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Traffic light nutrition labeling preferences among children

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Abstract

Objective: This study evaluates the effects of traffic light (TL) nutritional label attributes on children's food choices. Data were collected from a survey of 1179 Ecuadorian students attending public middle and high school in three major cities in the country's southern region (Machala, Loja, and Zamora). The survey instrument included two sets of choice experiments: one with yogurt products and the other with soft drinks (sodas and juices). In the choice scenarios, children were presented with two products that differed in price and the TL label colors for sugar, salt, and fat. Children's product selections in the choice experiments were analyzed using mixed logit models. The results indicate that labels affect food choices. Additionally, children are willing to pay increasing premium levels for products with yellow, green, and "does not contain" labels compared to products with red labels. Overall, the study's findings offer evidence that TL labels are effective in helping children make food choices consistent with their preferences for food products with TL labels representing healthier alternatives.

Keywords: Nutrition, Labeling, Choice experiment, Children, Willingness to pay, Ecuador

Introduction

Global obesity has been rising for decades, prompting many countries to adopt policies to address this widespread health problem. Worldwide, the rate of obesity has doubled since 1980 (Fox et al. 2019). Obesity is a problem since it has been found to increase the risk of noncommunicable diseases, estimated to cause about 74% of deaths globally (WHO 2022a). The global COVID-19 pandemic attracted even more attention to the obesity problem, as it was determined to be one of the top risk factors, as higher degrees of obesity were linked to increased COVID-19 hospitalizations, intensive care admissions, the need for specialized equipment such as ventilators and mortality (Yang et al. 2021).

While commonly thought to affect wealthier, high-income countries, lower- and middle-income countries are experiencing increasing trends in the rates of obesity (Malik et al. 2020). People of all age groups are also affected by the problem, including children.

Fig. 1 Traffic light label colors and nutrients of ecuadorian traffic light nutritional label system (Spanish: Alto = High; Medio = Medium; Bajo = Low)

According to the World Health Organization (WHO), 340 million children under the age of 5 and 340 million ages 5–19 are overweight or obese, and lower- and middle-income countries have seen dramatic increases in childhood obesity (WHO 2022b). For example, Africa has experienced a 24% increase in obesity for children under 5 in the past two decades (WHO, 2022b). Since obesity is a complex problem, there are no simple solutions, and various strategies for its prevention have been recommended across five environments: physical activity, food and beverage, marketing and messaging, health care and worksites, and schools (Chriqui 2013). Nutrition labeling is at the forefront of the battle to inform and influence healthy food and beverage choices among consumers. While many countries have a combination of mandatory and voluntary nutrition labeling requirements and specifications, the study of the efficacy of nutrition labeling policies is primarily focused on adult consumers (Jensen et al. 2022; Hall et al. 2022; Song et al. 2021). However, as explained previously, obesity is also a problem among children. Therefore, the main objective of this study is to evaluate the effects of TL nutritional labels' attributes on children's food choices and preferences. Conducting studies on children's food preferences and choices can be helpful in the design of educational programs and policies targeting this population group, as it is well documented that children have unique food preferences and habits (Michaels-Igbokwe et al. 2021; Pereira-Chaves and Salas-Melendez 2017).

Ecuador, a middle-income country in the northwestern part of South America, provides a unique context for evaluating the effects of nutritional labels on children's food choices. First, the country presents some of the highest levels of overweight and obesity among the children population in the region (UNICEF 2022). Results from the 2018 National Nutrition and Health Survey conducted in Ecuador (ENSANUT) show that being overweight or obese affects 29.9% of kids (5–11 years old) and 26.0% of adolescents (12–19 years old) (INEC 2018). Second, Ecuador was the first country in Latin America to adopt a mandatory supplemental nutritional labeling system in 2013 (Garcia 2023; MIP 2013).

The regulation introduced by the Ecuadorian Ministry of Industry and Productivity (MIP) requires using the traffic light (TL) supplemental nutritional labeling system on the packages of all processed food products (Fig. 1). There is, however, limited literature evaluating the use, preferences for, and effect of the TL nutritional label implemented in Ecuador almost a decade ago. Most studies on these topics were carried out using data one or two years after implementing the TL system and are qualitative (e.g., Sandoval et al., 2019; Peñaherrera et al. 2019; Poveda 2016; Díaz et al. 2017), and very few studies have evaluated preferences for TL labels among Ecuadorian children and, more generally, for children's preferences for supplementary nutritional labels in all countries (e.g., Galarza et al., 2019). This is especially important in developing countries, such as Ecuador, as children have a lot of freedom to purchase food at school or in the streets.

Background on the Ecuadorian nutritional labeling system

The general standards used around the globe for food labeling are primarily based on the Codex Alimentarius (Codex Alimentarius Commission 1999). These standards recommend using food labels that include the food's name, ingredients, weight, and address of manufacturer/packer/vendor, date, instructions, and notice of ionizing radiation. Although each government can regulate these standards, leading to considerable variability among nations (Meijer et al. 2021), most countries use a combination of voluntary and mandatory labeling practices that generally include some nutritional information.

Two main nutritional labels are used for packaged food products (FAO and WHO 2001). The first one is the nutrient declaration/facts label that provides consumers with a summary of the nutrient composition of the food product. The second one is the supplementary nutrition information label. Supplementary labels are included to facilitate consumers' understanding of the nutritional content of food products and are recommended by the WHO (2022b).

Supplementary nutritional labels generally fall into two categories: interpretative and noninterpretive. Interpretative labels use symbols, figures, and/or cautionary text to inform consumers about the healthfulness or nutrient contents. Traffic light labels, nutrient scores, nutrient warnings, and health warnings are the most used interpretative nutrition information labels (Song et al. 2021). In contrast, noninterpretive supplementary nutritional labels convey information using numbers.

The Ecuadorian TL nutritional label system provides consumers with graphical information about the content of total fat, sugar, and salt (sodium) in processed food products and beverages (MSP 2013; Sarasty et al. 2023) (Fig. 1); thus, it is an interpretative type of supplementary nutritional label. The TL label used in Ecuador has three different colors that represent the levels of three nutritional components (sugar, salt, and fat) in one serving of a processed food product (Appendix 1). For each nutrient, the red label indicates a high content of the nutritional component, yellow indicates a medium content, and green indicates a low content. Moreover, the phrase "does not contain" is used if no nutritional component is present. The TL nutritional labeling can be located on the package's front, side, or back (MSP 2013).

