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Impact of nutrient warning labels on choice of ultra-processed food and drinks high in sugar, sodium, and saturated fat in Colombia: A randomized controlled trial

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Abstract

Objective

This study assessed nutrient warnings' impact on product selection and identification of food products high in nutrients of concern in Colombia.

Methods

In an online experiment (October 2020), 8,061 Colombians were randomized to a nutrient warning, guideline daily amounts (GDA), Nutri-Score, or no-label condition. They viewed two fruit drinks labeled according to their condition, one high in sugar and one not, and completed selection tasks. Next, they assessed four products high in sugar, sodium, and/or saturated fat ("high in" product). Finally, they selected which label would most discourage them from consuming a "high in" product.

Results

The nutrient warning performed better on most outcomes. Twenty percent of participants exposed to the nutrient warning would purchase the high-sugar fruit drink compared to GDA (24%, p<0.01), Nutri-Score (33%, p<0.001), and no label (29%, p<0.001). GDA performed slightly better than the nutrient warning in identifying the high-sugar fruit drink (91% vs 88%, p<0.001). The nutrient warning best helped participants correctly identify other "high in" products (75% vs. 23% no-label, 26% Nutri-Score, and 43% GDA, all p<0.001) and had the highest perceived message effectiveness (3.86 on 5-point scale vs. 2.97 GDA and 2.70

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Nutri-Score, both p<0.001) and lowest likelihood of purchasing "high in" products (2.58 on 5-point scale vs. 3.23 GDA, 3.49 Nutri-Score, and 3.51 no label, all p<0.001). The nutrient warning most discouraged participants from wanting to consume "high in" products.

Conclusions

Nutrient warnings are a promising policy to help consumers identify and discourage consumption of products high in nutrients of concern.

Trial registration

Trial Registration: NCT04567004.

Introduction

Obesity and diet-related non-communicable diseases (NCD) have become great health challenges, posing risks to the health and lives of individuals, the well-being of families, and economic development [1,2]. Colombia is not immune to such health challenges; according to the Colombian National Nutritional Health Surveys (ENSIN) conducted in 2010 and 2015, the prevalence of overweight and obesity increased 5.6 percentage points in school-aged children (5–12 years old), 2.4 percentage points in adolescents (13–17 years old), and 5.2 percentage points in adults (18–64 years old) [3,4]. Furthermore, a recent study assessing the diseases for which obesity and overweight are risk factors found that in Colombia, obesity and overweight contribute to approximately 17% of years lived with a disability, 9% of disability-adjusted life years, and 3% of years of life lost [5].

There is compelling evidence about the link between the shift from consumption of unprocessed foods to ultra-processed foods and the increase in obesity and diet-related NCD [6–9]. Ultra-processed foods are generally low in beneficial nutrients like fiber, protein, micronutrients, and bioactive compounds [10–12] and tend to be high in nutrients related to chronic diseases such as sugar, sodium, and saturated fat ("high in" products) [13]. In Colombia, from 2000 to 2013, per capita sales of ultra-processed foods and beverages increased by 25% [14] and an analysis of responses to the ENSIN 2005 and ENSIN 2015, found that both children and adults had worsening diets with increased consumption of "high in" products including sugar-sweetened beverages and processed meats [15].

To address the rising prevalence in overweight, obesity and diet-related NCD, scholars, advocates and policymakers are increasingly calling for policies to communicate the health risks of consuming "high in" products and to discourage their consumption [16,17]. Front-of-package labels have emerged as one promising policy to guide and influence consumers to make healthier food choices and purchasing decisions [18]. Many countries in the world have applied different front-of-package designs such as guideline daily amounts (GDA) labels, Nutri-Score labels, and nutrient warning labels (hereinafter referred to as nutrient warnings) [19]. Currently, in Latin America, nutrient warnings dominate and are required in Peru, Uruguay, Chile, Mexico and Argentina. In fact, there is emerging evidence that of the different front-of-package labels, nutrient warnings may be most effective at helping consumers to identify "high in" products and discourage them from selecting such products [17]. Now, Colombia is considering implementing nutrient warnings as well. On July 30, 2021, the president signed a nutrient warning bill into law, which is expected to be fully implemented within one

year [20]. However, there are tensions between the law and the requirements that the Colombian Ministry of Health is proposing, which are weaker than what the government intended when signing the bill into law [21]. Currently, the food and health coalition in Colombia is advocating for a resolution in accordance with the original terms of the law, while the food industry in Colombia is advocating for requiring alternative front-of-package labels such as GDA [22]. Conducting research on different label types in Colombia is important in order to ensure the most evidence-based label is ultimately implemented.

While a recent online randomized controlled trial in Colombia, which assessed perceptions of and reactions to different nutrient warning designs, concluded that the octagonal nutrient warnings performed best, compared to circular and triangular nutrient warnings [23], there is a dearth of evidence demonstrating which type of front-of-package label would perform best in Colombia. There is also no information as to whether a low versus high level of education moderates the impact of the front-of-package labels on food and drink selections of Colombians. This is important to know in order to assess if a front-of-package label could potentially have a disparate impact on food and drink selections of Colombians with high versus low levels of education.

Because the nutrient warning label is the most likely label to be implemented in Colombia based on the current legislative and ministerial agendas, the objectives of this study were to identify the impact of nutrient warnings on participants' selection of "high in" products and ability to identify them, compared to GDA labels, Nutri-Score labels, and a no-label condition in Colombia. We also investigated whether these outcomes varied by education level.

