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Impact of front-of-package nutrition labels on acceptability and objective understanding: A randomized experiment in Latin American adults

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1. Introduction

Food systems have changed dramatically over the past 50 years, failing to provide nutritious, safe, affordable, and sustainable diets (Branca et al., 2019; Varyvoda & Taren, 2023). The most obvious change is the replacement of diverse and local, healthier diets with diets that are increasingly based on ultra-processed foods (Marrón-Ponce et al., 2022; Monteiro et al., 2018). The result is an excessively energy-dense diet, with high levels of free sugars, unhealthy fats and salt/sodium, and low dietary fiber, increasing the risk of obesity and other diet-related non-communicable diseases (Martinez Steele et al., 2022; Monteiro et al., 2018). People of all age groups, regions, and countries are affected by non-communicable diseases, and 86% of premature deaths occur in low- and middle-income countries (Siddiqi, 2010). In 2019, non-communicable diseases accounted for 81% of deaths in the Americas region (Pan American Health Organization, 2021). Structural actions to improve the food environment include, among others, interpretive front-of-package nutrition labels (Branca et al., 2019; Muzzioli et al., 2023).

Front-of-package nutrition labels are recognized as a cost-effective policy and action for controlling obesity and non-communicable diseases in the population through guidance on choosing healthy foods

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(Kaufer-Horwitz et al., 2018; Neyazi, Mosadeghrad, Afshari, Isfahani, & Safi, 2023; Pan American Health Organization, 2020). A modeling study predicted a reduction of 1.3 million cases of obesity and a reduction of US$1.8 billion in direct and indirect costs after 5 years of implementation of the Warning Label in Mexico (Basto-Abreu et al., 2020); in addition, the use of front-of-package nutrition labels led to a significant reduction in chronic disease mortality (approximately 3.4% using the Nutri-Score) (Egnell et al., 2019). However, to achieve significant reductions in mortality linked to food consumption, front-of-pack labels need to be part of a broader, multifaceted strategy that includes public health campaigns, education, fiscal policies (e.g., taxes on sugary drinks), and regulations on food marketing (Pan American Health Organization, 2015; World Health Organization (WHO), 2019). Moreover, the development and implementation of front-of-package nutrition labels must respond to each population's social, epidemiological, and nutritional needs. Front-of-package nutrition label systems are categorized according to their purpose and the information provided. Thus, different systems can be classified as nutrient-specific-systems interpretive labels (Warning Label and Multiple Traffic Light), informative systems/non-interpretive labels (Guideline Daily Amounts), and summary labeling systems (Nutri-Score) (Acton et al., 2023; Crosbie et al., 2023).

The food industry developed the Guideline Daily Amounts (GDA) or Reference Intake System (Stern, Tolentino, & Barquera, 2016). It provides information on energy alone or energy along with saturated fat, sugars, and salt. Specifically, energy must be expressed per 100g/100 ml, whereas the remaining four nutrients can be expressed either per 100g/100 ml or per portion. It might also include the percentage of the reference daily value for each nutrient and energy. This system lacks information on positive nutrients such as fiber. The GDA, initially implemented in the European Union, was mandatory in Mexico from 2014 to 2020 (White & Barquera, 2020).

The Multiple Traffic Light (MTL) was implemented in Ecuador in 2014 as part of an action plan to modify the obesogenic environment. Its purpose is to provide timely, accurate, and clear information regarding the nutritional content of processed foods to Ecuadorian consumers (Díaz et al., 2017). Bolivia started using this labeling system in 2017 (Asamblea Legislativa Plurinacional, 2016, pp. 1–8).

The Nutri-Score model is a voluntary labeling system presented as five colors based on a logo with five values ranging from A to E and from green to red, according to the nutritional value of a food product. It was included in the health law enacted in 2017, aiming to improve population nutrition and reduce non-communicable diseases morbidity in France (Julia & Hercberg, 2017). This system has also been employed in Portugal, Austria, Belgium, Spain, Germany, Switzerland, and Luxembourg (Roberto et al., 2021).

On the other hand, Chile pioneered a model in the Latin American region by implementing a front-of-package Warning Label (WL) system that includes statements referring to products with high content of calories, sugars, sodium, or saturated fats (Ministerio de Salud de Chile, 1997). Mandatory WL legislations have also been enforced in Mexico, Peru, Argentina, Uruguay, Brazil, Colombia, Venezuela, Canada, and Israel (Crosbie et al., 2023; Roberto et al., 2021).

Although several front-of-package nutrition label systems have been designed and implemented, their effectiveness depends on numerous factors, and their usefulness may be limited among different populations (Feunekes, Gortemaker, Willems, Lion, & van den Kommer, 2008). Different pathways through which a well-designed front-of-package nutrition labels influences consumers have been described (Roberto et al., 2021). First, the front-of-package nutrition labels must capture consumers' attention; second, the label imparts knowledge and alters product perceptions (cognitive effects); and third, the label evokes an emotional response, potentially leading to broader changes in social norms. These cognitive, emotional, and social influences can, in turn, modify attitudes toward foods or directly influence behavior (Roberto et al., 2021). Therefore, it is crucial to ensure that the front-of-package nutrition labels implemented in Latin American countries and worldwide are easily understandable and accepted by consumers. This involves ensuring that the information aids decision-making about a product, is easily identifiable on the front of the package, and does not represent a high perceived cognitive workload for interpretive front-of-package nutrition labels.

However, a key question is whether the acceptance and understanding of front-of-package nutrition labels is generalizable across countries. The evidence shows that the GDA system is poorly understood compared with systems that provide an evaluative judgment or interpretation of a food's nutritional content or quality. This is particularly the case for people in more socially disadvantaged groups (Ducrot et al., 2015; Kelly & Jewell, 2018; Tolentino-Mayo, Rincón-Gallardo Patiño, Bahena-Espina, Ríos, & Barquera, 2018, 2020), where the GDA had the lowest acceptability (Vargas-Meza, Jáuregui, Contreras-Manzano et al., 2019). Nutri-Score is recognized as a useful instrument in guiding consumers' alimentary choices, particularly concerning objective understanding and providing sufficient information for consumers (Ducrot et al., 2015; Egnell, Ducrot, et al., 2018; Goiana-da-Silva et al., 2021; Song et al., 2021). However, a study by Italian medical professionals showed that participants' actual understanding of its rationale was insufficient (Ricco et al., 2022). Similar results were observed among Mexican consumers regarding the French 5-Color Nutrition Label (a preliminary version of the Nutri-Score) (Vargas-Meza, Jáuregui, Pacheco-Miranda, Contreras-Manzano, & Barquera, 2019). On the other hand, a systematic review suggests that interpretive front-of-package nutrition labels schemes such as Nutri-Score, MTL, and WL are more comprehensible and equitable in effect across socioeconomic status (Shrestha, Cullerton, White, Mays, & Sendall, 2023; Temple, 2020). The WL was evaluated as the easiest to understand (Song et al., 2021), had higher levels of awareness, use, and understanding than other front-of-package nutrition labels in young and adult people (Acton et al., 2023; Hammond et al., 2023), and demonstrated the greatest efficacy to decrease the perceived healthfulness of a sweetened fruit drink across Australia, Canada, Mexico, the United Kingdom, and the United States. This effect was similar across demographic characteristics (Jáuregui et al., 2022) and helped consumers with non-communicable diseases to classify unhealthy food products (Sagaceta-Mejía, Tolentino-Mayo, Cruz-Casarrubias, Nieto, & Barquera, 2022). The MTL and the WL were the most accepted front-of-package nutrition labels, allowing low- and middle-income consumers to make nutrition-quality-related decisions more quickly (Vargas-Meza, Jáuregui, Contreras-Manzano et al., 2019).

