Indigenous	338	16.4	220	12.6
Age group				
10–13 years			899	50.2
14–17 years			891	49.8
18–29 years	660	31.3		
30–39 years	544	25.8		
40–49 years	454	21.5		
50–59 years	338	16.0		
60 years and over	112	5.3		
Education level*				
Low	473	22.5	63	3.5
Medium	279	13.3	594	33.2
High	1352	64.3	1131	63.3
Income adequacy*				
Very difficult/difficult	1026	49.3	640	36.0
Neither easy nor difficult	778	37.4	721	40.5
Easy/very easy	276	13.3	418	23.5
Nutrition knowledge*				
Not at all or a little knowledgeable	695	33.0		
Somewhat knowledgeable	1141	54.2		
Very or extremely knowledgeable	268	12.7		
Nutrition knowledge			Mean	SD
			6.8	1.92
	n	%	n	%
Food shopping in your household				
Most	1508	71.6		
Share equally	425	20.2		
Some	142	6.7		
None	33	1.6		
Frequency of using nutrition information				
Never/rarely	681	32.7	914	51.7
Sometimes	634	30.4	465	26.3
Often/all the time	770	36.9	390	22.1
BMI category				
Underweight	37	1.8	21	1.3
Normal weight	790	37.5	735	43.1
Overweight	654	31.0	426	25.0
Obesity	304	14.4	183	10.7
Don't know or no response	323	15.3	339	19.9
Having a child in the household*				
No	1376	63.4		
Yes	729	34.6		
Boys and girls should not consume foods or drinks with sweeteners*				
Strongly agree/agree	1696	80.7	596	67.3
Neither agree nor disagree	266	12.7	209	23.6
Disagree/strongly disagree	141	6.7	81	9.1

*Smaller sample sizes are presented due to missing information.

those who disagreed or strongly disagreed that children should not consume foods or drinks with sweeteners (interaction $\beta = 0.67$, 95% CI (0.21, 1.13), Fig. 5 Panel C) compared with those who agreed with this belief. No other differences in label effects across key demographic characteristics (i.e. age category, income adequacy, ethnicity, nutrition knowledge, frequency of using the nutrition facts table or BMI category) were observed among youth.

Experiment 2. Effect of the caffeine disclaimer on the perceived healthfulness of a caffeinated drink

No differences in the perceived healthfulness of a caffeinated drink for a child were observed between adults assigned to the no-disclaimer condition (2.05 ± 1.30) *v.* the caffeine disclaimer (1.98 ± 1.32 ; $t = 0.861$, P value = 0.389) (Fig. 6). Similar results were observed in a linear regression model adjusted for nutrition knowledge (unbalanced