Literature review

There is already a body of literature evaluating the effectiveness of TL and other interpretative labels modifying several outcomes, including understanding labels and products, consumers' perceptions of products, purchases, and consumption. Song et al. (2021) provide a meta-analysis of this literature covering 156 studies, including 97 studies related to TL labels. These authors find that TL labels increase the likelihood of choosing healthier products and are the government's most endorsed labeling system. Of the 156 studies reviewed, 88% had a population of adults, leaving out a large population of younger individuals with rising obesity rates. The meta-analysis also identified only 30 studies evaluating the effects of TL labels on behavioral changes (intended or actual).

Studies evaluating the effectiveness of interpretative nutrition labels on children have mainly focused on children's perceptions (e.g., Lima et al. 2018, Ares et al., 2021a; Hémar-Nicolas et al. 2021) and much less on food preferences and choices (Saavedra-Garcia et al. 2022; Ares et al. 2021b). Saavedra-Garcia et al. (2022) studied Peruvian adolescents (10–14 years old) to determine whether warning labels influenced their purchase intention. The study concluded that warning labels did not influence healthier purchase intentions. Another study among children in grades 4–6 in Uruguay found that including TL labels had a minor effect on children's choice of cookies and no influence on the selection of orange juice (Arrúa et al. 2017). Both studies excluded price in the selection process. Studies evaluating the effectiveness of the TL labels among children in Ecuador are also limited. The few studies we identified focused on label knowledge and self-reported preferences and use (Cabrera et al. 2022; INEC 2018; Galarza et al. 2019).

Our study aims to fill gaps in the literature related to interpretative nutrition labels' influence on children's food choices and preferences, primarily focusing on the effect of TL labels. Moreover, relative to previous studies, the experiments represent a more realistic situation where children are asked to make trade-offs between food quality attributes and the price paid, describing the scenario common in many countries where children make consumption and purchase decisions. The choice experiments use yogurt and soft drinks to evaluate the heterogeneity of the effects of TL on food choices related to product type. We aim to examine how TL label effects vary across various food categories by using more than one product. Finally, the study evaluates the impact of attribute levels (i.e., colors) rather than the presence or absence of the TL label, which has not been considered in previous research evaluating the effects of TL labels on children's food choices.

Methods

Data collection

Data were collected from a survey of 1179 Ecuadorian students attending public middle and high schools in three major cities in the country's southern region (Machala, Loja, and Zamora). The city of Machala is the capital of the Province of El Oro. Its population is 261,422, and 25,147 adolescents are enrolled in middle and high schools. The city of Loja, the capital of the province of the same name, has a population of 214,855, and 28,745 adolescents are enrolled in middle and high schools. Finally, Zamora, the capital of the Province of Zamora Chinchipe, has a population of 120,416, and 2654 adolescents are enrolled in middle and high schools. These three cities represent populations of three geographic regions: the Coastal area (Machala), the Sierra (Loja), and the Amazon region (Zamora), but they belong to the same regional educational authority. Students selected were between 12 and 18 years of age. Middle school students are from the ages of 12 to 15 years old, and the high school students are from 16 to 18 years old.

The survey was conducted from November 2020 to January 2021. The sample selection process was carried out in two stages. First, we randomly selected four schools in each city. Second, about 100 students were randomly selected within each school. At the time the survey was conducted, students were receiving classes virtually due to lockdowns

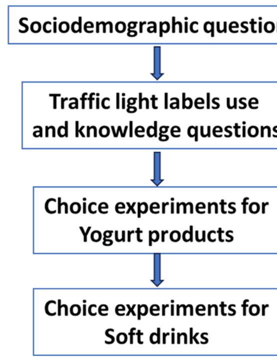


Fig. 2 Survey diagram

and restrictions related to the SARS-CoV2 pandemic. So, the survey was done online using Qualtrics.

Educational authorities within each school provided all the teachers' names and contacts. During the pandemic, groups of students were assigned to teachers who coordinated class activities. These teachers gave the researchers access to the virtual classrooms to contact the participating students. The researchers explained the study's objective to the students within the virtual classroom and shared the survey link for its application.

Texas Tech University's Institutional Review Board (IRB) approved the study on November 20, 2019 [IRB2019-1246]. The research protocol required authorization from the regional educational authority, each school, parents and/or legal representatives of the participating adolescents, and the participating students (informed consent).

Survey development

A research group that included economists, public health, and educational professionals from Ecuador and the USA developed the survey instrument. Given the study's objectives, the survey was organized into three sections: (1) sociodemographic characteristics (age, province, gender, and grade); (2) students' use and knowledge of TL labels and purchasing habits at school; and (3) choice experiment scenarios to assess their preferences for nutrient levels represented by the traffic light labels. A survey diagram can be seen in Fig. 2. The survey instrument is available in Appendix 2.

A pilot test was conducted with 100 adolescents in the city of Loja (educational unit different from those who participated in the final survey) to assess children's understanding of the survey and its feasibility. The time to complete the survey averaged less than eight minutes, and the quality of the responses (number of complete responses) were analyzed. Some students were also informally interviewed to assess their understanding of the instrument. The information obtained in the pilot survey was used to refine the final survey instrument.

Students' knowledge of TL labels was evaluated using two questions:

(1) What components are included in the traffic light nutritional label? (one item)
(2) What is the level of the nutritional content associated with each color on the traffic light label? (three items)

A knowledge score was assigned from 0 to 4 points, depending on the number of correct answers (Cabrera et al. 2022). Students' TL label use was assessed by a question asking them about their frequency of use.

Finally, information on students' shopping habits was obtained using questions about the amount of money provided by their parents for buying food at school, the place of purchases (school, street, or stores), and the types of products purchased (see Appendix 2).

Choice experiment

The survey instrument consisted of two sets of choice experiments. One included yogurt products and the other soft drinks (sodas and juices). The first set of choice experiments had six scenarios. In each scenario, respondents faced two yogurt bottles with the same package, flavor, and amount of 150 g, but differed in price and the TL label colors for sugar, salt, and fat (Fig. 2a). The second set of choice experiments also included six scenarios where respondents faced two bottles of soft drinks (soda or juices) of 600 ml that differed in price and had the TL label colors for sugar (Fig. 2b). Respondents were asked to select between two product profiles or a "none" option in each choice scenario (Fig. 2). Yogurt was chosen for this study because it contains the three attributes presented in the TL labels (sugar, salt, and fat) at varying concentration levels. Additionally, yogurt is a popular food in Ecuador, commonly consumed as a snack and during breakfast and lunch (El Universo 2021). Similarly, soft drinks were selected because they are among the most popular beverages consumed in the country, with reported consumption rates of 84% among teenagers aged 15–19 years (El Universo 2014) (Fig. 3).