Despite available evidence on the effects of front-of-package nutrition labels, most of the labeling systems were not developed in Latin American countries, whose sociodemographic and cultural characteristics are different from the rest of the world's. In the region of the Americas, 11 countries (Argentina, Bolivia, Brazil, Canada, Chile, Colombia, Ecuador, Mexico, Peru, Uruguay, and Venezuela) have adopted front-of-package nutrition label systems (as of August 2022) (Crosbie et al., 2023), of which nine are WL. This trend in the region is a strategic response to the increasing burden of non-communicable diseases. The evidence and practical insights regarding the implementation of WL in the region have continued to evolve with ongoing improvements in the application of octagonal WL (Crosbie et al., 2023). Therefore, the aim of the study was to test the objective understanding and acceptability of different kinds of front-of-package nutrition labels (GDA, MTL, Nutri-Score, and WL) among an international sample of Latin American adult consumers.

2. Methods

2.1. Study design

From April to July 2022, a five-arm, unblinded, online randomized experiment was conducted as part of the broader "Nutritional Labeling

Study among Latin American Consumers." A cross-sectional online survey was applied to adults aged ≥18 years from five Latin American countries: Argentina, Colombia, Ecuador, Mexico, and Panama. The study assesses several domains of nutrition labeling, including objective understanding, acceptability, and potential impact on purchase intentions. For this study, we analyzed responses to measures about the objective understanding and acceptability of different front-of-package nutrition labels.

The Ethics, Research, and Biosafety Committees of the Mexican National Institute of Public Health evaluated and approved this study (CI: 1122).

2.2. Recruitment

A convenience sample of adults was used for this study. Trained undergraduate and graduate research assistants from 43 universities in Argentina, Colombia, Ecuador, Mexico, and Panama recruited the study participants. First, the research team from Mexico trained researchers who had no conflicts of interest to declare from the participating countries (Argentina, Colombia, Ecuador, and Panama) on how to approach and recruit participants and obtain informed consent; then, researchers from each Latin American country instructed research assistants to recruit at least 20 participants from each country. Finally, research assistants identified potential participants through acquaintances, relatives, friends, neighbors, or in public places selected by convenience by the country's research team. Research assistants approached potential participants, explained the study objectives, and invited them to participate.

Potential participants were screened for eligibility using a 3-item screener. To access the screener, recruiters used a laptop with internet access to a unique URL where our online survey was hosted. Eligible participants were adults (≥18 years) who consumed at least one of the five food groups included in the experiment (non-dairy beverages, breakfast cereals, dairy products, ready-made foods, and savory snacks) and who shopped at least twice a month. Participants were excluded if they or a close relative worked in the food or beverage industry or were health professionals. Research assistants were automatically informed of participant eligibility, and informed consent was obtained from all participants. The laptop was then temporarily loaned to the participant to complete the rest of the survey independently. Participants completed the survey at the location where they were recruited.

2.3. Participant's allocation

Using a simple randomization algorithm, participants were automatically and randomly allocated to one of five study groups (Fig. 1): 1) No label (control), 2) GDA, 3) MTL, 4) Nutri-Score, and 5) WL. These labeling systems were chosen because they were either implemented or considered as a policy option in the countries included in this study. Researchers were blinded to the assigned intervention, but blinding participants was not possible due to the nature of the intervention.

2.4. Outcome measures

2.4.1. Objective understanding

We tested objective understanding of the front-of-package nutrition labels with a series of five exercises per participant, corresponding to each of five food categories: sugary drinks, savory snacks, breakfast cereals, dairy products, and ready-to-eat foods. These food groups were chosen because they include products that have been associated with increasing diet-related non-communicable diseases (Martinez Steele et al., 2022) and are susceptible to changes in consumer behavior toward these food categories (Roberto et al., 2021; Shangguan et al., 2019).

For each task, participants viewed on-screen images of three labeled items from the same food group but with a different nutritional quality.

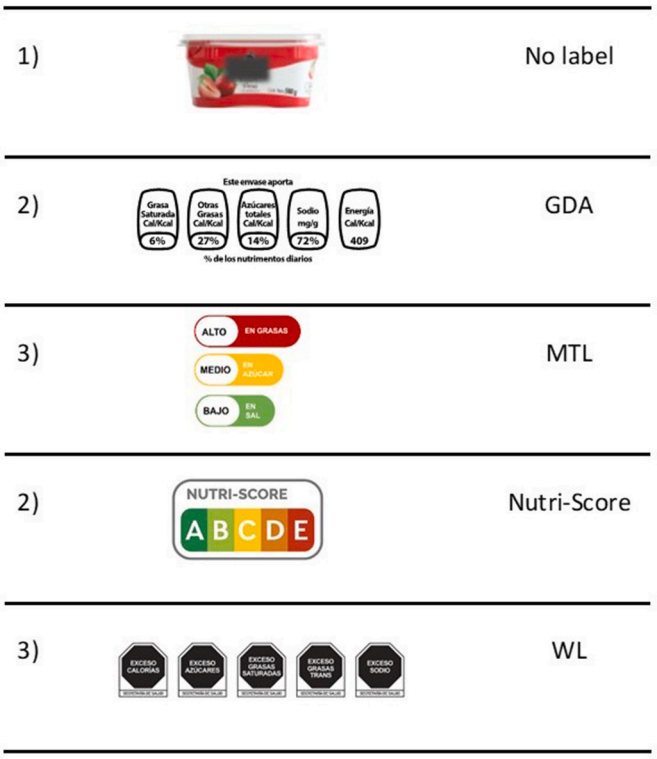

Fig. 1. Front-of-package labeling systems tested. 1) No label, 2) GDA: Guideline Daily Amounts, 3) MTL: Multiple Traffic Lights, 4) Nutri-Score, 5) WL: Warning label.

The front-of-package nutrition labels were displayed in the bottom right-hand corner of the front of the package (Fig. 2 and Supplementary Fig. 1), covering approximately the same surface area. In addition, the enlarged label image was displayed on the top of each product.