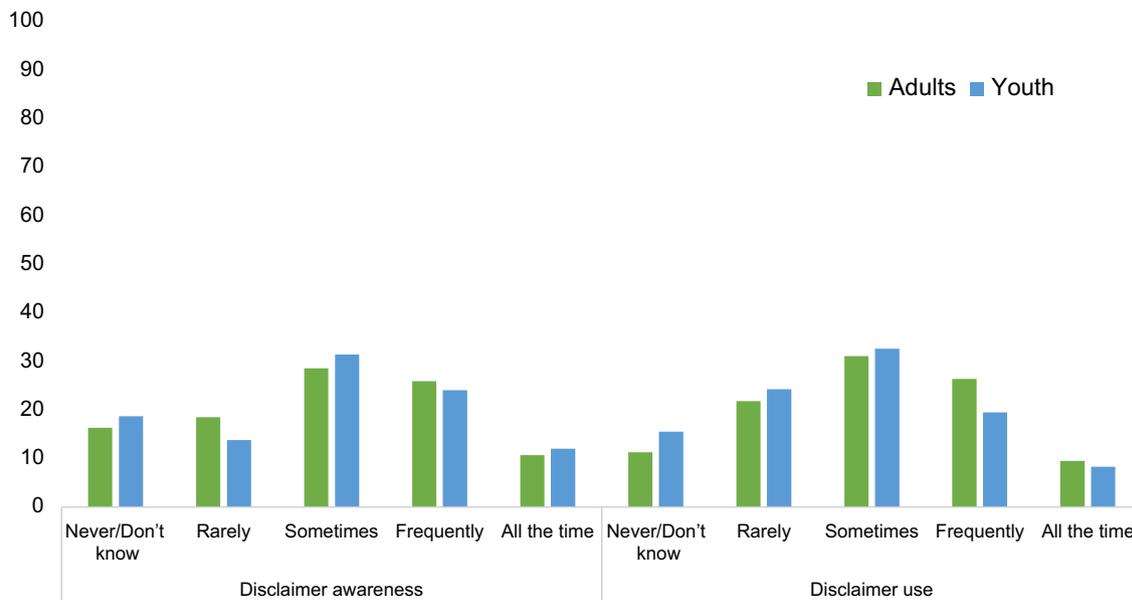


Fig. 3 Awareness and use of disclaimer-type labels among Mexican adults and youth

variable across experimental groups) ($\beta = -0.06$, P value = 0.442). No differences in label effects were observed across key demographic characteristics (i.e. sex, age category, income adequacy, ethnicity, education, nutrition knowledge, food shopping in the household, frequency of using the nutrition facts table, BMI category or the belief that children should not consume foods or drinks with sweeteners).

Discussion

This study found that shortly after implementing the new warning labels in Mexico, over 80 % of adult and youth participants were aware of the sweetener disclaimers. Over 60 % reported using this type of disclaimer sometimes or frequently. These findings are consistent with those from a study among Uruguayan adults showing that 77 % had seen nutritional warnings when making food purchases during the first month of full compliance⁽²⁸⁾ and studies in Chile reported that the regulation was well known in the country after the first year of implementation^(29,30). In Mexico, some retailers started applying warning labels and disclaimer stickers to products already in stock immediately after the regulation was approved in April 2020⁽⁶⁾. These stickers were progressively replaced by labels printed on the front of food packages by the end of March 2021. Therefore, consumers were exposed to the new warning labels and disclaimers well before manufacturers were required to comply with the regulation in October 2020 fully, either by a sticker (until 31 March 2021) or printed in the package.

Our randomised experiments showed that a sweetener disclaimer led youth and adults to perceive a sweetened drink as less healthy than a drink without a label. Although

research on the health impacts of artificial sweeteners is novel, evidence has consistently questioned their safety for children^(10–13) and, more recently, for adults⁽¹⁴⁾. Studies among adults⁽³¹⁾, parents^(32,33) and children⁽³³⁾ have suggested that sweeteners are generally perceived as unhealthy due to their synthetic origin, carcinogenic and addictive potential. In line with these perceptions, our data showed that a high proportion of adults and adolescents believed children should not consume products with sweeteners. The inclusion of these disclaimers in the recently implemented warning label systems in Mexico and Argentina was based on this evidence. The findings of this study support the potential effect of this additional disclaimer in the warning label system to help adults and young consumers identify the harmful properties of industrialised drinks consumed by children and promote the purchase and consumption of beverages that do not have sweeteners. To further elucidate the potential impact of these warning labels on health outcomes, future experimental or real-life studies may wish to explore how sweetened drinks are substituted (e.g. by plain water or other types of processed drinks) among those who indeed modify their purchasing intentions due to the sweetener disclaimers.

Our findings also suggest that the effect of the sweetener disclaimer may differ across demographic characteristics. Among adults, sweetener disclaimers led to a lower perceived healthfulness of the sugary drink among older compared with younger participants. Similarly, a larger effect of warning labels on the perceived healthfulness ratings of a sugary drink was observed among older adults than younger adults from the UK⁽³⁴⁾. It has been stated that older adults have greater health risk perceptions (how individuals subjectively estimate and feel about the risks