Table 1 shows the product price and non-price attributes for yogurt and soft drinks. These non-price attributes (sugar, salt, and fat) and levels were defined after reviewing the product database from the Kantar World Panel Company and a nutrient composition database of yogurt and soft drink products of the National Agency for Health Regulation, Control and Surveillance of Ecuador (ARCSA) (Kantar World Panel, 2019). Soft drinks' TL label characteristics for salt (green) and fat ("it does not contain") did not vary across the products, as most soft drink products in the country only differ in terms of the TL label indications for sugar.

The price attributes included in the experiment were defined based on a sample of prices from four retail locations in the country (supermarkets and convenience stores) between October and November 2020. The average price for yogurt was \$0.71 for a 150-g product and \$0.57 for a 600-ml soft drink product. Consequently, price levels in the experiments were set using 5% and 15% values above and below the average observed price in those cities.

SAS software was used for the experimental design of the choice experiments. For the yogurt experiment, the combination of all labels for sugar, salt, and fat and price levels resulted in a total of 72 ($3 \times 3 \times 2 \times 4$) product profiles and 2566 possible choice scenarios $\left(C_{72}^{2}\right)$. For the soft drink experiment, the combination of sugar labels, drinks, and price resulted in a total of 32 ($4 \times 2 \times 4$) product profiles and 496 possible choice scenarios $\left(C_{32}^{2}\right)$. Fractional factorial design selection procedures were used to create 18 possible choice scenarios for yogurt and soft drinks. The choice scenarios were then blocked into

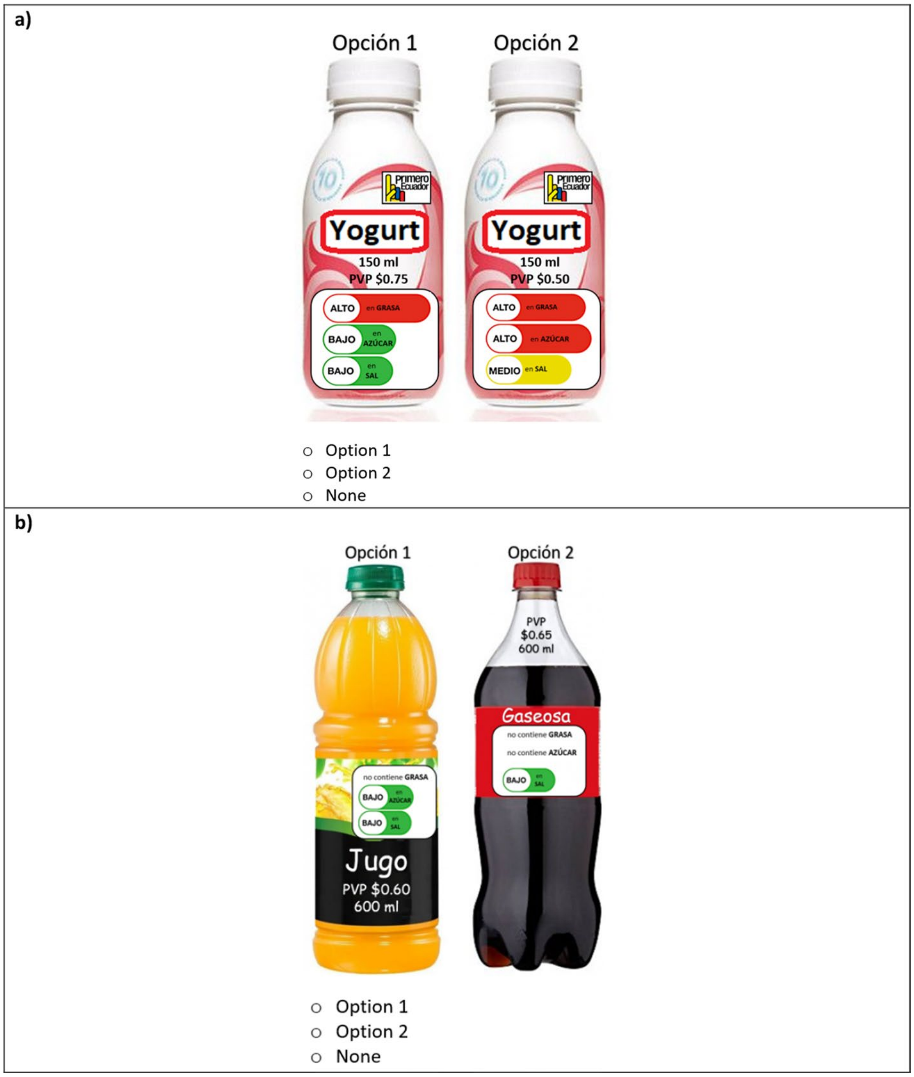


Fig. 3 Choice experiments examples: **a** yogurt products and **b** soft drink products

three versions of the questionnaires for each product. Therefore, every respondent was offered only six choice scenarios for yogurt and soft drinks, respectively.

Data analysis

Discrete mixed logit regression procedures were used to model children's product selection in the choice experiments as a function of products' attributes (price and TL label colors for sugar, salt, and fat) (Fig. 1). Results of the mixed logit models were subsequently used to estimate the effects of the attributes on the probability of food choices and individual-level willingness-to-pay (WTP) values for the TL label colors for each nutrient. Finally, we analyzed the effects of sociodemographic characteristics and TL label use and knowledge of children's WTP values for the TL colors using panel data regression models.

Table 1 Attributes and levels for the choice experiments

Product	Attribute	Level
Yogurt	Fat label	Red label
		Yellow label
		Green label
	Sugar label	Red label
		Yellow label
		Green label
	Salt label	Yellow label
		Green label
	Price	\$0.50
		\$0.65
		\$0.75
		\$0.90
Soft drinks	Type of drink	Soda
		Juice
	Sugar label	Red label
		Yellow label
		Green label
		Does not contain sugar[a]
	Price	\$0.50
		\$0.55
		\$0.60
		\$0.65

[a] This is the statement included in the TL label when the ingredient is not present