The three foods shown were randomly selected from a set of 24 images per food group (120 in total) of real products in Mexico, digitally modified to show the assigned front-of-package nutrition label. Supplementary Fig. 2 shows the nutritional information used in developing

Fig. 2. Illustrative example of the objective understanding task for front-of-pack nutrition labeling displaying Multiple Traffic Lights.

the front-of-package nutrition labels for the food products. The nutrient profile for the GDA system corresponded to the labeling implemented in Mexico from 2014 to 2020 (NOM-051-SCFI/SSA1-2010). The thresholds express the percentage contribution (according to nutrient intake reference values) of saturated fat, other fats, sugars, and sodium and include each nutrient's energy contribution and the package's total (e.g., reference values: saturated fat 200 kcal). The amount of energy and nutrients was standardized according to the portion size information on the package (Secretaría de Economía, 2010, pp. 1–31). The MTL status was classified according to the criteria implemented in Ecuador (Acuerdo No. 00004522). This profile applies to foods and beverages containing added sugars, fats, or sodium, except for some groups, such as ingredients used in culinary preparations (salt, sugar, spices, etc.). The thresholds for fat, sugar, and salt were evaluated independently, with three possible indicators for each (low, medium, and high) (e.g., low sodium ≤120 mg per 100g). The application of the nutritional criteria requires the standardization of the nutrient content to 100g or ml; in the case of yogurt and ice cream, these were evaluated in milliliters (Reglamento Sanitario de Etiquetado de Alimentos Procesados Para El Consumo Humano Acuerdo No. 00004522, 2013). The Nutri-Score is applicable to all packaged foods and packaged beverages and considers a simple equation on the content of unfavorable components (calories, sugars, saturated fats, and sodium) and their difference from the favorable components (fruit/vegetables, protein, and fiber content) (e.g., food points 0–2 light green "B"). The energy and nutrient content was standardized per 100g or ml to apply the nutritional criteria and determine each component's corresponding score (Julia & Hercberg, 2017). The WL was applied based on the criteria used in the nutrient profile of the Mexican WL (MODIFICACIÓN a la Norma Official Mexicana NOM-051-SCFI/SSA1-2010), in which all energy and nutrient thresholds are evaluated when packaged foods and bottled beverages contain added sugars, fats, or sodium, and when sweeteners or caffeine are added (e.g., excess sugars when ≥10% of total energy from free sugars) (Diario Oficial de la Federación, 2020). In addition, we used the NPSC model to assign a health score to all foods and to select various products of different nutritional quality (*Food Standard Australia New Zealand. Nutrient Profiling Scoring Calculator. 1.2.7*, 2021).

Participants were instructed to drag and drop the product with the lowest nutritional quality into a box area on the screen in less than 30 s. This instruction was designed to simplify the task and reduce cognitive workload. In real-world scenarios, consumers often face situations where they need to avoid the least healthy option among several alternatives, especially given the high availability of ultra-processed foods (Contreras-Manzano et al., 2018, 2022). This procedure was repeated for each one of the five food categories. The order in which the food categories were presented was randomized to avoid order effects. The average score for correctly identifying the food product with the lowest nutritional quality (from 0 to 5 foods correctly identified) was estimated.

2.4.2. Acceptability of front-of-package nutritional labels

Label acceptability was assessed along three dimensions reflecting label likeability, attractiveness, and perceived cognitive load (Nielsen, 1993). Participants were asked to rate the assigned label based on six statements: one evaluating label likeability ('This label is useful for choosing products'); three evaluating label attractiveness ('This label provides me with the information I need; ' 'This label is easy to see on the front of the products,' and 'This label provides reliable information'), and two evaluating perceived cognitive workload ('This label is too complex to understand' and 'This label takes too long to understand'). These dimensions and questions have been previously used to explore the acceptability of front-of-package labels among French consumers (Ducrot et al., 2015). Each item was rated on a Likert scale with five response options: 1) Strongly agree, 2) Agree, 3) Neither agree nor disagree, 4) Disagree, and 5) Strongly disagree. For the likability dimension, participants responding options 1) and 2) were classified as agreeing, whereas those selecting options 3), 4), or 5) were classified as disagreeing. The response option "Neither agree nor disagree" (scored as 3) was included in the "disagree" category to emphasize the responses of consumers who "strongly agree" or "agree" with the statements of the label likability. For the attractiveness and perceived cognitive workload dimensions, the average of the scores of their respective statements were estimated. Similarly, participants with an average of <3 were classified as agreeing, and those with ≥3 were classified as disagreeing. This section was not included for participants allocated to the control group (n = 1406).

2.5. Covariates

Demographic information and health status were collected. Variables were recoded and harmonized for comparison across countries and included sex (male, female), age group (18–29, 30–39, 40–49, 50–59, 60 and over), marital status (recoded as divorced/single/widowed and married/living with a partner), household monthly income (low, medium, high), educational level (elementary school and lower; secondary school, high school; graduate or postgraduate), occupation (unemployed, student, homemaker, employee, salesman or woman, other), body mass index (underweight, normal weight, overweight, and obesity according to self-reported height and weight and WHO criteria) (World Health Organization, 2021), presence of chronic diseases (diabetes, hypertension, overweight, high cholesterol, high triglycerides, cancer, and cardiovascular disease), interest in health (measured by the question: "How interested are you in your health?," and response options of nothing, somewhat, and a lot), and nutrition knowledge (collected with the question: "In your opinion, how knowledgeable are you in nutrition?," and response options nothing, a little, somewhat, and a lot). Household monthly income categories by country were recoded according to national benchmarks as follows: Argentina (Low: Less than one Canasta Basica Alimentaria (CBA) (Instituto Nacional de Estadística y Censos - I.N.D.E.C., 2020); Medium: between 1 and 3 CBA; High: more than 3 CBA); Colombia (Low: Less than one minimum wage; Medium: between 1 and 5 minimum wages; High: more than 5 minimum wages); Ecuador (Low: Less than $100 to $500; Medium: $501 to $900; High: $901 or more); Mexico (Low: Less than $3040 to $12,990; Medium: $12,991 to $26,199; High: $26,200 or more), and Panama (Low: Less than $100 to $300; Medium: $301 to $900; High: $901 or more).

2.6. Data analysis

The study sample size was powered to examine differences in nutritional outcomes between countries and not for each task within the survey. Post-hoc analyses indicated that with a sample size of 650 participants in each labeling condition per country and a standard deviation of 1.5, this study had an estimated 85% power to detect a 0.25 mean difference on the 5-point Likert scale.

We tested the success of randomization of covariates by comparing demographic and health characteristics between experimental groups using Chi-squared tests (Supplementary Table 1). Since differences were observed between groups, subsequent analyses controlled for these variables.

Preliminary analyses indicated differences in the association between front-of-package labels and objective understanding (overall interaction effect: $\times^2 = 2.49$, $P = 0.0009$) as well as label acceptability (likability: overall interaction effect: $X^2 = 41.65$, $P = <0.0001$; attractiveness: overall interaction effect: $X^2 = 40.53$, $P = 0.0001$; perceived cognitive workload: overall interaction effect: $X^2 = 66.97$, $P = <0.0001$) across countries; thus, separate country models were estimated.