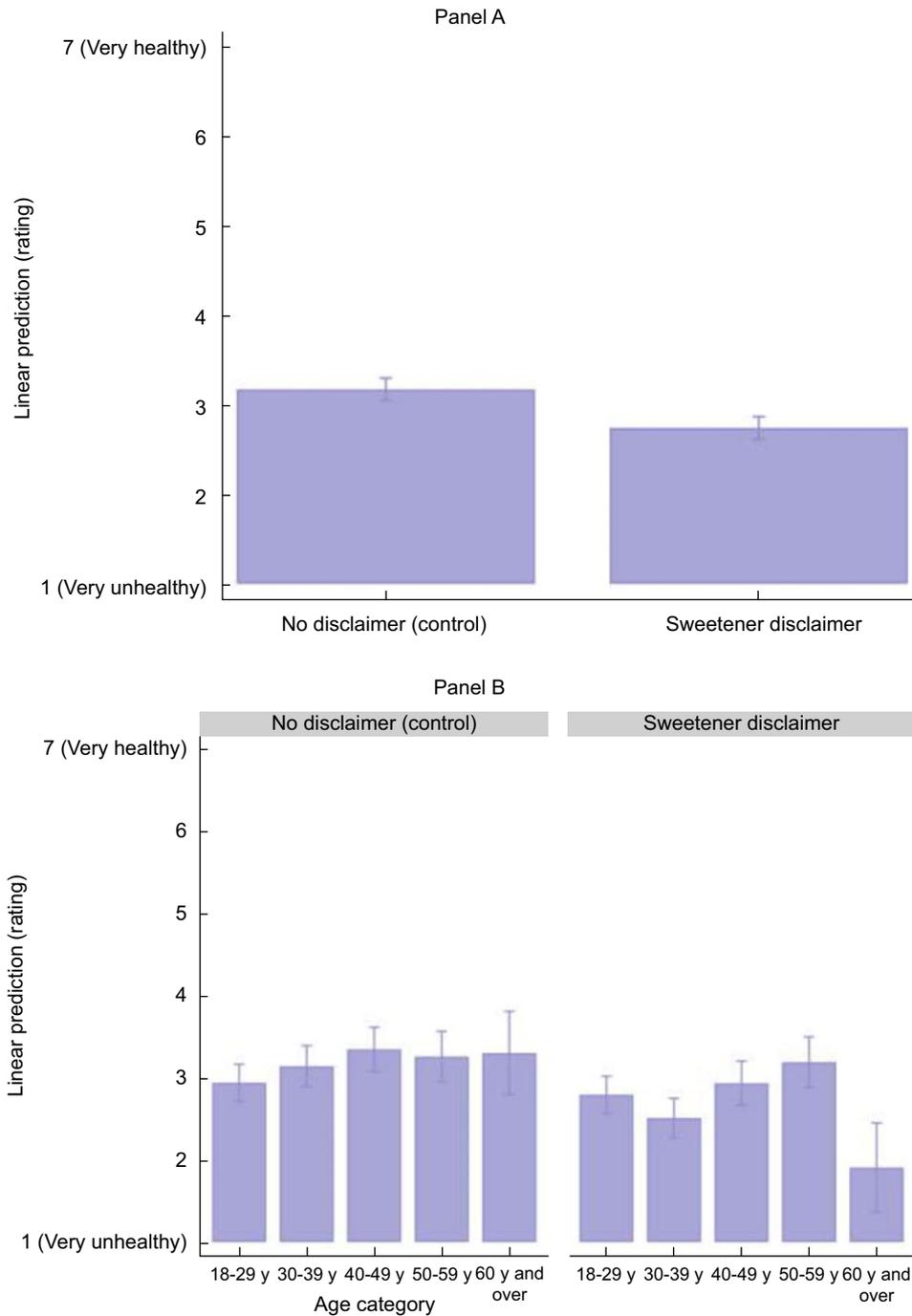


Fig. 4 Perceived healthfulness of a sweetened fruit drink with and without the sweetener disclaimer among adults. Estimations in the total sample (a) and across age categories (b) (*n* 1020). Linear predictions in the total sample were derived from linear regression models adjusted for the belief that children should not consume foods or drinks with sweeteners (unbalanced variable across experimental conditions). Linear predictions across age categories were derived from linear regression models introducing multiplicative interactions between age categories and experimental condition and adjusted for the same covariate

they face) compared with their younger counterparts^(35,36). Others have suggested that older age is associated with an increased tendency to use nutrition labels because of an increased interest in healthy eating as individuals get older⁽³⁷⁾ and/or increased efforts to meet specific dietary requirements as the metabolism declines with age⁽³⁸⁾. However, the measure in our study was about whether the

beverage with the sweetener disclaimer was healthy for children, not for themselves. It is possible that this higher risk perception could also increase adults' responsiveness to sweetener disclaimers on products for children.