Methods

The online randomized study (Fig 1) was approved by the institutional review board at the University of North Carolina at Chapel Hill and designated as exempt from review at Universidad Nacional de Colombia. Prior to the study, participants read the consent form online and acknowledged their informed consent by proceeding onto the study. We pre-registered the design, hypotheses, and analytic plan on ClinicalTrials.gov (#NCT04567004).

Study design and procedures

As the purpose of the study was to inform Colombia's front-of-package labeling policy, we set out to test front-of-package labels that have been implemented in other countries and could potentially be implemented in Colombia. Potential labeling options were determined through consultation with a food and health advocacy coalition in Colombia, who provided insight on which labels were most likely to be proposed as regulatory options in the Colombian legislature or Ministry of Health. As a result of these conversations, we decided to compare the GDA label (which the food industry has promoted), Nutri-Score label, and a no-label alternative to the nutrient warnings on specific outcomes related to identifying and discouraging selection of ultra-processed foods. We hypothesized that the nutrient warnings would perform best on all outcomes, as previous research has found nutrient warnings to perform best on such outcomes [24]. The labels tested are shown in Fig 2.

We selected the octagonal nutrient warnings, because they performed best in our previous randomized experiment (compared to two other nutrient warnings and a control) which investigated front-of-package nutrient warnings [23]. The octagonal nutrient warnings were the label type that the most participants selected as discouraging them from purchasing foods and sugary drinks high in nutrients of concern and were scored with the highest perceived message effectiveness (PME) [23]. The octagonal nutrient warning was a black octagon that contained a statement about the product containing excess of a nutrient of concern (sugar,

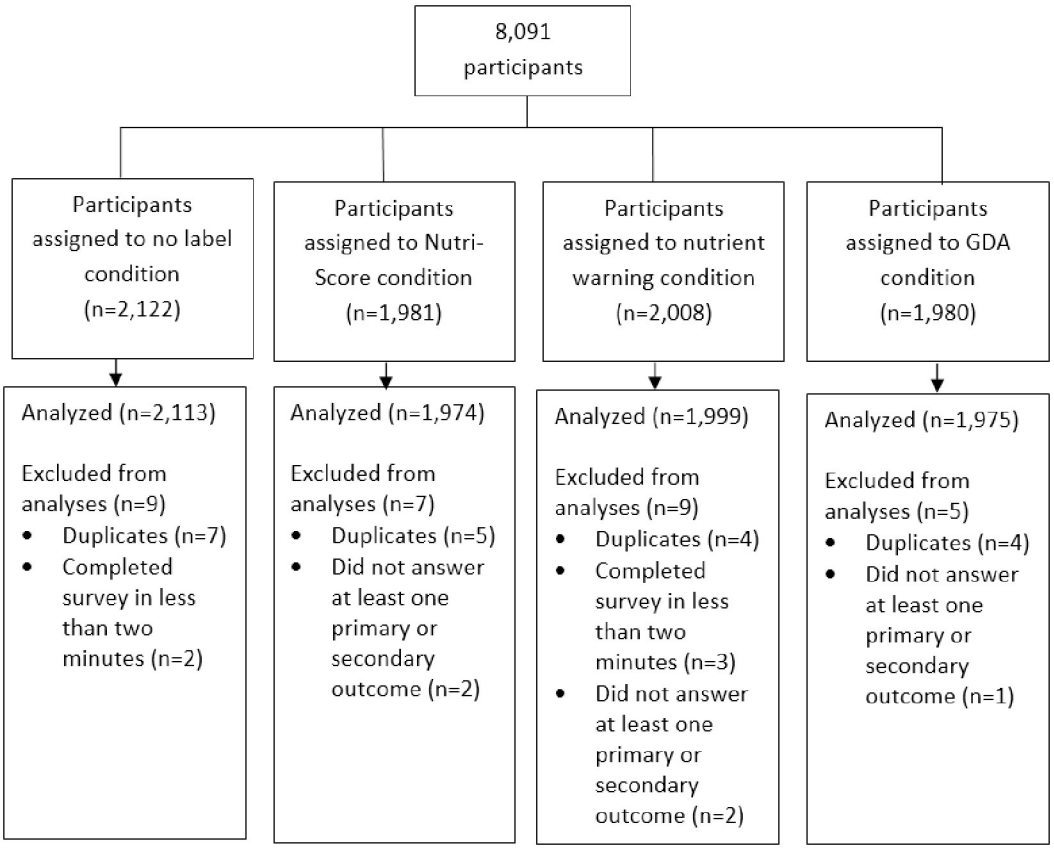

Fig 1. CONSORT flow diagram.

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sodium, or saturated fat). For example, "EXCESO DE AZÚCAR" (Excess sugar). The octagon also contained "MINSALUD" indicating the message was authorized by the Colombian Ministry of Health and the text "EVITAR SU ALTO CONSUMO" (Avoid high consumption). To determine if a product would receive a nutrient warning, we used the Chilean Ministry of Health's third stage cutoff limits for sugar, sodium, and saturated fat [25].

The GDA label included Spanish text above the GDA figure stating the product serving size. Below the serving size, a row of light blue blocks listed the Calories, total fat, saturated fat, sugar, and sodium per serving, as well as percentages indicating what percent of the GDA the serving contained. Underneath the light blue blocks, Spanish text explained the percentages were based on the guideline daily amounts for a 2,000-Calorie diet [26]. The GDA label was the only label condition that provided nutrition information on the product.

The Nutri-Score label system, which is currently used voluntarily in some European countries [27], is a color coded and letter rated (A-E) system. A dark green "A" indicates the best nutritional value and a dark red "E" indicates the worst nutritional value. A product's letter rating is determined based on a point system. A higher point value indicates a less healthy product. The more calories, sugar, sodium, and saturated fat a product contains, the more points it receives. However, a product can also receive negative points for containing fiber, protein, and fruits and vegetables, which can decrease the product's total points [28].