Comparisons between study groups were used to explore the overall objective understanding of front-of-package nutrition labels. Linear regression models were fitted to estimate the adjusted score of correctly identifying the least healthy option across label groups. For these models, the front-of-package label assigned was the independent variable, while the dependent variable was the objective understanding

score. Models were adjusted by sex, age, marital status, monthly household income, education level, occupation, body mass index, previous chronic disease diagnosis, interest in health, and nutrition knowledge.

To compare the acceptability of the assigned labels, we estimated the adjusted proportion of participants agreeing to each of the three acceptability statements using logistic regression models. The front-of-package label assigned was introduced as independent variable, while each of the three acceptability statements were considered as the dependent variable. Models were adjusted by the same previously mentioned covariates. Sensitivity analyses categorizing participants to include the "Neither agree nor disagree" response option in the Agree category showed similar results. Therefore, only the results from our original classification are presented.

To account for the use of several models and multiple comparisons within each model, significance was set at $p < 0.01$ for regression models and test comparisons. Data analysis was performed using STATA 17 (StataCorp LLC., 2022).

3. Results

Of the 10,394 potential participants who agreed to take part in the study, 1508 did not pass the data quality check (completed the survey in less than 15 min). In total, 8886 participants were recruited, completed the survey, and were retained in the analyses (Argentina: 1792; Colombia: 1190; Ecuador: 1203; Mexico: 3283; and Panama: 1418) (Fig. 3). In all countries, the majority were female (58%), aged between 18 and 29 years (66%), divorced, single, or widowed (73%), with a normal self-reported BMI (53%), and with a lot of interest in their health (82%) (Table 1). Differences between study groups were observed in terms of household monthly income, education level, occupation, BMI, and previous diagnosis of some chronic diseases ($p < 0.01$) (Supplementary Table 1).

3.1. Objective understanding

The adjusted average score of correctly identifying the food product with the least nutritional quality is shown in Fig. 4. The multiple comparisons of this outcome across labels for each country are shown in Supplementary Table 2. In all countries, the WL led to higher scores of correctly identifying the food product with the least nutritional quality (Ranges: 3.3 in Ecuador to 3.9 out of 5 in Colombia) compared to the no-label condition (1.9 out of 5 in all countries) and the rest of the labels (Ranges: 1.7 for the GDA in Colombia to 3.0 for the MTL in Ecuador) (all p-values <0.01). The MTL and the Nutri-Score also led to higher scores compared with the control group and the GDA in all countries (all p-values <0.01) but to a lower magnitude than WL (Range of average scores: MTL 2.7–3.0; Nutri-Score: 2.3–2.7). The MTL led to higher scores compared with the Nutri-Score in Argentina (2.8 vs. 2.3), Ecuador (3.0 vs. 2.5), and Mexico (2.8 vs. 2.5) (all p-values <0.01).

3.2. Acceptability of front-of-pack nutrition labeling

The adjusted percentage of participants who strongly agreed or agreed to each of the dimensions evaluating the acceptability of the labels is presented in Fig. 5. The multiple comparisons across the labels for each country are shown in Supplementary Table 3. Separate country models showed that in Argentina, Colombia, Mexico, and Panama, the GDA had the lowest adjusted percentage of likability (Ranges: 52.8% in Argentina to 68.1% in Panama) and attractiveness (Ranges: 56.4% in Argentina to 72.8% in Mexico), compared to the rest of the labels (all p-values <0.01). Conversely, in these countries, this labeling format was considered the one with the highest cognitive workload (Ranges: 51.8% in Panama to 62.3% in Argentina) compared to the rest of the labels (all p-values <0.01).

In Colombia and Panama, no differences were observed in the ratings of the three acceptability dimensions between the MTL, the WL, and the Nutri-Score (all p-values >0.01). Around 90% of participants in both countries considered these labeling formats equally useful for selecting food products (likability dimension). Around 90% of Panamanian and 80% of Colombian participants considered these labels attractive. Around 25% of participants from Panama and between 13.9 and 19.4% from Colombia perceived these labeling formats as having a high cognitive workload.

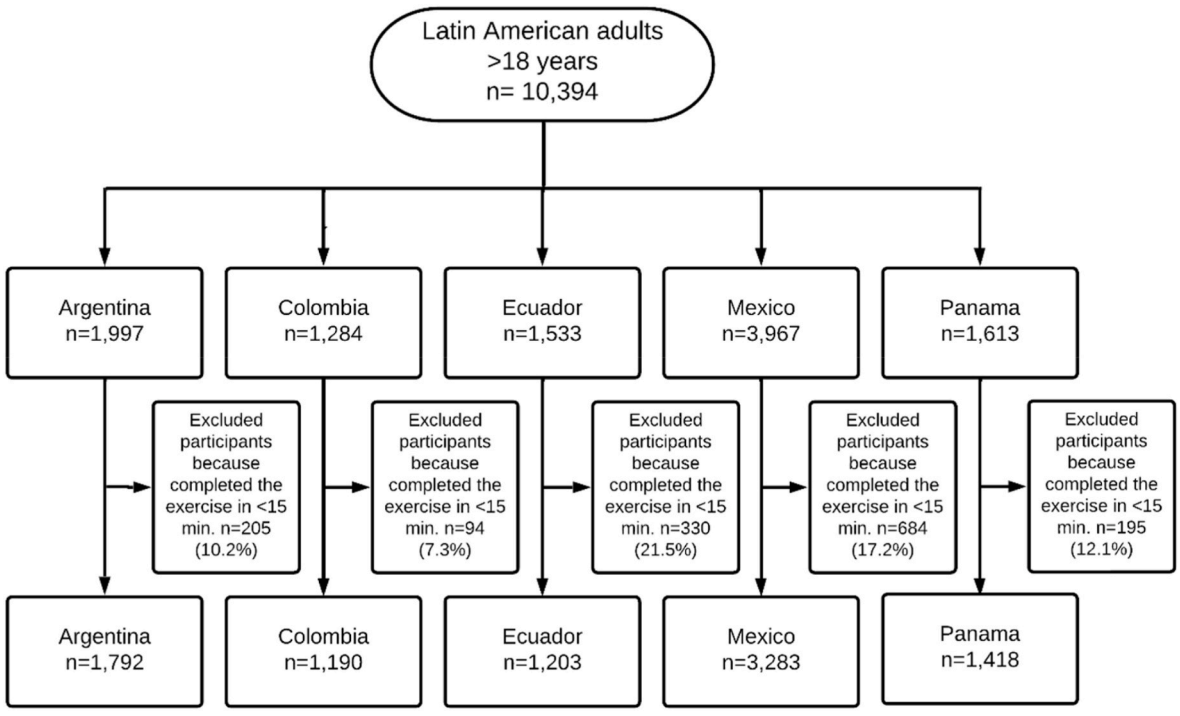

Fig. 3. Participant flowchart by Latin American country.

Table 1
Socio-demographic characteristics of participants by country.