Similarly, the effect of the sweetener disclaimer among youth differed by sex, with larger effects among males compared with females. To date, few studies have

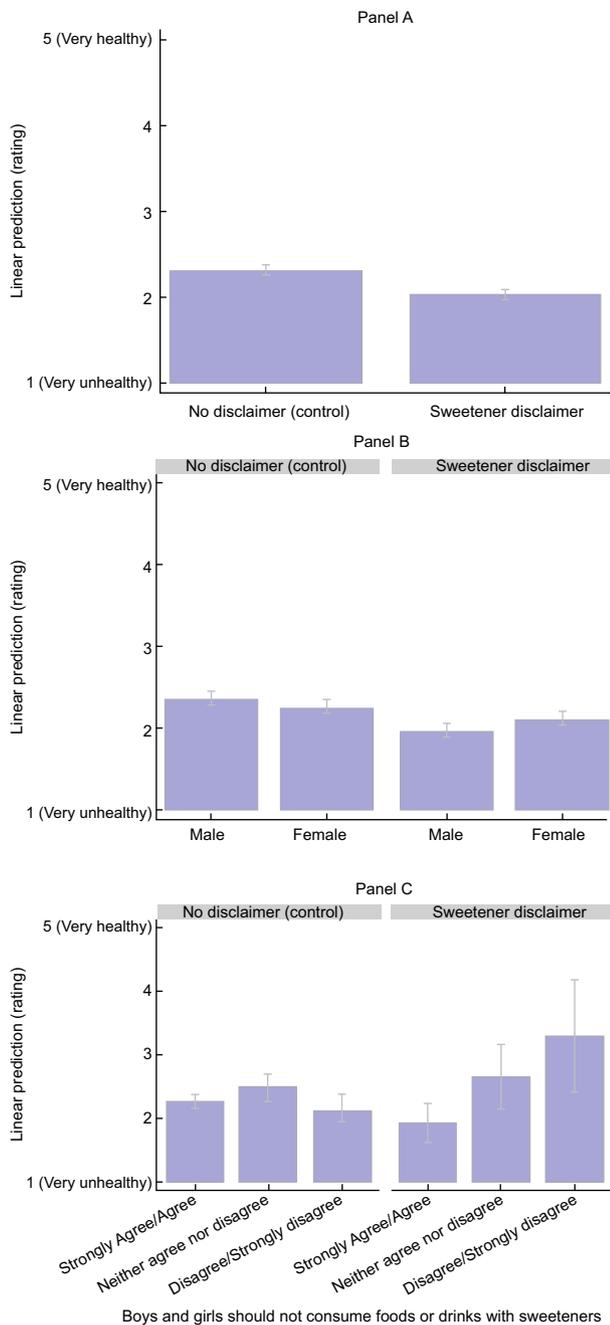


Fig. 5 Perceived healthfulness of a sweetened fruit drink with and without the sweetener disclaimer among youth. Estimations in the total sample (a), across sex (b) and the belief that children should not consume sweeteners (c) (*n* 1790). Linear predictions in the total sample were derived from linear regression models adjusted for ethnicity (unbalanced variable across experimental conditions). Linear predictions across categories were derived from linear regression models introducing multiplicative interactions between categorical variables and experimental condition and adjusted for the same covariate

investigated the effect of front-of-pack labels among youth^(39–41), and, to the authors' knowledge, none has reported sex differences in their effects. Differences in usual beverage consumption patterns may help explain these differential findings by sex. Studies in Mexico and

other countries suggest that male adolescents are more likely to consume unhealthy beverages, including soda^(42,43). Therefore, males may be more susceptible to this disclaimer because they are heavier consumers of these sorts of drinks.