Discrete choice experiments can be rationalized using a random utility framework (Train 2003). Within this framework, consumer n is assumed to derive utility from choice alternative j in choice scenario t: $U_{njt} = V_{njt} + \varepsilon_{njt}$, where V_{njt} is the systematic component of utility, and ε_{njt} is a random component. The systematic component V_{njt} includes the utility derived from the product characteristics and it is assumed to be linear in parameters $V_{njt} = p_{jt}\alpha_n + \boldsymbol{x_{jt}}'\boldsymbol{\beta_n}$, where p_{jt} is the product price, $\boldsymbol{x_{jt}}$ is a vector of non-price attributes, and α_n and $\boldsymbol{\beta_n}$ are individual-level coefficients (i.e., they are random); thus, the utility model can be written as:

$$U_{njt} = p_{jt}\alpha_n + \boldsymbol{x_{jt}}'\boldsymbol{\beta_n} + \varepsilon_{njt}. \tag{1}$$

The behavioral model implies the consumer chooses alternative j if and only if $U_{njt} > U_{nit}, \forall i \neq j$. The probability that the consumer n chooses alternative j in choice occasion t is then

$$P_{njt} = \text{Prob}\left(p_{jt}\alpha_n + \boldsymbol{x}'_{\boldsymbol{jt}}\boldsymbol{\beta_n} + \varepsilon_{njt} > p_{it}\alpha_n + \boldsymbol{x}'_{\boldsymbol{it}}\boldsymbol{\beta_n} + \varepsilon_{nit}\right)\forall i \neq j. \tag{2}$$

Estimation of the parameters of the utility model requires an assumption about the random components ε_{njt}'s. If these errors are assumed independently and identically distributed extreme value, the unconditional choice probability of individual n choosing j in choice occasion t is then (Train 2003):

$$P_{njt} = \int_{\boldsymbol{\theta_n}} \frac{V_{njt}}{\sum_j e^{V_{njt}}} f(\boldsymbol{\theta_n}|\Gamma) d\boldsymbol{\theta_n}, \tag{3}$$

where $\boldsymbol{\theta_n} = [\boldsymbol{\beta_n}\prime\alpha_n]\prime$ is the vector of coefficients and $f(\boldsymbol{\theta_n}|\boldsymbol{\Gamma})$ represents the probability density function of the random coefficients in the population with parameters **Γ.** Equation (3) is the basis for the specification of the likelihood function, considering the sequence of choices made by all respondents (Rigby and Burton 2006; Train 1998, 2003). The probability distribution for the non-price attributes was assumed to be normal. The price coefficient was assumed to be fixed. Model parameters were estimated using simulated maximum likelihood procedures with 500 draws in STATA.[1]

The average marginal effects of the explanatory variables on the probability of choice were estimated as the average of the marginal effects over the observations (Wooldridge 2010). For the price variable, a continuous variable, marginal effects are calculated using derivatives in Eq. (3). For the label attributes, which are discrete variables, the marginal effects are calculated as the difference in the predicted probabilities of two scenarios. In the first scenario, the label of interest value is fixed at one, and all other attributes are kept at their original values. In the second scenario, the label of interest value is set at zero, and other attribute values are maintained at their initial values. The probability difference across scenarios represents the label effect on the probability of choosing a product.

Model parameters were subsequently used to estimate the expected value of individuals' willingness-to-pay values $\mathbf{WTP}_{\boldsymbol{n}}$ (i.e., estimates of E $[\mathbf{WTP}_{\boldsymbol{n}}]=\boldsymbol{E}[-\boldsymbol{\beta_n}/\alpha_n]$) (Hess 2007). Finally, the following panel data model was used to evaluate the association between sociodemographic characteristics ($\boldsymbol{z_n}$) and the **WTP** values for each non-price attributes (WTP_{nk}):

$$\mathrm{WTP}_{nk} = \gamma + \tau_k + \boldsymbol{z}_{\boldsymbol{n}}^{\prime}\boldsymbol{\delta} + \mu_n + e_{nk}, \tag{4}$$

where WTP_{nk} corresponds to the willingness-to-pay value for an attribute level k (e.g., TL color within a nutrient category), relative to a baseline attribute level (e.g., the red color), μ_n is the individual level random error, e_{nk} is the idiosyncratic error, and γ, τ_k, and $\boldsymbol{\delta}$ are the parameters. The data can be analyzed using panel data models given the presence of various attribute levels (i.e., $k > 1$); thus, the τ_k coefficients can be interpreted as attribute level "fixed-effects." Model coefficients were estimated using the random-effects estimator in STATA (xtreg command).

Data

Sample characteristics

Table 2 presents summary statistics of the respondents' characteristics, food purchase behavior, and knowledge about the TL label. The average age of the survey respondent was 14 years. The sample was approximately equally split between males (47%)

[1] Two STATA commands were used mixlogit and cmxtmixlogit. Models estimated using both commands gave very similar results. Both commands were needed to complete further analyses. The mixlogit was used to estimate individual levels WTP values. The cmxtmixlogit was needed to estimate marginal effects on the probability of choice.

Table 2 Sample summary statistics ($n = 1172$)

Variable	Mean (std. dev)	Percentage (n)
Age years (Std. Dev)	14.41 (1.82)	
Gender		
Male		47.44 (556)
Female		52.56 (616)
Education		
Middle School		56.23 (659)
High School		43.77 (513)
Lunch money[a]		
Less than $1.00		18.43 (216)
$1.00—$1.99		55.55 (651)
$2.00—$2.99		12.37 (145)
$3.00 or more		4.27 (50)
None		7.42 (87)
Knowledge		
Low (0–1 points)		36.01 (422)
Medium (2–3 points)		22.10 (259)
High (4 points)		41.89 (491)
Purchasing location[b]		
School cafeteria		69.62 (816)
Street vendors		17.49 (205)
Stores and supermarkets		41.04 (481)
Products purchased frequently at school[c]		
Packed snacks (potato chips, corn chips, and peanuts)		41.47 (486)
Bakery products (cupcakes, toasts, and cookies)		43.60 (511)
Fruit		30.03 (352)
Chocolate and candies		23.72 (278)
Water		30.97 (363)
Soda		20.48 (240)
Juice		25.60 (300)
Yogurt		28.16 (330)
Ice cream		34.81 (408)

[a] Summary of responses to the question "How much money do your parents give you daily to buy food at your school?."

[b] Summary of responses to the question Where do you buy food with the money your parents give you? (students could select multiple options)

[c] Summary of responses to the question What are the foods you buy with the money your parents give you? (students could select multiple options)

and females (53%) and between middle school (56%) and high school students (44%). Concerning knowledge of TL labels, about 42% of respondents obtained a perfect knowledge score of 4 points, 22% received between 2 and 3 points, and 36% scored between 0 and 1 point. The average daily monetary amount students received to make food purchases at school was $1.12. Summary statistics also show that almost 1 in 3 children interviewed indicated that yogurt is among their most frequently consumed products, 1 in 4 reports the same for juices, and 1 in 5 for soda products. Most students spend their "food" money mainly in the school cafeteria (70%), but a high percentage also bought food in the street (18%) and other places (41%).