Finally, we decided to also test a no-label condition. Previous experiments on nutrient warnings have used a neutral barcode as a control in order to measure perceptions of and

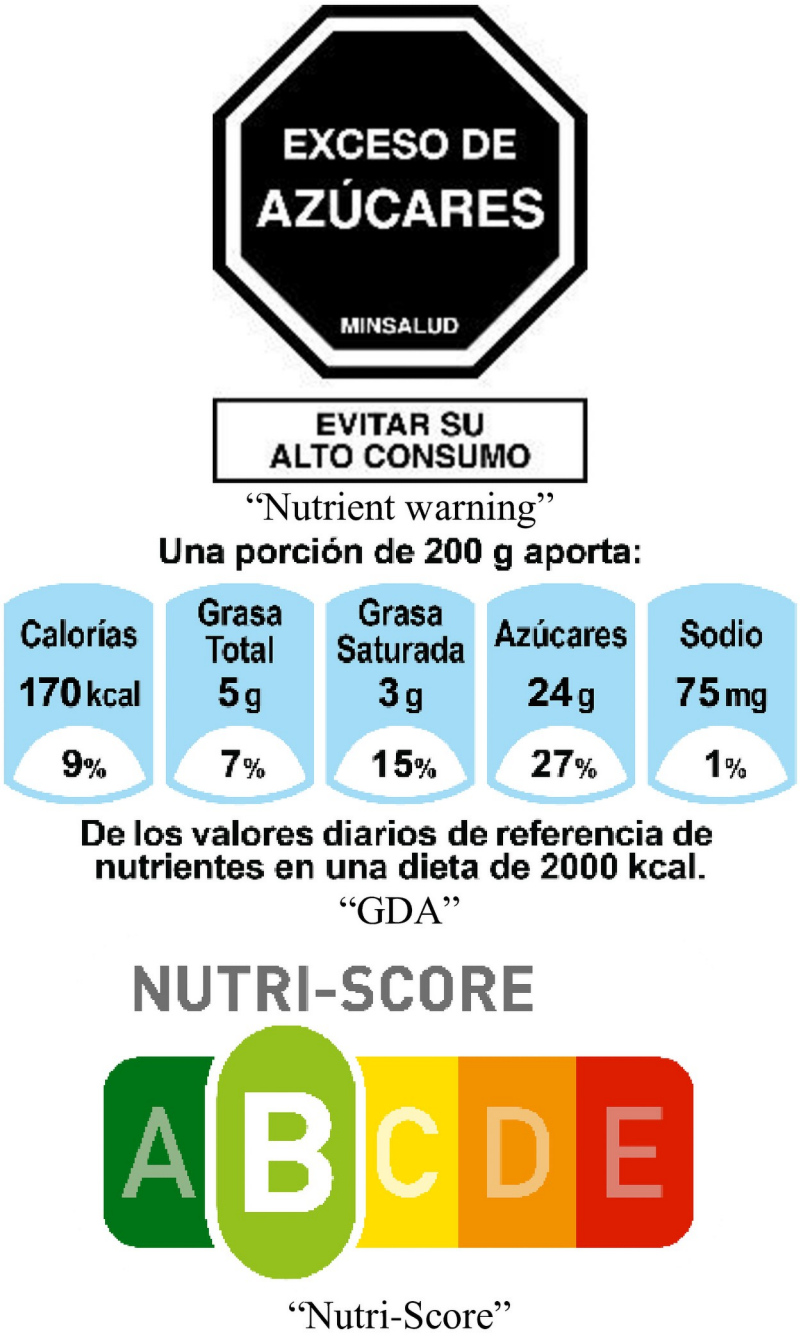

Fig 2. Front-of-package labels used in experiment. *Note*. Labels listed above represent the version of each label used on the yogurt (excess sugar).

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reactions to front-of-package labels [23]. However, in this study, we wanted to test actual policies that could be implemented by the Colombian government. It is possible that the government could decide to not implement a front-of-package labelling system (status quo), so we also tested a no-label condition to measure the outcomes of maintaining the status quo compared to implementing the nutrient warnings. We used the Peruvian nutrient warning guidelines to design the size and placement of the label conditions [29].

Product development and applied labels. Images of the products can be found in S1 Fig. We selected food and drink products from categories that make up some of the most commonly consumed ultra-processed foods in Colombia [17], and modeled the products after real Colombian ultra-processed products that are high in nutrients of concern (sugar, sodium, and saturated fat). We used three products we had previously tested (fruit drink, oatmeal cookies, and sliced bread) [23], and the same graphic designer who developed our previous products helped in the development of three new products: a no-sugar-added fruit drink, breakfast cereal, and strawberry yogurt. The breakfast cereal was slightly different from the other products because it contained excess amounts of both sugar and sodium. Therefore, the breakfast cereal fashioned two nutrient warnings, while the other products only had one. All products contained fictional brand names to avoid consumer brand loyalty bias.

For each labelling system, the presence or absence of the label (nutrient warning) or content of the label (Nutri-score, GDA) depended on the nutritional composition of the product. Thus, we created nutrition profiles for each product, adapted from real products sold in Colombia. Table 1 provides each product's nutritional profile and the corresponding label applied. The backs of the mock products were not visible; as such, there was no nutrition facts panel available for participants to review.