Among youth, the effect of the sweetener disclaimer also differed by the belief that children should not consume sweeteners. Opposite to the expected effect, the sweetener disclaimer led to a higher beverage perceived healthfulness among youth who disagreed that children should not consume foods or drinks with sweeteners. These results suggest that, among this population group, the disclaimer is misinterpreted as a positive attribute of the beverage. Mixed-methods studies by our research team have suggested that Mexican children and adolescents do not understand what sweeteners are and are generally interpreted as colour additives perhaps because these two words are very similar in Spanish: sweetener in Spanish is *edulcorante*, while colour additive is translated as *colorante* in this language (unpublished data). Additionally, although the Mexican regulation considers caffeine and sweetener disclaimers targeting children as defined by the United Nations ('a person under the age of 18 years')⁽⁴⁴⁾, this word in Mexico is generally interpreted as school-age children. Therefore, youth participants may not consider themselves children and may believe this artificially sweetened drink is healthier than a regular sugary drink. It is also possible that this population group could not identify sweeteners as harmful, possibly because the food industry promotes them as a positive ingredient, producing a potential misunderstanding of their health impact. Marketing used in some 'diet,' 'organic' or 'healthier' food products promotes sweeteners as a beneficial ingredient, frequently placed in front of the package as a desirable characteristic (e.g. using logos), indirectly indicating that it is better than sugar.

Our study also suggests that a caffeine disclaimer does not influence the perceived healthfulness of a caffeinated soda for children among Mexican adults. This null finding may be explained by the type of drink used to test the disclaimer. Soda is commonly assumed to be an unhealthy beverage, leaving little place for the caffeine disclaimer to modify this perception. However, we used this beverage because sodas comprise the vast majority of products labelled with the caffeine disclaimer in Mexico⁽⁴⁵⁾. Another potential explanation for this finding may be related to the fact that caffeine is highly consumed among the Mexican population, including infants, children and youth, which could contribute to the normalisation of the high and extensive consumption of caffeinated drinks. In Mexico, introducing tea or coffee to the diet of infants is a common practice^(20,46), and coffee and soda are highly consumed by children and youth⁽⁴²⁾. These consumption practices are deep-seated social norms and essential to Mexican cultural and culinary traditions, on special occasions (e.g. holidays) and daily life. However, we did not measure the perceived healthfulness of caffeine among participants. Despite the

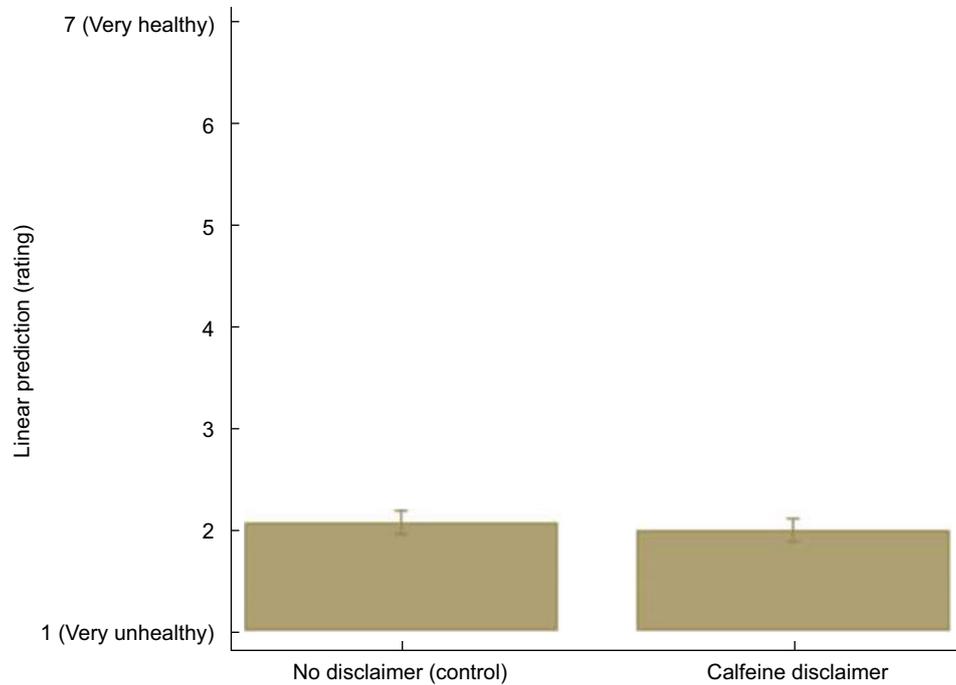


Fig. 6 Perceived healthfulness of a caffeinated drink with and without the caffeine disclaimer among adults. *n* 1041. Linear predictions derived from linear regression models adjusted for nutrition knowledge

null effect of the caffeine disclaimer alone on the perceived healthfulness of a caffeinated soda observed in our study, future studies should explore how the caffeine disclaimer may contribute to the overall effect of warning labels and how the social normalisation of caffeine consumption in Mexico may contribute to a low perceived risk of caffeine. It is desirable to assess the effect of the caffeine disclaimer on youth since they are likely to consume coffee, sodas and energy drinks that contain caffeine⁽⁴²⁾, and they may be unaware that sodas are unhealthy and of the health effects of caffeine⁽⁴⁷⁾.