Results

Choice experiments

The mixed logit models estimated using data from the yogurt and soft drinks choice experiments are presented in Table 3. Estimated coefficients represent the parameters of the mean of the distribution of the random coefficients (α_n, $\boldsymbol{\beta_n}$), and all were statistically significant at the 1% level. Coefficients can be interpreted as the effects of the attributes on the indirect utility function.

Table 3 Mixed logit estimation results

Attribute	Model for yogurt	Model for soft drinks
	Coefficient	**Coefficient**
Yellow label fat	1.679 (0.065)***	
Green label fat	1.922 (0.066)***	
Yellow label sugar	1.435 (0.063)***	1.633 (0.072)***
Green label sugar	1.754 (0.066)***	2.446 (0.080)***
Does not contain sugar		2.892 (0.102)***
Green label salt	0.261 (0.049)***	
Juice		0.514 (0.065)***
ASC	− 1.057 (0.166)***	− 2.233 (0.282)***
Price	− 1.870 (0.143)***	− 2.746 (0.417)***
	Standard deviation	**Standard deviation**
Yellow label fat	0.010 (0.168)	
Green label fat	0.363 (0.204)*	
Yellow label sugar	0.009 (0.159)	0.009 (0.137)
Green label sugar	0.427 (0.133)***	0.012 (0.191)
Does not contain sugar		1.589 (0.110)***
Green label salt	0.564 (0.089)***	
Juice		1.521 (0.085)***
ASC	2.898 (0.136)***	3.051 (0.154)***
Observations	20,754	20,754
Log-likelihood	− 5,288.7621	− 5,332.6902

Panel Mixed Logit model using 500 Halton draws

Attributes assigned a normal distribution except for price that was assumed constant

Values in parenthesis indicate the standard error of the coefficient

ASC Alternative specific constant

***, **, * indicate significance at the 1%, 5%, and 10%, respectively

Focusing first on the TL color attributes represented with dummy variables, the less healthy colors were selected as the baseline attribute levels (red color for fat and sugar and yellow for sugar). Therefore, the positive estimated values indicate that children obtained higher levels of utility when consuming products with TL color labels representing healthier alternatives (i.e., lower fat, sugar, and salt). The negative signs for the alternative specific constant indicated that children preferred to consume the selected item rather than choosing the "none" option. The positive sign of the "juice" coefficient in the soft drinks model indicates children prefer juices to sodas. Finally, the negative coefficients for the price attribute indicated an increase in prices decreases demand for the products (i.e., consistent with the law of demand).

Several estimated standard deviations of the coefficients' distributions were also significant, indicating heterogeneity in children's preferences for some product attributes. Model results suggest children have heterogeneous preferences for the "healthiest" label option in every nutrient and product combination; thus, in yogurt, heterogeneous preferences were found for green labels in sugar, salt, and fat. Heterogeneous preferences were identified in soda drinks for the "does not contain sugar" label.

One alternative to analyzing the relative importance of products' attributes on individuals' choices is their effect on the probability of choosing a product (Table 4). For yogurt products, children are more likely to choose products with yellow (18–22% more likely) and green labels (23–26% more likely) relative to red ones. The presence of a green salt label in yogurt, relative to a yellow label, increases the probability of selection by 3.2%. Similarly, in soda products, children are more likely to choose products with yellow, green, and "does not contain" sugar labels (18.3%, 28.9%, and 33.5%, respectively) than those with red labels. In addition, juice products are more likely to be selected (5.7% more) than sodas. Finally, as expected, higher prices decreased the probability of product selection (Table 4). A 10-cent increase in product prices decreased the likelihood of children choosing yogurt and soft drink products by 2.3% and 2.8%, respectively.

Table 4 Estimated marginal effects on the probability of choosing a product

Attribute	Model for yogurt Marginal effect	Model for soft drinks Marginal effect
Yellow label fat	0.217 (0.008)***	
Green label fat	0.259 (0.008)***	
Yellow label sugar	0.183 (0.008)***	0.183 (0.007)***
Green label sugar	0.233 (0.008)***	0.289 (0.008)***
Does not contain sugar		0.335 (0.009)***
Green label salt	0.032 (0.006)***	
Juice		0.057 (0.007)***
Price	− 0.234 (0.018)***	− 0.281 (0.037)***

***, **, *Indicate significance at the 1%, 5%, and 10%, respectively

Table 5 Estimated marginal willingness-to-pay (WTP) estimates

Attribute	WTP[a]	
	Yogurt ($/150 g)	Soft drinks ($/600 ml)
Yellow label fat[a]	0.898 (0.074)***	
Green label fat[a]	1.028 (0.084)***	
Yellow label sugar[b]	0.767 (0.065)***	0.595 (0.090)***
Green label sugar[b]	0.938 (0.080)***	0.891 (0.133)***
Does not contain sugar[b]		1.053 (0.157)***
Green label salt[c]	0.140 (0.026)***	
Juice[d]		0.187 (0.036)***

***, **, *Indicate significance at the 1%, 5%, and 10%, respectively

[a] Red label fat was assigned as the base attribute

[b] Red label sugar was assigned as the base attribute

[c] Yellow label salt was assigned as the base attribute

[d] Soda was used as the base attribute

Table 5 presents the estimated mean WTP values for the attributes, which represent the monetary values children are willing to pay, on average, for a specific characteristic relative to a baseline level; thus, they can be interpreted as premiums. For yogurt products, on average, children are willing to pay $0.90 and $1.03 premiums for yellow and green labels for fat, respectively, relative to the baseline red label. For the sugar attribute, the mean WTP was $0.77 and $0.94 more for the yellow and green labels for sugar, respectively, compared to the baseline attribute red sugar label. Finally, the calculated mean WTP for salt was $0.14 more for the green salt label than the yellow label.

For soft drinks, the mean premium children are willing to pay for juice was $0.19 compared to a soda product (Table 5). Children are also willing to pay $0.60 more for a yellow label, $0.89 more for a green label, and $1.05 more for the "does not contain sugar label" relative to a product with a red label for sugar.

Panel data models' results

The results of regression models exploring the relationship between the WTP values and children's sociodemographic characteristics, and their knowledge of the TL labels are presented in Tables 6 and 7. Three regression models were estimated for yogurt: one for the WTP for fat yellow and green labels, one for the WTP for sugar yellow and green labels, and one for the WTP for salt green labels (Table 6). Two regression models were estimated for soft drinks: one for WTP for juice and one for WTP for a green sugar label (Table 7).