	Total sample	Argentina	Colombia	Ecuador	Mexico	Panama
	n = 8,886	n = 1,792	n = 1,190	n = 1,203	n = 3,283	n = 1,418
Sex, n(%)						
Female	5177 (58)	1136 (64)	717 (61)	628 (52)	1857 (57)	839 (59)
Male	3686 (42)	650 (36)	465 (39)	572 (48)	1422 (43)	577 (41)
Age, n(%)						
18–29 y	5849 (66)	892 (50)	690 (58)	764 (64)	2508 (76)	995 (70)
30–39 y	1190 (13)	398 (22)	145 (12)	237 (20)	267 (8)	143 (10)
40–49 y	744 (8)	170 (9)	138 (12)	117 (10)	205 (6)	114 (8)
50–59 y	718 (8)	191 (11)	141 (12)	67 (6)	201 (6)	118 (8)
60 and over	385 (4)	141 (8)	76 (6)	18 (1)	102 (3)	48 (3)
Marital Status, n(%)						
Divorced/Single/Widow	6479 (73)	1244 (69)	799 (67)	840 (70)	2594 (79)	1002 (71)
Married/partner	2401 (27)	542 (30)	391 (33)	363 (30)	689 (21)	416 (29)
Household monthly income [a], n(%)						
Low	3802 (43)	275 (15)	129 (11)	497 (41)	2613 (80)	288 (20)
Medium	3103 (35)	793 (44)	886 (74)	356 (30)	490 (15)	578 (41)
High	1979 (22)	723 (40)	175 (15)	350 (29)	180 (5)	551 (39)
Education level, n (%)						
Elementary school and lower	252 (3)	68 (4)	32 (3)	38 (3)	78 (2)	36 (3)
Secondary school	2103 (24)	809 (45)	254 (21)	276 (23)	242 (7)	522 (37)
High-school	2841 (32)	442 (25)	381 (32)	453 (38)	1520 (46)	45 (3)
Graduate and postgraduate	3690 (42)	473 (26)	523 (44)	436 (36)	1443 (44)	815 (57)
Occupation, n (%)						
Unemployed	497 (6)	64 (4)	72 (6)	67 (6)	204 (6)	90 (6)
Student	3379 (40)	396 (25)	394 (35)	449 (39)	1569 (50)	571 (41)
Homemaker	100 (1)	100 (6)	0 (0)	0 (0)	0 (0)	0 (0)
Employee	3160 (37)	908 (57)	433 (38)	382 (33)	945 (30)	492 (35)
Salesman/woman	138 (2)	138 (9)	0 (0)	0 (0)	0 (0)	0 (0)
Other	1158 (14)	0 (0)	228 (20)	259 (22)	423 (13)	248 (18)
Body Mass Index [b], n (%)						
Underweight	328 (4)	40 (2)	54 (5)	50 (4)	104 (3)	80 (6)
Normal weight	4684 (53)	897 (50)	704 (59)	700 (58)	1694 (52)	689 (49)
Overweight	2748 (31)	598 (33)	352 (30)	359 (30)	1041 (32)	398 (28)
Obesity	1126 (13)	257 (14)	80 (7)	94 (8)	444 (14)	251 (18)
Previous diagnosis of chronic disease, n (%)						
Diabetes	272 (3)	56 (3)	30 (3)	21 (2)	123 (4)	42 (3)
Hypertension	575 (6)	163 (9)	71 (6)	49 (4)	187 (6)	105 (7)
Overweight	1585 (18)	335 (19)	194 (16)	202 (17)	683 (21)	171 (12)
Obesity	505 (6)	84 (5)	57 (5)	36 (3)	258 (8)	70 (5)
High cholesterol	703 (8)	208 (12)	114 (10)	120 (10)	166 (5)	95 (7)
High triglycerides	619 (7)	127 (7)	108 (9)	137 (11)	191 (6)	56 (4)
Cancer	53 (1)	19 (1)	8 (1)	10 (1)	13 (0)	3 (0)
Cardiovascular disease	136 (2)	31 (2)	21 (2)	14 (1)	49 (1)	21 (1)
Interest in health [c], n (%)						
Nothing	87 (1)	17 (1)	8 (1)	12 (1)	34 (1)	16 (1)
Somewhat	1476 (17)	384 (21)	181 (15)	185 (15)	518 (16)	208 (15)
A lot	7323 (82)	1391 (78)	1001 (84)	1006 (84)	2731 (83)	1194 (84)
Nutrition knowledge [d], n (%)						
Nothing	750 (8)	271 (15)	81 (7)	70 (6)	208 (6)	120 (8)
A little	3174 (36)	664 (37)	434 (37)	394 (33)	1194 (37)	488 (35)
Somewhat	4465 (50)	719 (40)	624 (53)	699 (58)	1712 (52)	711 (50)
A lot	471 (5)	138 (8)	48 (4)	37 (3)	155 (5)	93 (7)

[a] Argentina (Low: < $40,000; Medium: $40,001 - $100,000; High: $100,001). Colombia (Low: Less than one minimum salary; Medium: between 1 and 5 minimum salaries; High: more than five minimum salaries). Ecuador (Low: Less than $100 to $500; Medium: $501 to $900; High: $901 or more). Mexico (Low: Less than $3040 to $12,990; Medium: $12,991 to $26,199; High: $26,200 or more). Panama (Low: Less than $100 to $300; Medium: $301 to $900; High: $901 or more).
[b] Estimated with self-reported height and weight.
[c] Information collected with the question: "How interested are you in your health."
[d] Data collected with the question: "In your opinion, how knowledgeable are you in nutrition?.

In Argentina, more than 80% of participants considered the MTL, the Nutri-Score, and the WL equally likable (all p-values >0.01). Compared to the Nutri-Score, the MTL and the WL were more attractive (MTL: 87.3% and WL: 88.3% vs. Nutri-Score: 78.2%) for a higher percentage of participants. A lower percentage considered that these labels required a high cognitive workload (MTL: 18.0% and WL: 19.0% vs. Nutri-Score: 28.4%) (all p-values <0.01).

In Mexico, a similar proportion of participants considered the MTL and the WL as the most likable (MTL: 88.5%, WL: 84.2%), followed by the Nutri-Score (83.6%, p-value <0.01). Similarly, for most participants, the MTL (87.7%) and the WL (90.7%) were attractive (p-values >0.01), with no significant differences between them. Conversely, a higher percentage considered the WL to need a higher cognitive workload (28.4%) than MTL (20.9%) (p-value <0.01).

In Ecuador, most participants considered the MTL and the Nutri-Score equally useful for choosing food products (likability dimension) (MTL: 89.2%, Nutri-Score: 88.2%). The MTL, the Nutri-Score, and the WL were equally attractive (86.4, 84.3, and 81.1%, respectively) (p > 0.01). Conversely, participants from this country considered that both the MTL (21.3%) and the Nutri-Score (27.4%) required the least cognitive workload, with no significant differences between them (p > 0.01).