The findings of this study may provide relevant insights for policy- and decision-makers regarding front-of-pack labelling systems and may be used to monitor and improve the warning label policy implemented in Mexico. Results clearly suggest that communication strategies should be implemented in Mexico, and possibly in other countries using similar warning label systems, to change the social norm around the consumption of caffeinated beverages by children and promote awareness of the negative impacts of caffeine on children’s health⁽⁴⁷⁾. In addition, these findings also offer valuable information for better targeting communication campaigns. These campaigns can include personalised messages about the adverse health effects of sugar, sweeteners and caffeine. By targeting different audiences appropriately, such campaigns can have a more profound and positive impact on healthy decision-making in the population. Despite plausible explanations for the counterintuitive findings on the effect of the sweetener disclaimer among specific population groups, our results emphasise the need to implement communication

strategies that clearly explain what sweeteners are and how to interpret this disclaimer correctly, specifically among children. It is also necessary to apply more robust policies to the food industry regarding the ‘placement’ of sweeteners as something good for health and to regulate their use in foods and beverages and marketing, especially in those made for children.

To our knowledge, this is the first study investigating the potential impact of caffeine and sweetener disclaimers on the perceived healthfulness of industrialised beverages consumed by children. Strengths of this study include using a randomised design, limiting the influence of confounding from observed and unobserved factors, and a national sample of Mexican adults and youth. Nonetheless, results should be interpreted within the context of several limitations. Respondents were recruited using non-probability-based sampling; therefore, the findings do not provide nationally representative estimates. This study examined the potential impact of disclaimers on perceived healthfulness using a single-item measure. To expand evidence on the effectiveness of labels in communicating the relative healthfulness of products, future studies should explore the effect of labels using multiple measures across a range of healthy products, including direct comparisons between their healthfulness and the likelihood of purchase. Further, these disclaimers were evaluated alone on the front of the pack of the product, and the experiment was not performed in a store. In real-life situations, caffeine and sweetener disclaimers are generally presented in combination with other warnings (e.g. regular cola drinks are



also labelled with warnings for calories, sugar, sweeteners and caffeine). Therefore, the effect may differ in a real-life situation or shopping environment.

Conclusion

There were high awareness and use of the disclaimers among study participants shortly after implementing the warning label regulation in Mexico. A sweetener disclaimer appears to be an effective intervention for helping consumers modify their perceived healthfulness of industrialised beverages consumed by children. Meanwhile, the caffeine disclaimer did not affect the perceived healthfulness of a caffeinated drink for a child among adults. Findings may be used by decision-makers to improve the front-of-pack labelling regulation in Mexico or other countries considering similar warning label systems. Our results highlight the need to implement communication strategies to promote awareness of the negative impacts of caffeine and sweeteners on children's health and the correct interpretation of warning labels and provide relevant data for better targeting these efforts.

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Conflicts of interest

There are no conflicts of interest.

Authorship

L.P.A.G. contributed to the statistical analysis and data interpretation and drafted the manuscript. A.J. conceived the study, participated in the design of the study, analysed and interpreted the data and helped draft the manuscript. C.N. and A.C.M. helped conceive and design the study, interpreted the data and substantively revised the manuscript. K.L.Q. helped interpret the data and substantively revised the manuscript. C.M.W., J.F.T., R.E.D., D.H. and S.B. helped conceive of the study, participated in the design of the study and substantively revised the manuscript. All authors read and approved the final manuscript and have agreed both to be personally accountable for their own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which they were not personally involved, are appropriately investigated, resolved and the resolution documented in the literature.

Ethics of human subject participation

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving research study participants were approved, reviewed by and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE# 30829 and 41477) and the Research Ethics Committee from the National Institute of Public Health in Mexico (CI # 1641). Written informed consent was obtained from all subjects/patients.

Supplementary material

For supplementary material accompanying this paper visit <https://doi.org/10.1017/S1368980023002100>

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