Participants

In October 2020, we recruited an online national convenience quota sample of 8,061 adults in Colombia to participate in an experiment. We recruited participants through Offerwise, a market research company with over 300,000 panel participants in Colombia. Inclusion criteria included presently residing in Colombia and being between 18 and 65 years of age. We excluded panel members that participated in a previous study of ours investigating the efficacy of different front-of-package nutrient warnings [23]. We set sample quotas for gender to reflect the Colombian population and for education level (half high school graduate or less, half college degree or higher) to ensure our sample was powered to detect differences in the primary outcome by education level. Participants earned a pre-determined amount of points from Offerwise for completing the study. Participants are able to convert points into money once they accumulate a specified amount.

Procedures

Participants completed an online survey programmed in Spanish using Qualtrics survey software. After providing informed consent, Qualtrics equally randomized participants to one of the four front-of-package label conditions: nutrient warning, Nutri-Score, GDA, or a no-label condition. They first completed a fruit drink selection task, where they were asked a series of questions about two fruit drinks, one of which was healthier (contained 15.8 grams of naturally occurring sugar in the fruit—the product did not contain added sugar) and one of which was less healthy (contained 39.4 grams of total sugars, including added sugar). In the selection task, participants were asked to select which fruit drink was higher in sugar, which they would rather buy, and which was most unhealthy. The fruit drinks were displayed with the labels corresponding to the participant's randomly assigned label condition. We only included selection tasks for one type of product due to survey space constraints. We decided to use fruit drinks for the selection tasks because of the increasing consumption of sugar-sweetened beverages in Colombia [15].

Next, participants completed single product assessment tasks. They viewed a prompt that read: *"The next questions are about food products. You will look at a few different products and answer questions about each one. Please keep in mind that this study seeks to evaluate your*

Table 1. Product nutrition details and label applied to each product.

Mock Product	Product Modeled After	Nutrition profile	GDA Label (% of GDA)	Nutri-Score Label	Nutrient warning Label
No-sugar added fruit drink (450 mL)	Hit mango without added sugar	Serving: 450mL Calories: 33.8 Fat: 0g Saturated Fat: 0g Sugars: 15.8g* Sodium: 33.8mg	Serving: 450mL Calories: 2% Fat: 0% Saturated fat: 0% Sugars: 18% Sodium: 1%	B	None
Fruit drink (450 mL)	Hit tropical fruits	Serving: 450mL Calories: 168.8 Fat: 0g Saturated Fat: 0g Sugars: 39.4g** Sodium: 28.1mg	Serving: 450mL Calories: 8% Fat: 0% Saturated Fat: 0% Sugars: 44% Sodium: 0%	B	Excess sugar
Strawberry yogurt (200 g)	Colanta strawberry yogurt	Serving: 200g Calories: 170 Fat: 5g Saturated Fat: 3g Sugars: 24g** Sodium: 75mg	Serving: 200g Calories: 9% Fat: 7% Saturated Fat: 15% Sugars: 27% Sodium: 1%	B	Excess sugar
Oatmeal cookies (150 g)	Tosh oatmeal cookies with apple and peanuts	Serving: 150g Calories: 700 Fat: 35g Saturated Fat: 15g Sugars: 15g** Sodium: 200mg	Serving: 150g Calories: 35% Fat: 50% Saturated Fat: 75% Sugars: 17% Sodium: 3%	C	Excess saturated fat
Sliced bread (450 g)	Comapan extra large butter flavored bread	Serving: 37g Calories: 100 Fat: 2g Saturated Fat: 1g Sugars: 0g Sodium:180mg	Serving: 37g Calories: 5% Fat: 3% Saturated Fat: 5% Sugars: 0% Sodium: 3%	B	Excess salt/sodium
Cereal (500 g)	Post honey bunches of oats with almonds	Serving: 32g Calories: 130 Fat: 2.5g Saturated Fat: 0g Sugars: 6g** Sodium: 135mg	Serving: 32g Calories: 7% Fat: 4% Saturated Fat: 0% Sugars: 7% Sodium: 2%	C	Excess sugar; Excess salt/ sodium

*Includes natural sugars present in foods.

**Includes natural sugars present in foods and added sugars.

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survey responses and not the sale of the product." Then, they answered a series of questions about the yogurt, cookies, and sliced bread, which showed the participant's randomly assigned label condition. The questions measured objective understanding, or whether participants could correctly identify if the product contained excess of the nutrient of concern, perceived message effectiveness (PME), and likelihood of wanting to purchase the product. The participants answered all questions about one product at a time (displayed in random order). After these, the participants answered objective understanding and PME questions about the breakfast cereal. The breakfast cereal was always displayed last as the nutrient warning condition contained two labels.

Finally, the participants were randomly assigned to see the yogurt, cookies, or sliced bread again (one product only). However, this time, the product did not fashion a label. Instead, the three label types (nutrient warnings, GDA, and Nutri-Score) were displayed underneath the

product and the participant was asked to select the most discouraging label. The study ended with standard demographic questions.

Measures

Our study had two primary outcomes, 1) selection of the less healthy fruit drink as the fruit drink the participant would rather buy and 2) correctly identifying which fruit drink was higher in sugar. These outcomes were selected as primary outcomes because they are key steps on the pathway from labels to discouraging consumption of less healthy foods [24]. Secondary outcomes included the ability to identify the less healthy fruit drink, objective understanding, PME, intentions to purchase the products, and the most discouraging label. All measures were cognitively tested with Colombians of different education levels to make sure the measures were properly adapted to the Colombian context and accessible to all education levels [30].

For the fruit drink selection task, participants were asked to select one of the two fruit drinks for each of the following questions:*"Which of these products is MOST unhealthy?"*, *"Which of these products is higher in sugar?"*, and *"Which of these products would you rather buy?"* Both the order of the three questions and the order of the two fruit drinks (left or right) were randomized in order to avoid any potential question ordering effects [31].