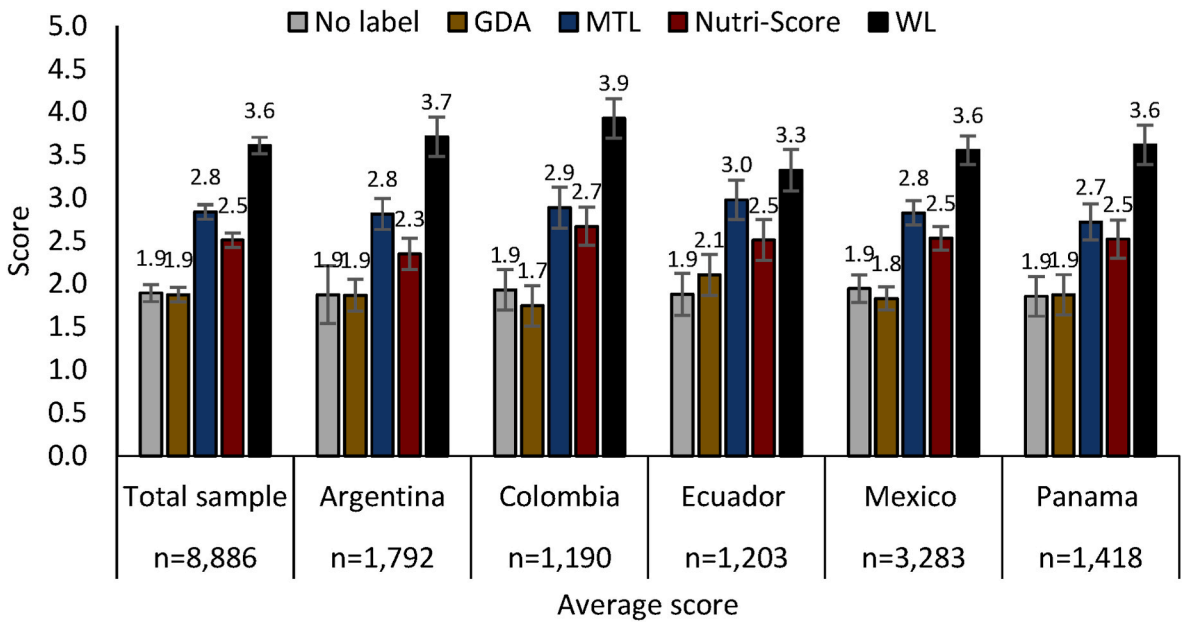

Fig. 4. Average score for correctly identifying the product with the lowest nutritional quality (Range 0 to 5 foods correctly identified). GDA: Guideline Daily Amount; MTL: Multiple Traffic Light; WL: Warning Label. Estimates adjusted by sex, age, marital status, household monthly income, educational level, occupation, body mass index, previous diagnosis of chronic disease, interest in health, and nutrition knowledge. Total sample also adjusted by country.

4. Discussion

This randomized experiment showed that label acceptability and objective understanding differed across countries. The WL was the only front-of-package nutrition label that consistently led to higher scores of correctly identifying the food product with the least nutritional quality compared to other front-of-package nutrition labels or a control condition across all countries. Other labels, such as the MTL and the Nutri-Score, were effective in helping consumers in all countries identify unhealthy food products, but to a lower extent. The GDA did not exert this effect in any country. Results also showed that the GDA was consistently rated as the least accepted in all countries, while the MTL, followed by the WL, was the most accepted in most countries.

4.1. Objective understanding and acceptability of front-of-package nutrition labels

The WL were the most effective in helping participants identify products with the least nutritional quality in all countries. These results are consistent with evidence in other studies showing that WL were associated with greater levels of understanding among adults (Acton et al., 2023; Ares et al., 2021; Nieto et al., 2019; Song et al., 2021; Taillie, Hall, Popkin, Ng, & Murukutla, 2020) and demonstrated the greatest efficacy in decreasing the perceived healthfulness of sugary drinks and other unhealthy products compared to other labels (Health, 2018; Jáuregui et al., 2022; World Heart Federation, 2020). The results support the recommendations of international organizations such as FAO, OPS, and UNICEF (FAO et al., 2022), which state that WL are the most useful for helping people choose healthier products. This labeling system communicates clear, non-quantitative messages about high levels of nutrients of concern, which may help consumers readily identify unhealthy food products (Health, 2018; Jáuregui et al., 2022; World Heart Federation, 2020). However, it is important to note that while our results suggest that WL are better understood, the overall level of understanding reported in this study remains at an average level. Factors such as varying levels of health literacy, differences in education, and exposure to nutritional education can influence the effectiveness of these labels. This underscores the importance of implementing front-of-package nutrition labeling initiatives as part of a suite of complementary measures, supported by educational campaigns, to increase their public health impact.

Results of this study also indicate that WL were well accepted by participants. In line with our results, other studies have shown that WL are preferred by parents with vulnerable conditions (i.e., low education levels and overweight) across four Latin American countries (Argentina, Chile, Costa Rica, and Mexico). It has been suggested that familiarity plays an important role in the understanding and acceptability of front-of-package nutrition label systems (Kelly & Jewell, 2018; Rincón et al., 2019). However, the favorable acceptability and high understanding observed in our study across countries where WL have not been implemented suggest that familiarity may not be relevant for this labeling system.

Results of this study also suggest that MTL may help consumers easily identify unhealthy food products, especially in Ecuador and Panama, and that this labeling format is highly accepted. Regarding Ecuador, this result can be potentially attributed to implementing this front-of-package nutrition label for almost 10 years (Díaz et al., 2017). Thus, the MTL is expected to be better understood and used by the population (Kelly & Jewell, 2018). A study in Uruguayan adults reported that the MTL system is more effective in reducing the perceived healthfulness of ultra-processed foods than the GDA for low-income participants (Machín et al., 2017). Among low- and middle-income Mexican consumers, MTL and WL were more understood compared to GDA, allowing quicker nutrition-quality-related decisions (Vargas-Meza, Jáuregui, Contreras-Manzano et al., 2019), consistent with qualitative findings (Vargas-Meza, Jáuregui, Pacheco-Miranda, et al., 2019). Nevertheless, in Hispanic consumers, this labeling system proved to be confusing when a single product was labeled with a variation of colors instead of a predominant one, which decreased the effectiveness of this front-of-package nutrition label in influencing participants' intention to make a healthy choice (De la Cruz-Góngora et al., 2017). Another study highlighted inconsistencies in how the MTL classifies certain products, causing some to be perceived as healthy and nutritious based on their green labels or lack of salt, fat, or sugar. However, this may not always hold true, as illustrated by "light" sodas, which are neither nutritious nor healthy, and the consumption of non-caloric sweeteners is not recommended, especially for children and pregnant women (Morales-Avilez, Cruz-Casarrubias, Tolentino-Mayo, Encalada-Torres, & Abril-Ulloa,