Table 6 Panel data regression models: yogurt

Parameter	Model for fat	Model for sugar	Model for salt
Constant	0.892 (0.007)***	0.748 (0.011)***	0.135 (0.039)***
Traffic label attribute			
Green label fat	0.131 (0.001)***		
Green label sugar		0.171 (0.002)***	
Respondent characteristics			
Age	0.001 (0.001)	0.002 (0.001)*	− 0.001 (0.003)
Gender (1 = male, 0 = female)	− 0.002 (0.001)*	− 0.001 (0.002)	0.010 (0.007)
High School (1 = Yes, 0 = No)	0.001 (0.002)	− 0.008 (0.003)**	0.007 (0.010)
Lunch money ($/day)	− 0.001 (0.001)*	0.001 (0.001)	0.001 (0.004)
Knowledge (0–4 points)	− 0.000 (0.001)	− 0.001 (0.001)	0.007 (0.004)*
R^2	0.8344	0.7781	0.11162
Observations	2106	2106	1053

Standard error in parenthesis

***, **, *Indicate significance at the 1%, 5%, and 10%, respectively

Table 7 Panel data regression models: soft drinks

Parameter	Model for juice	Model for sugar
Constant	0.292 (0.149)*	0.569 (0.044)***
Traffic label attribute		
Green label sugar		0.296 (0.000)***
Does not contain sugar		0.455 (0.011)***
Respondent characteristics		
Age	− 0.005 (0.011)	0.001 (0.003)
Gender (1 = male, 0 = female)	− 0.015 (0.024)	0.006 (0.008)
High School (1 = Yes, 0 = No)	0.024 (0.040)	0.010 (0.013)
Lunch money ($/day)	− 0.023 (0.015)	0.009 (0.005)*
Knowledge (0–4 points)	− 0.009 (0.014)	− 0.002 (0.004)
R^2	0.0033	0.4312
Observations	1053	3159

***Indicates significance at 1%

**Indicates significance at 5%

*Indicates significance at 10%

The regression model results for fat in yogurt indicate that the premium children are WTP for a green label is $0.13 higher than the premium they are willing to pay for a yellow label. Gender and lunch money were also found to have a statistically significant effect (at a 10% level) on the premiums children are WTP for green and yellow labels, but both effects were small. Male children are WTP $0.002 less for green and yellow labels than female children, and an additional dollar in lunch money is associated with a $0.001 decrease in the WTP premiums for these labels.

The regression model results for sugar also indicate that the premium children are WTP for a green label is higher ($0.171) than the premium they are willing to pay for a yellow label (both relative to a red label). Age and grade level had statistically significant effects on the WTP premiums for green and yellow labels (at least at the 10% level). An additional year added to students' ages is related to an increase of the WTP of $0.002 for green and yellow labels. High school students are willing to pay less ($0.008) for these labels than middle schoolers.

Regression model results using WTP values for TL colors in salt in yogurt products as the dependent variable indicated a higher knowledge score is associated with a higher WTP for the green label ($0.007 for each additional point in the score) relative to the red label.

Table 7 presents the regression results for soft drinks. Children are WTP $0.30 and $0.46 higher premiums for a green and a "does not contain sugar" label than for a yellow label (all relative to a red sugar label). Concerning the sociodemographic characteristics, only lunch money shows statistical significance (at 10%), where an additional dollar increases children's WTP by 0.009. Moreover, regression results for the model using the premium for the juice attribute show no statistically significant effect of any explanatory variables.

Discussion

Supplementary nutrition labeling, such as the TL labeling used in Ecuador, is one of the public policies implemented to improve dietary behavior. Most of the previous research on the effectiveness of TL labels has been conducted with adults (Song et al. 2021). However, children make independent food purchases in many countries. In our sample, 92% reported receiving money to purchase food "at school." Therefore, evaluating the effect of nutritional labels on their food preferences and choices is relevant. Moreover, most of the previous literature evaluated TL labels' influence on various outcomes relative to a control scenario without the labels (Song et al. 2021) (i.e., the extensive margin). In contrast, this study evaluates the effect of variations in TL labels' characteristics (i.e., colors and text) on children's food choices (i.e., the intensive margin).

Marginal effects show that children prefer, and are more likely to buy, products with TL labels representing healthier alternatives (Table 4). This result was consistent across the three nutrients (fat, sugar, and salt) and two products (yogurt and soft drinks). Estimated marginal effects of yellow, green, and the "does not contain" labels reveal significant effects of the presence of these labels relative to a red label (increases the probability of choice by about 18% or more).

Marginal effects on the choice probability also decreased when moving from the more to the less healthy alternatives. For example, for yogurt, a product with a yellow label for sugar is 18.3% more likely to be chosen relative to a product with a red label. One with a green label is 23.3% more likely to be selected than a product with a red label. Thus, yogurt with a sugar green label is only 5% more likely to be chosen than yogurt with a yellow label.

Given that preferences and choices are related, WTP results confirm the results found using the marginal effects of choice probabilities; however, WTP values provide more information about trade-offs respondents make between money and attributes. The WTP results in Table 5 indicate children, on average, are willing to pay significant premiums for products with yellow and green labels relative to products with red labels. The estimated premium values for yellow labels in yogurt range from $0.77 in the case of sugar to $0.90 per product in the case of fat (Table 5). The premium values for green labels range from $0.94 for sugar to $1.03 for fat. The difference in premiums between yellow and green colors on the labels is less than $0.20 per product. This is significantly lower than the differences in the willingness-to-pay premiums between products with yellow and red labels.

These estimated premiums are substantial, considering that the average price in the choice experiments was $0.70 per product; however, these values only reflect the demand from a small group of consumers. Market prices are ultimately determined by the supply and demand of all market agents (consumers and producers).

WTP results from the choice experiment with soft drinks, which only included different color labels for sugar, were consistent with those found with yogurt and reflected children's preferences for healthier alternatives. Premiums children are willing to pay for green and yellow labels relative to a red label are significantly higher than the difference in premiums between green and yellow labels. Results also indicate that children are willing to pay a substantial premium for products with the "does not contain sugar" label. This premium is estimated to be even higher than the premium for a green label, revealing children's stated preferences for products without sugar relative to products with some sugar content (ceteris paribus). The soft drink choice experiment's results also reflected children's preference for juices relative to sodas.