Next, for the questions about the yogurt, cookies, and sliced bread, we measured objective understanding, "Do you think this product has excess [sugar, sodium, or saturated fat]?" (yes/no), and we measured the participants' likelihood of wanting to purchase the product in the next week if it were available (range from "very much" (coded as 5) to "not at all" (coded as 1)).

We measured PME of the labels, using three items from the UNC PME scale, which has been found to reliably and validly measure PME [32,33]. The three items read: *"How much does the label. . ."* *"make you worried about the health consequences of consuming this product?"* (range from "very much" (coded as 5) to "not at all" (coded as 1)), *"make consuming this product seem unpleasant to you?"* (range from "very much" (coded as 5) to "not at all" (coded as 1)), and *"discourage you from wanting to consume this product?"* (range from "very much" (coded as 5) to "not at all" (coded as 1)). Because PME is specifically about labels, we did not measure PME for the no-label condition. For the breakfast cereal, we measured participants' objective understanding (product high in sugar and sodium), and we measured PME.

Finally, participants viewed all three label types below one of the randomly selected products (yogurt, cookies, bread), and they were asked to select which label would most discourage them from wanting to consume the product.

Analyses

All analyses were conducted in STATA version 16.0. A two-sided critical alpha of 0.05 was used to assess statistical significance. Using an ANOVA model in G.Power 3.1.9.4, we estimated that with a sample of ~8,000, alpha of 0.05, and 80% power, we could detect an effect of f = 0.037 for each of the primary outcomes between each arm and the control, which translates to an odds ratio of 1.14. We excluded participants from analysis if they were duplicate responders (dropped all responses except first), completed the study in less than two minutes, or if they did not answer at least one primary or secondary outcome (Fig 1).

We calculated unadjusted means (and standard deviations) and percentages for the primary and secondary outcomes. For the secondary outcome, PME, we took the average of the 3 items for each product type (Cronbach's alpha for each product type was >.70). We then assessed whether primary and secondary outcomes varied by condition compared to the nutrient warnings. Because the breakfast cereal contained excess of two nutrients of concern, we examined

whether the breakfast cereal outcomes exhibited the same pattern prior to adding them to the overall reported measures. We used linear regression for continuous outcomes (including PME) and logistic regression for binary outcomes. For outcomes that were assessed using repeated measures for multiple product types, we used mixed models treating the intercept as random at the respondent level to account for repeated measures. These models included the between-subjects factor (i.e., label type), the within-subjects factor (i.e., product type), and their interaction. We conducted pairwise comparisons of the predicted means or predicted percentages between each label type. We applied Holm's sequentially rejective procedure [34] to the primary outcomes, objective understanding, PME, and the likelihood of purchasing the product to account for multiple comparisons.

To evaluate the most discouraging label, we examined the proportion of participants that selected each label type as the one that most discouraged them from consuming products high in sugar, sodium, or saturated fat.

Finally, to assess whether the effect of label type on the primary outcomes differed by education, we tested for an interaction of nutrient warnings with education level specified as low (high school diploma or less) vs. high (college degree or higher) and used a Wald chunk test to determine the joint interaction. We conducted pairwise comparisons to predict percentages by label type and education level. We only assessed moderation for the two primary outcomes to minimize type 1 error resulting from multiple comparisons.

Results

Descriptive statistics

Participant characteristics are listed in Table 2.

Fruit drink selection task

The nutrient warnings were more effective than the no-label, GDA, and Nutri-Score conditions at decreasing the percentage of people who wanted to purchase the less-healthy fruit drink. Only 20% of participants in the nutrient warnings condition selected the less healthy fruit drink as the drink they most wanted to buy compared to 24% in the GDA condition, 29% in the no-label condition, and 33% in the Nutri-Score condition ($p < .001$ for Nutri-Score and no-label conditions compared to the nutrient warnings, accounting for repeated measures; $p<0.01$ for GDA condition compared to the nutrient warnings, accounting for repeated measures) (Fig 3).

The nutrient warnings were also more effective at helping consumers identify which fruit drink was higher in sugar, relative to the no-label and Nutri-score conditions; while only 65% in the Nutri-Score condition and 68% in the no-label condition correctly identified the fruit drink higher in sugar, 88% in the nutrient warnings condition were able to correctly identify which fruit drink was higher in sugar ($p<0.001$ for both conditions compared to the nutrient warnings, accounting for repeated measures). The GDA label was more effective than the nutrient warnings with 91% of participants in the GDA condition correctly identifying which fruit drink was higher in sugar ($p<0.001$ compared to the nutrient warnings, accounting for repeated measures).

Finally, when asked which fruit drink was less healthy, the nutrient warnings were more effective at helping participants to correctly identify the less healthy fruit drink with 87% in the nutrient warnings condition making the correct identification compared to 68% in the Nutri-Score condition and 71% in the no-label condition ($p<0.001$ for both conditions compared to the nutrient warnings, accounting for repeated measures). There were no differences between the nutrient warning and GDA labels.

Table 2. Socio-demographic characteristics (n = 8,061).