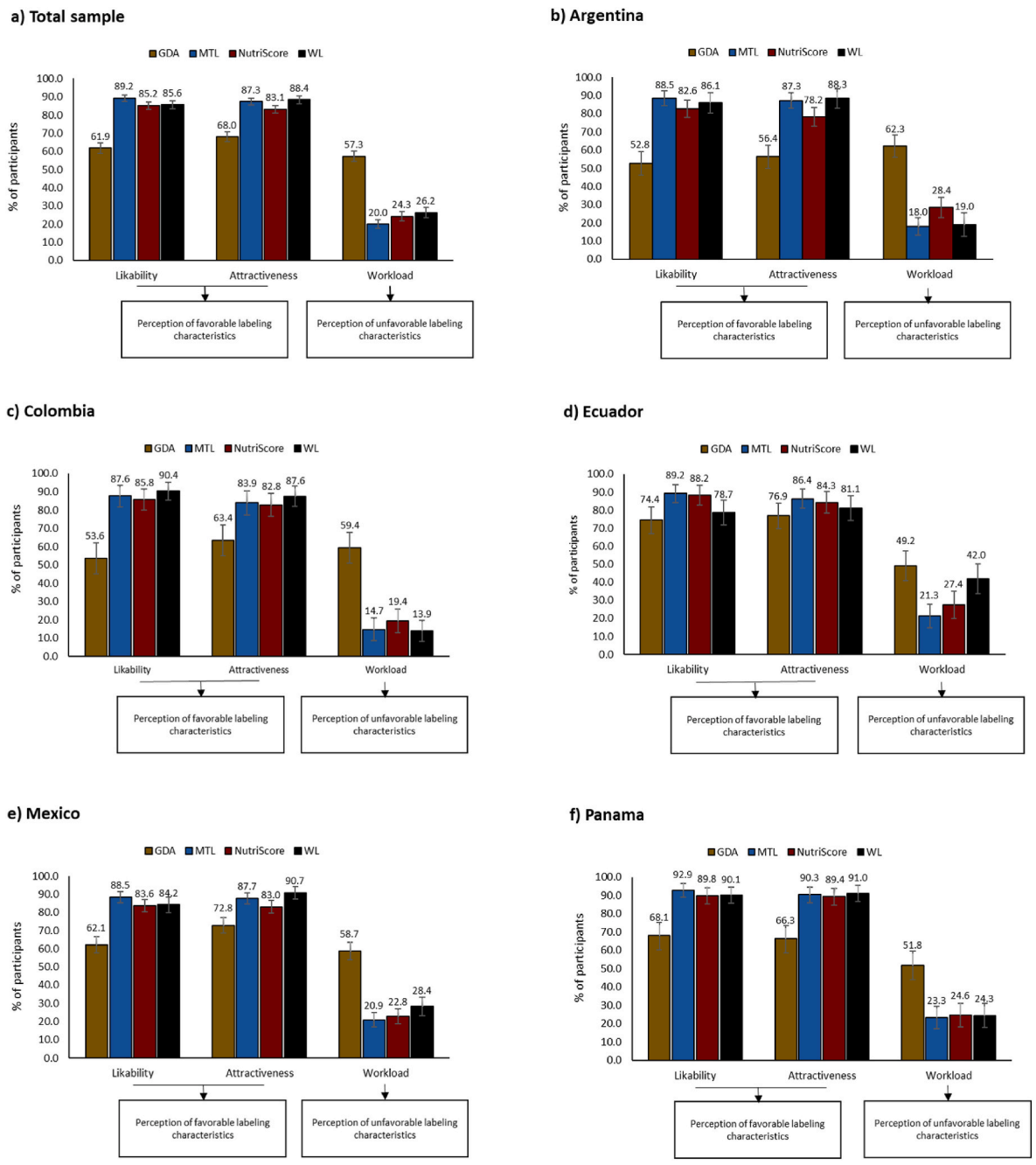

Fig. 5. Proportion of participants who strongly agreed or agreed to each of the dimensions evaluating label acceptability by Latin American country. GDA: Guideline Daily Amount; MTL: Multiple Traffic Light; WL: Warning Label.

2020). Conversely, according to the MTL, other products, such as yogurt, may appear unhealthy due to their natural saturated fat content (Wilma B. Freire et al., 2021).

Our results are in line with consistent evidence supporting the greater acceptance of the MTL among consumers in Mexico (De la Cruz-Góngora et al., 2017), France (Méjean, Macouillard, Péneau, Hercberg, & Castetbon, 2013), and elsewhere (Hawley et al., 2013). Previous studies in Ecuador indicated that individuals associated the MTL with a traffic light, perceiving it as an easy-to-understand tool that provides information on processed products' fat, salt, and sugar content (Wilma B. Freire et al., 2021). Despite the latter, MTL is more understood by individuals with higher nutrition knowledge and who are frequent readers of front-of-package information, suggesting that the ability to understand this front-of-package nutrition label system may differ among social characteristics (Mejean et al., 2013). Although MTL had the highest acceptance, this label was not the most useful in aiding participants identify the product with the lowest nutritional quality. This inconsistency may be explained by the fact that consumer preference for a label format does not always indicate label comprehension or the ability to use a label to choose a healthy product, as suggested by previous research (Hawley et al., 2013). Label preference may also reflect familiarity with a front-of-package nutrition label system. In Belgium, participants preferred the GDA label instead of the MTL, potentially due to their familiarity with the GDA symbols (Hawley et al., 2013).

Findings of this study suggest that the Nutri-Score may also help consumers easily identify unhealthy food products and is highly accepted across the included countries. A study conducted in 12

countries (Argentina, Australia, Bulgaria, Canada, Denmark, France, Germany, Mexico, Singapore, Spain, the United Kingdom, and the United States) showed that Nutri-Score performed best in enabling individuals to rank products according to their nutritional quality (Egnell, Talati, Hercberg, Pettigrew, & Julia, 2018). According to a systematic review, interpretive front-of-package nutrition labels schemes such as Nutri-Score, MTL, and WL are more comprehensible and produce more equitable effects (Shrestha et al., 2023). The authors of this review also suggest that consumers with low socioeconomic status prefer simplified and easy-to-use labels (Shrestha et al., 2023). Those findings are consistent with our results, where the Nutri-Score was more useful than the control condition and the GDA in aiding participants identify the product with the lowest nutritional quality. However, despite high acceptability, the Nutri-Score did not outperform the MTL or the WL in terms of objective understanding. Further analyses are required to explore potential differences in the effects of front-of-package nutrition labels by sociodemographic characteristics in these countries.