Overall, these results for evaluating the marginal effects of attributes on the probability of choice and willingness-to-pay values suggest children prefer to avoid products with red labels. Products with green labels are also preferred over products with yellow labels. Still, the differences in marginal effects and willingness-to-pay values between green and yellow label premiums are not as large as those observed between yellow and red colors. Therefore, children's perceived level of healthfulness, as reflected by the colors in the TL labels, appears to be nonlinear. Larger gains in "healthfulness" seem to be perceived when choosing a product with a yellow label over one with a red label than when selecting a product with a green label over one with a yellow label or one with a "does not contain" label relative to a product with a green label.

Although the previous literature found that, relative to other interpretative supplementary nutritional labels, the TL labels caused more confusion (Song et al. 2021), this study's WTP estimates for TL colors align with the final policy objective of reducing the purchase and consumption of products with high levels of sugar, fat, and salt.

How do the results of the study compare to previous similar literature? Results of this study are also in line with a similar study conducted in Ecuador but targeting the adult population (Sarasty et al. 2023). The study used yogurt products of the same size and found a similar pattern of preferences for green and yellow labels over red labels, as measured by the premium values they were willing to pay for these attributes (about $1.00 per product). A smaller premium was found for green labels than yellow ones ($0.20 per product or less) (Sarasty et al. 2023).

Saavedra-Garcia et al. (2022) and Arrua et al. (2017) studied the effect of supplementary nutritional labels on children's food choices in Peru and Uruguay. Whereas Ecuador implemented the TL labeling policy in 2014, Peru and Uruguay adopted the octagon warning supplemental labeling in 2019 and 2020, respectively (Garcia 2023). Saavedra-Garcia et al. (2022) found that front-of-package warning labels with similar attributes to TL labels (sugar, fat, and salt) did not affect purchase intention and the identification of healthier alternatives among Peruvian adolescents. However, their study was conducted shortly after adopting the food label policy in Peru, whereas ours took place more than five years after policy implementation. The study by Arrua et al. (2017) in Uruguay found that TL labels did not affect children's cookies and orange juice selection. The absence of a mandatory labeling policy in Uruguay during their study might have influenced their results. The results of these studies suggest that more extended periods and educational efforts may be needed for nutritional labels to affect children's product selection.

The regression models suggest some of the heterogeneity of preferences for TL label colors is associated with some of the explanatory variables included in the models. However, coefficients measuring these associations are very small, and the estimated associations had no clear pattern. For example, male children were willing to pay lower premiums for yellow and green labels than female children, but only for green and yellow labels in yogurt, and the difference in premiums is minimal ($0.002). Similarly, a positive association was found between the premiums for green and yellow labels and the TL label knowledge score, but only for the green label for salt in the yogurt model: A one-point increase in the knowledge score was associated with a $0.007 increase in the willingness to pay for it. Thus, the estimated heterogeneity in preferences for the labels does not appear to be strongly related to age, gender, grade level, money available, and knowledge.

From a broader perspective, the study has shown that economic stated choice experiments can be used to analyze children's preferences and demand for food products. Study results are consistent with rational economic behavior where children make choices considering the trade-offs between prices and other food product attributes (e.g., various nutrient concentration levels). Previous studies evaluating the effect of nutritional labels have omitted price as a product attribute. Its omission limits the analyses because preferences for non-price characteristics cannot be expressed in dollar values. Moreover, choice experiments without prices represent less realistic scenarios if children are already responsible for food product purchases.

The study findings have important policy implications for public health interventions and educational programs targeting children. The results show that TL labels effectively provide information and guide children toward healthier food choices. Thus, children's use of TL labels can be promoted through educational campaigns that emphasize the benefits of healthier food choices in the short and long run. Mandatory TL labels on the front of food packages rather than on the back or the side of the product (as the Ecuadorian TL policy currently allows) can also enhance children's awareness and understanding of their food choices.

Furthermore, the results have implications for the food industry. The findings suggest some market opportunities for manufacturers to produce products that feature TL labels with yellow and green colors for fat, sugar, and salt. The study indicates that children are willing to pay premiums for products with TL labels that present healthier attributes, providing an opportunity for food manufacturers to develop and market new products that align with children's preferences for healthier options.

Some limitations of this study need to be noted. First, we used stated choice experiments instead of actual shopping behavior. The use of hypothetical behaviors was necessary, given the context of the COVID-19 pandemic. Stated choice experiments also offered more flexibility regarding the range of product attribute levels that can be studied while keeping other attributes fixed. This may not be possible if actual products are used because, for example, a specific branded product has a unique nutritional profile. Second, the study only used drink products, but preferences for TL colors may differ across product categories. Third, the choice experiments included TL labels on the front of the drinks; the label regulations in Ecuador allow companies to place the label on the products' front, side, or back. Fourth, the study did not consider the influence of parents or guardians on children's preferences and beliefs. Parental attitudes and behaviors regarding food choices and nutrition could significantly impact children's perceptions and decision-making, especially for children who purchase food in stores and supermarkets accompanied by their parents or guardians.

Fifth, the data were only collected in three cities in the country's south. Although the cities represent the three natural regions of the country: Coastal Lowlands (Costa), the Andean Highlands (Sierra), and the Amazon Rainforest (Oriente), preferences for TL labels and products may differ in cities located in other parts of the country. Sixth, our study population was limited to middle and high school children in three cities. Future studies could focus on younger children's preferences for TL labels and other areas. However, the logistics of working with children are more involved as more permissions are needed from regional and local educational authorities and parents. Finally, the choice experiments employed hypothetical products with consistent packaging to isolate and study the impact of changes in traffic light colors and prices; however, this approach might cause confusion since products with differing prices tend to have different packaging and presentations. Future studies could explore differences in the results of the analyses obtained using choice experiments that show product packaging and choice experiments presenting the attributes in a table format (and asking respondents to assume all other attributes are the same).

Conclusion

The increasing prevalence of being obese or overweight is prompting governments to implement public policies encouraging improved dietary habits. The implementation of such policies should be followed by their evaluation in all segments of the population (e.g., adults, children, etc.). Study findings show that TL nutritional labels adopted in Ecuador are effective at helping children make food choices consistent with preferences for food products with TL labels representing healthier alternatives. Therefore, the findings support the use of TL labels to facilitate children's understanding of the nutritional quality of a product.

We need to emphasize that the study results do not necessarily imply that adopting the TL policy has been effective in changing children's dietary habits. Data on children's preferences for nutrient levels (as reflected by the TL colors) before the TL label policy was implemented are unavailable. However, this study's results can also be used to monitor children's preferences for nutrient levels as the label policy evolves (e.g., changing the label from the back of the package to the front). We believe that stated preferences data provide a lower-cost alternative for evaluating the effect of nutritional labeling policies, as actual purchase data from children are unavailable or difficult to access.