	No label (n = 2,113)		Nutri-Score (n = 1,974)		Nutrient Warning (n = 1,999)		GDA (n = 1,975)	
	n	%	n	%	n	%	n	%
Age								
18–24	804	38.1	756	38.3	738	36.9	730	37.0
25–34	640	30.3	615	31.2	622	31.1	611	30.9
35–44	419	19.8	385	19.5	390	19.5	409	20.7
45–54	188	8.9	169	8.6	184	9.2	182	9.2
55–64	62	2.9	49	2.5	65	3.3	43	2.2
Gender								
Man	1016	48.1	961	48.7	971	48.6	962	48.7
Woman	1089	51.5	1006	51.0	1020	51.0	1003	50.8
Other gender identity	8	0.4	7	0.4	8	0.4	10	0.5
Body mass index (BMI, kg/m^2)								
Underweight (<18.5)	138	6.8	148	7.8	126	6.6	134	7.0
Healthy weight (18.5–24.9)	1072	52.7	984	51.8	1038	54.6	1054	55.4
Overweight (25.0–29.9)	578	28.4	537	28.3	527	27.7	511	26.9
Obese (>29.9)	248	12.2	231	12.2	209	11.0	203	10.7
Mean BMI (SD)	25	(7.2)	24.8	(6.6)	24.8	(6.7)	24.6	(6.3)
Education level								
Low (High school diploma or less)	1065	50.4	981	49.7	955	47.8	1009	51.1
High (College degree or higher)	1048	49.6	993	50.3	1044	52.2	966	48.9
Region								
Atlantica	270	12.9	262	13.4	269	13.6	293	15.0
Oriental	310	14.8	300	15.4	292	14.8	287	14.7
Central	451	21.5	386	19.8	428	21.7	390	20.0
Pacifica	309	14.7	258	13.2	261	13.2	267	13.7
Orinoquia	23	1.1	20	1.0	23	1.2	21	1.1
Bogota	737	35.1	722	37.1	703	35.6	694	35.6
Children in household (ages 0–18)								
Yes	1402	66.7	1297	66.5	1311	66.1	1276	65.2
Ethnicity								
Indigenous	32	1.5	38	1.9	38	1.9	30	1.5
Afro-descendent	115	5.5	113	5.8	111	5.6	106	5.4
White	570	27.1	528	27.1	577	29.1	517	26.4
Mestizo	895	42.6	765	39.2	794	40.0	804	41.1
Other ethnic group	130	6.2	124	6.4	128	6.5	115	5.9
No ethnic group	359	17.1	383	19.6	335	16.9	385	19.7
Financial situation								
Can pay bills and buy additional things	532	25.3	570	29.3	561	28.4	550	28.1
Can pay bills and buy what is needed	927	44.1	858	44.1	856	43.4	829	42.4
Can pay bills but not buy everything that is needed	478	22.8	381	19.6	404	20.5	411	21.0
Can't pay the bills	163	7.8	137	7.0	151	7.7	165	8.4

Missing demographic data ranged from 0% to 4.01%.

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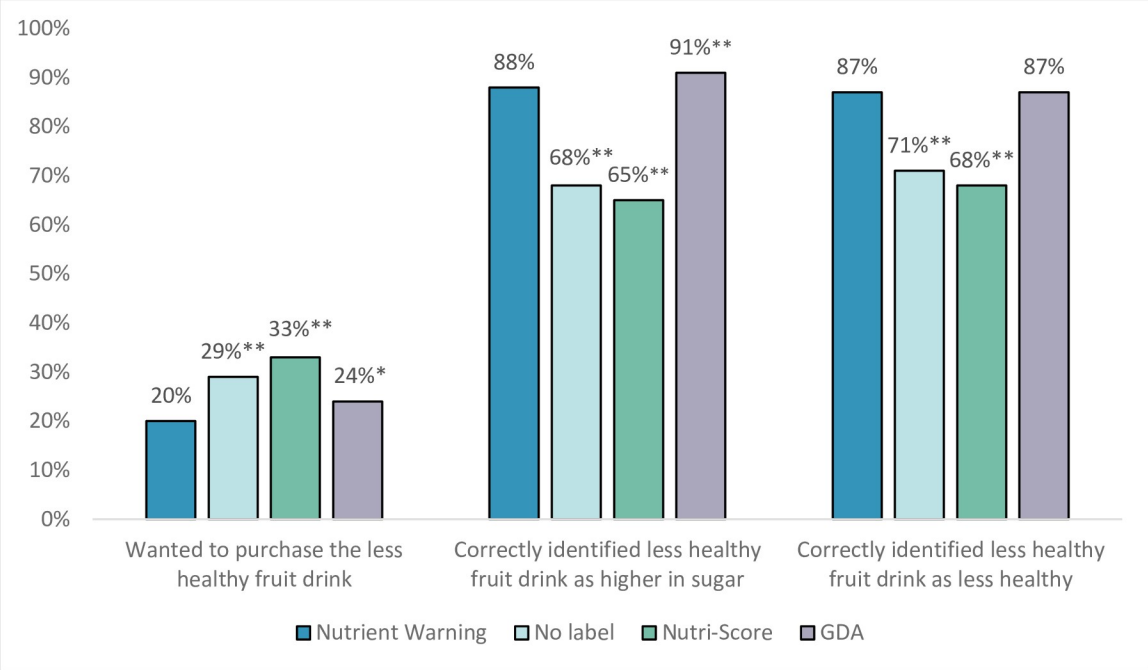

Fig 3. Predicted percent, by label condition. *Note*. *p<0.01 compared to nutrient warning. **p<0.001 compared to nutrient warning.