On the other hand, the GDA performed poorly in guiding consumers to identify products with lower nutritional quality and had the lowest acceptability among the labels tested in all countries. Notably, although the GDA had been implemented between 2014 and 2020 in the Mexican population, its acceptability was poor compared to the rest of the front-of-package nutrition labels evaluated. Previous studies in Mexico have found that GDA labeling is little used and hard to understand, even for people with nutrition training (Stern et al., 2016). Additionally, considering the time and nutritional knowledge required for its interpretation, this front-of-package nutrition label is less understood among vulnerable populations (De la Cruz-Góngora et al., 2017; Kroker-Lobos et al., 2023; Stern et al., 2016; Tolentino-Mayo et al., 2020; Vargas-Meza, Jáuregui, Contreras-Manzano et al., 2019). Furthermore, previous studies showed that participants do not like nor perceive the usefulness of the GDA label because of their lack of understanding of technical terms, the arithmetic procedure needed to identify the serving size equivalent, the time required to analyze the elements displayed, and the overall lack of comprehension of the nutrition information provided (De la Cruz-Góngora et al., 2017). Consistent with these findings, in our study, over 50% of the participants considered this label too complex and time-consuming to understand. Consumers generally have limited time to process nutritional information on nutritional labels, making decisions in as little as a third of a second (Milosavljevic, Koch, & Rangel, 2011). However, the GDA takes more time (>15s) to be interpreted than simpler ones like the MTL or the WL (11s) (Vargas-Meza, Jáuregui, Contreras-Manzano et al., 2019). These results underscore the need for front-of-package nutrition labels to inform consumers in minimum time (Jáuregui et al., 2020; Stern et al., 2016; Tolentino-Mayo et al., 2018).

4.2. Strengths and limitations

To the author's knowledge, this is the first international study using a large sample of Latin American consumers that compares the objective understanding and acceptability of different front-of-package nutrition labels. This study employed an experimental design, ensuring minimal influence of confounding factors. However, it is necessary to consider some limitations. First, the non-representative nature of the sample at the local or population level for each country may limit the external validity of the results to individuals with similar characteristics to the sample. Specifically, a high proportion of study participants were young with a high educational level, which likely reflects both the type of individuals more inclined to agree participate in the study and the recruitment methods employed. Nevertheless, previous experiences in Mexico show that the comprehension of the front-of-package nutrition label alternatives is not different by socioeconomic status (Vargas-Meza, Jáuregui, Contreras-Manzano et al., 2019). Second, our research was only focused on four nutrition labeling systems; however, these systems are used or considered for implementation in Latin American countries, highlighting the regional relevance. We also included a control group to estimate their effect compared to a no label on the front of the products, which is the case in most Latin American countries. Thirdly, participants gave their answers after being informed about the interpretation of the label assigned to them. This step was essential to standardize the information received by consumers, which may have been exposed to different labeling campaigns before our study. For example, in Mexico communication campaigns aiming to improve the understanding of WL and GDA labels were implemented in 2020 (*Héroes Por La Salud*, 2020) and 2016 (*Checa y Elige*, 2016), respectively; in Ecuador, a similar campaign was implemented in 2017 regarding the MTL (Andrade, Solis, Rodríguez, Calderón, & Domínguez, 2017). Therefore, this controlled setting does not reflect a real-world situation, where decisions are influenced by various factors such as time pressure, product placement, and habitual purchasing patterns, and may not fully capture influences to habitual food purchasing decisions (Temple, 2020). Nonetheless, a recent study with young and adult Mexican populations showed that WL labeling decreases the self-reported purchases of unhealthy foods (Contreras-Manzano et al., 2024). Fourthly, outcome variables were transformed into nominal variables to simplify the presentation of the results and communicate the results more efficiently, which may have resulted in a loss of precision. However, given the large sample size in our study, the impact of this loss in precision was mitigated, allowing us to capture patterns in the data despite the transformation. Additionally, our study focused on the ability of nutritional labels to help consumers identify unhealthy foods, ignoring healthy foods. This decision may have limited the ability of the study to present a fuller picture of the value of front-of-package nutritional labels. However, this decision was made in alignment with regional recommendations to highlighting products with poor nutritional profiles to improve consumer purchase decisions by avoiding excessive amounts of sugars, total fats, saturated fats, trans fats, and sodium (Organización Panamericana De La Salud, 2022). There is evidence that products with excessive amounts of these critical nutrients tend to be ultra-processed foods and beverages, which are also associated with a lower intake of positive nutrients such as vitamins, minerals, protein, and fiber (Marrón-Ponce, Flores, Cediel, Monteiro, & Batis, 2019; Neri et al., 2022). Moreover, front-of-package nutrition labeling that includes positive nutrients may encourage the overconsumption of ultra-processed and processed products, potentially distracting consumers from overall dietary recommendations (Franco-Arellano, Vanderlee, Ahmed, Oh, & L'Abbé, 2020). Finally, we used a limited number of food items, and participants could only view the front of the product packages. However, we used real food products consumed in Latin American countries and kept any nutritional or health declarations on the frontal display of the product.

5. Conclusion

Our findings underscore the potential of the WL labeling system as an option to aid consumers in improving purchasing decisions. Specifically, WL may be particularly effective in helping Latin American consumers correctly identify products with high contents of critical nutrients related to non-communicable diseases. Considering that WL have been successfully implemented in various Latin American countries and are aligned with international recommendations to address unhealthy food environments, the current study contributes to the growing body of evidence supporting the implementation of WL on the front of packages as a robust policy option. The study also provides insights regarding other labels considered policy options in some countries, including the Nutri-Score and the MTL. However, despite the high acceptability of these labels, our study has shown that WL performed best in helping consumers identify unhealthy food products. In contrast, the study found little support for the GDA system as a policy option since this labeling showed less acceptability and lacked effectiveness in helping identify the products with poor nutritional quality.

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Data and code availability

The corresponding author has full access to the data reported in the manuscript.

Ethical statement

The Ethics, Research, and Biosafety Committees of the Mexican National Institute of Public Health evaluated and approved this study (CI: 1122).

CRediT authorship contribution statement

Cecilia I. Oviedo-Solís: Writing – original draft, Supervision, Investigation, Formal analysis. **Lizbeth Tolentino-Mayo:** Writing – review & editing, Supervision, Resources, Methodology, Conceptualization. **Kathia Larissa Quevedo:** Writing – review & editing, Investigation. **Sonia Ana Naumann:** Writing – review & editing, Investigation. **Gustavo Cediel:** Writing – review & editing, Investigation. **Mercedes Mora:** Writing – review & editing, Investigation. **Victoria Abril-Ulloa:** Writing – review & editing, Investigation. **Israel Ríos-Castillo:** Writing – review & editing, Investigation. **Victoria Valdes:** Writing – review & editing, Investigation. **Flavia Fontes:** Writing – review & editing, Investigation. **Janine Sagaceta:** Writing – review & editing, Investigation. **Daniela García:** Writing – review & editing, Investigation. **Mariana Andrea Janjetic:** Writing – review & editing, Investigation. **Lecticia Azzaretti:** Writing – review & editing, Investigation. **Gabriela Flores:** Writing – review & editing, Investigation. **Eliana Hansen:** Writing – review & editing, Investigation. **María Valeria Souto Brey:** Writing – review & editing, Investigation. **Andrea Paula Cravero Bruneri:** Writing – review & editing, Investigation. **Natalia Romero Mathieu:** Writing – review & editing, Investigation. **Alejandra Jáuregui:** Writing – review & editing, Resources, Project administration, Methodology, Conceptualization. **Simón Barquera:** Writing – review & editing, Project administration, Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2024.107691.

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