Appendix 1

See Table 8.

Table 8 Attribute and levels assigned to traffic light colors (MSP 2013)

Attribute		Level		
		Green (Low concentration)	**Yellow (Medium concentration)**	**Red (High concentration)**
Total fat	Processed food	≤ 3 gr/100 gr	between 3 and 20 gr/100 gr	≥ 20 gr/100 gr
	Beverage	≤ 1.5 gr/100 ml	between 1.5 and 10 gr/100 ml	≥ 10 gr/100 ml
Sugar	Processed food	≤ 5 gr/100 gr	between 5 and 15 gr/100 gr	≥ 15 gr/100 gr
	Beverage	≤ 2.5 gr/100 ml	between 2.5 and 7.5 gr/100 ml	≥ 7.5 gr/100 ml
Salt (Sodium)	Processed food	≤ 120 mg/100 gr	between 120 and 600 mg/100 gr	≥ 600 mg/100 gr
	Beverage	≤ 120 mg/100 ml	between 120 and 600 mg/100 ml	≥ 600 mg/100 ml

Appendix 2: Survey instrument

Age: _____

Gender:

- o Male
- o Female

Grade: _____

Select your school location:

- o Machala
- o Loja
- o Zamora

How much money do your parents give you daily to buy food at your school?______

Q1. Do you know the nutritional traffic light label of food?

- o Yes
- o No

Q2. What nutritional components are included on the nutritional traffic light label? (You can select more than one)

- ☐ Fat, sugar, and salt
- ☐ Vitamins, minerals, and fiber
- ☐ Proteins
- ☐ None of the above

Q3. According to the traffic light nutritional labeling, what is the level of the nutritional content of foods? (Select one option in each row)

	Nutritional content			
	High	Medium	Low	Don't know
Red				
Yellow				
Green				

Q4. According to the traffic light nutritional labeling, what is the nutritional quality of the product you choose for consumption? (Select one option in each row)

	Nutritional quality				
	Very bad	Bad	Acceptable	Good	Very Good
Red					
Yellow					
Green					

Q5. Do you make your purchases based on the nutritional traffic light?

- Yes
- No

Q6. What are the components you check when buying food? (You can mark more than one)

- Fat
- Sugar
- Salt
- None

Q7. What color of the traffic light label do you prefer when buying food?

- Red
- Yellow
- Green
- Does not contain
- I don't look at the color of the labels

Q8. Where do you buy food with the money your parents give you? (You can select more than one)

- ☐ Bar of your school
- ☐ Street vendors
- ☐ Shops near your school
- ☐ Supermarket
- ☐ Shop in your neighborhood
- ☐ Other (Please indicate) _____

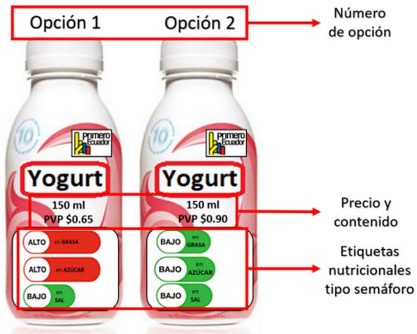
Q9. What are the foods you buy with the money your parents give you? (You can select more than one)

- ☐ French fries, doritos, chifles, and/or k-chitos
- ☐ Peanuts
- ☐ Bakery or pastry products (toast, cakes, etc.)
- ☐ Cereal
- ☐ Fruits
- ☐ Chocolates
- ☐ Candies
- ☐ Cookies
- ☐ Energy drinks
- ☐ Water
- ☐ Soft drinks
- ☐ Juices
- ☐ Yogurt
- ☐ Ice cream
- ☐ Other (Please specify) _____

Q10. Do you consume yogurt?

- Yes
- No

Q59. Imagine you are in your school bar, supermarket, store, or other place where you buy food. You want to buy yogurt, and you have two options:

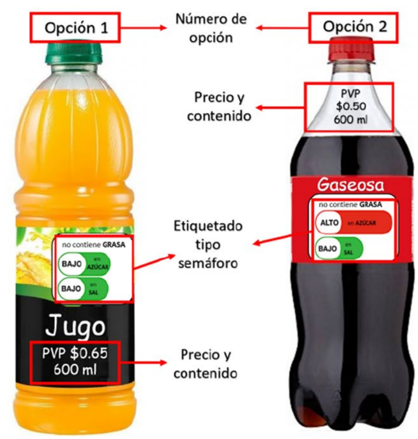


*Please pay attention as there are only **DIFFERENCES** in prices and colors of the labels on yogurts. Imagine that all other characteristics like quantity and taste are the same; then choose an option. If you don't like the options presented, you can choose "None." Remember that you will have less money for food or other things if you buy yogurt.*

yf1.1. Choose your favorite yogurt option.

- Option 1
- Option 2
- None

Q61. Now you want to buy another drink, and you are trying to decide between colas and juices:



*Please pay attention to the **DIFFERENCES** in prices, colors of the labels, and type of drink. Other characteristics, such as quantity, are the same. Then choose an option. If you don't like the options presented, you can choose "None." Remember that you will have less money for food* or other things *if you buy a drink.*

sd1.1. Choose your favorite drink option.

- Option 1
- Option 2
- None

Abbreviations

ARCSA	Agencia Nacional de Regulación, Control y Vigilancia Sanitaria (National Agency for Health Regulation, Control and Surveillance)
COVID-19	Coronavirus disease caused by the SARS-CoV-2 virus
ENSANUT	Encuesta Nacional de Salud y Nutrición (National Nutrition and Health Survey)
FAO	Food and Agriculture Organization
INEC	Instituto Nacional de Estadísticas y Censos (National Instituto of Statistics and Census)
OMS	Organización Mundial de la Salud (World Health Organization)
OPS	Organización Panamericana de la Salud (Panamerican Health Organization)
MIP	Ministerio de Industria y Productividad (Ministry of Industry and Productivity)
TL	Traffic light
WHO	World Health Organization
WTP	Willingness to pay

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TC contributed to conceptualization, methodology, investigation, supervision, funding acquisition, program administration. CC contributed to conceptualization, methodology, supervision, formal analysis, writing—review and editing. OS contributed to conceptualization, methodology, data curation, formal analysis, software. SW contributed to investigation, writing—review and editing. MSG contributed to conceptualization, methodology, investigation.

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Declarations

Competing interests
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