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Interaction of label type and education, primary outcomes

There was no significant interaction between label condition and education level on likelihood of wanting to purchase the less healthy fruit drink relative to the nutrient warning (Wald test of joint significance for the condition-education level interactions: p = 0.521;see S3 Table). However, there was a significant interaction between the label condition and education level on the likelihood of correctly identifying the fruit drink higher in sugar (Wald test of joint significance for the condition-education level interactions: p<0.01). This finding was driven by differences between the nutrient warning and Nutri-Score conditions. Education level moderated the effect of the Nutri-Score on the probability of correctly identifying the fruit drink higher in sugar relative to the nutrient warning (p = 0.041). In the nutrient warning condition, there was a difference of two percentage points in the ability of low (87%) versus high (89%) education participants to correctly identify the fruit drink higher in sugar. In the Nutri-Score condition, this difference was more pronounced, with a difference of four percentage points in low (67%) versus high (63%) education participants' ability to correctly identify the fruit drink higher in sugar.

Single product assessment of yogurt, bread, cookies, and cereal high in sugar, sodium, saturated fat, or sugar and sodium

In the single product assessment tasks, compared to the no-label, Nutri-Score, and GDA conditions, the nutrient warnings were more effective in helping participants to correctly identify that the products contained excess of a nutrient of concern and more effective in decreasing the participants' likelihood of wanting to purchase the product if it were available (Table 3; p<0.001 for each condition compared to the nutrient warnings). While 75% of participants in the nutrient warnings condition correctly identified that the product contained excess of the

Table 3. Predicted percent and predicted means of secondary outcomes, by label type.

	Correctly identified product as having excess of nutrient				Likelihood of purchasing the product in the next week if it were available (scale 1–5)				PME (scale 1–5)			
	n	%	SE (pp)	*p*	n	Mean	SE	*p*	n	Mean	SE	*p*
Condition												
Nutrient warning	1,997	75%	0.01	(ref)	1,996	2.58	0.02	(ref)	1,998	3.86	0.02	(ref)
No label	2,110	23%	0.01	< .001	2,111	3.51	0.02	< .001	-	-	-	-
Nutri-Score	1,964	26%	0.01	< .001	1,954	3.49	0.02	< .001	1,967	2.70	0.02	< .001
GDA	1,972	43%	0.01	< .001	1,971	3.23	0.02	< .001	1,973	2.97	0.02	< .001

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nutrient of concern, only 23% in the no-label condition, 26% in the Nutri-Score condition, and 43% in the GDA condition were able to do so. The nutrient warnings also led to greater perceived message effectiveness compared to both the Nutri-Score and GDA ($p<0.001$ for each condition compared to the nutrient warnings; PME not applicable in the no-label condition).

Other outcomes

Participants overwhelmingly selected the nutrient warnings as the label type that most discouraged them from wanting to consume a product high in sugar, saturated fat, or sodium (Fig 4). Seventy-two percent of participants selected the nutrient warnings as most discouraging compared to only 20% selecting the GDA label and 9% selecting the Nutri-Score label.

Discussion

The goal of this study was to understand how well nutrient warnings work in the adult Colombian population, to inform current legislative and ministerial actions on warning label regulations. Specifically, this online randomized control trial aimed to assess the impact of nutrient warnings on product selection and identification of less healthy products, among other outcomes, compared to GDA, Nutri-Score, and no label, among adults aged 18 to 64 years in Colombia. In general, the pattern of results suggests that nutrient warnings most consistently achieve desired outcomes. The nutrient warning was more effective than GDA and Nutri-Score in discouraging Colombian consumers from wanting to purchase the less healthy fruit drink. Both the nutrient warning and GDA helped participants identify the high-in sugar fruit drink, with the GDA performing slightly better (91% vs 88%); however, the nutrient warning performed better than the GDA on most other outcomes. Furthermore, the nutrient warnings helped participants correctly identify products with excess sugar, saturated fat, and/or sodium, lead to a low likelihood of wanting to purchase the product if it were available, most discouraged wanting to consume a product high in nutrients of concern, and had a high PME. These results illustrate the benefits of nutrient warnings and support the need for policies in Colombia that require this labeling system on products high in nutrients of concern.

The findings of this study regarding nutrient warnings are consistent with prior studies conducted in several Latin American countries [24]. Although the overall results suggest that nutrient warnings consistently performed best relative to the GDA, Nutri-Score, and no-label conditions, it is important to note that the GDA label had a slightly better performance (91%) than the octagonal nutrient warnings (88%) at helping consumers identify which fruit drink was higher in sugar when comparing two fruit drinks. One possible reason for this could be due to the large difference in sugar content of the two fruit drinks (44% daily value vs. 18% daily value, a difference of 26 percentage points). In a real life shopping situation, the ability to

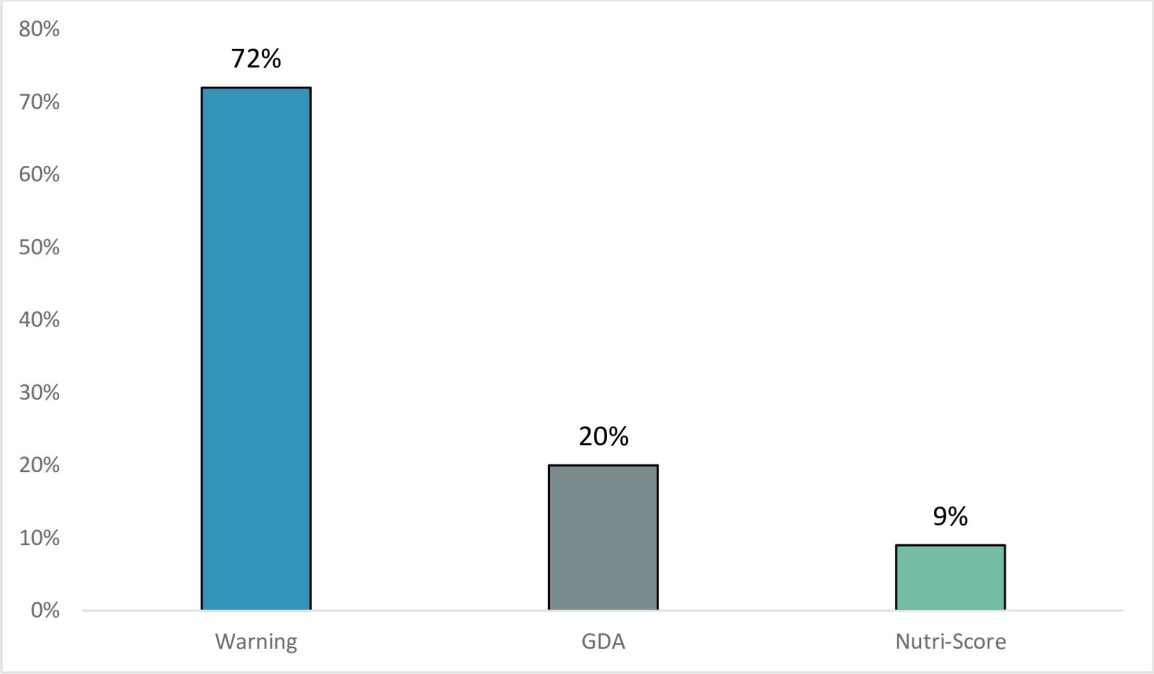

Fig 4. Percent of participants selecting each label type as the most discouraging.

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closely compare GDA labels on numerous products might be more limited as people may have less time to examine the labels in detail [35]. The difference in results between the GDA and the nutrient warning in correctly identifying the fruit drink as high in sugar (91% vs 88%, respectively) was of a small magnitude.

The findings of this study are in contrast to some previous studies that have found more favorable outcomes for Nutri-Score [36,37]. However, such studies have typically involved ranking tasks, while this study was concerned with identifying the less healthy products and the product that was "high in" the nutrient of concern. We selected these outcomes as primary outcomes, rather than ability to rank products, in order to align with the overarching public health goal of labeling laws in Colombia, which is to help consumers understand and reduce purchases of unhealthy foods. Another reason why Nutri-Score may have performed less favorably is due to the underlying nutritional profile model of the fruit drink products in this study. In this study, both fruit drinks received a score of "B" in the Nutri-Score condition. Provided that both products had the same score, it is understandable that consumers would be unable to use the Nutri-Score to identify the less healthy product. However, this reveals one of the innate features of Nutri-Score as products of different nutritional quality can ultimately have the same score. In addition, the items asked participants to identify whether products were high in a specific nutrient; however, Nutri-Score does not provide information about specific nutrients, only a summary score. Thus, some of the differences between Nutri-Score and the nutrient warning are in part a function of how the study was designed (to understand impact on identification of "high in" products) and in part, a function of the design of the Nutri-Score system (e.g., the nutrition profile model and the use of a single summary score vs. a set of binary nutrient-specific labels). It would be helpful to understand how Nutri-Score and other label types compare in a more realistic food environment, with a larger array of food products, which would allow for more diverse comparisons.

Regarding educational level moderation analyses, overall, this study found little evidence of differential effect by education for nutrient warnings. In other words, it seems unlikely that nutrient warnings would exacerbate any food choice disparity between people of high versus low educational levels in their likelihood of selecting a less healthy fruit drink or in their ability to correctly identify a fruit drink higher in sugar. There were no differences in the impact of any labels on wanting to purchase the less healthy fruit drink by level of educational attainment relative to the nutrient warning. Similarly, the impact of label condition on the likelihood of correctly identifying the less healthy product did not differ by education level relative to the nutrient warning, with the exception of the Nutri-Score condition, which had a slightly smaller benefit among those with higher education than those with lower education. It is not clear what drives this difference in effect, though it is possible such a result is due to chance provided that both fruit drinks had the same Nutri-Score. If the nutrient warning law is implemented in Colombia, evaluation research should monitor whether the law differentially impacts consumer understanding and food purchases for high- vs. low-educated consumers.

Strengths and limitations

This is the first randomized online experiment to be carried out in Colombia that assessed the effectiveness of several nutrition labelling systems. In addition, this study used standardized questions from previous studies, which have shown appropriate psychometric characteristics [23,32,33].

However, several limitations can be identified in this study. Firstly, because this study examined real-world nutrition labels, we were unable to assess what specific characteristics of each label influenced participants' responses. Nevertheless, the use of real-world labels enabled us to study the effectiveness of labelling systems that could actually be implemented in Colombia. Secondly, although the study population included participants from different Colombian regions, most of them lived in urban areas, which could restrict the external validity of the study. However, the study population included adults from different Colombian regions with diverse social identities which may attenuate this external validity limitation. Finally, this study does not examine the impact of labels on real-world consumer behaviors. However, results from a recent meta-analysis [33] have found that nutrient warnings are effective at reducing objectively measured purchases of sugar-sweetened beverages; furthermore, the first study to evaluate a real-world nutrient warning system found that after its implementation, along with the implementation of child-directed marketing restrictions and school sales bans, purchases of sugar-sweetened beverages dropped by 24% [23].

Conclusion

Colombian advocacy groups working on the labeling law in Colombia, as well as international scholars, have emphasized reducing excess consumption of unhealthy foods high in nutrients of concern as a key first step towards obesity prevention [38–40]. Front-of-package nutrient warnings are a promising policy strategy to help combat overweight, obesity, and diet-related NCD in Colombia. The pattern of results when comparing nutrient warnings with Nutri-Score, GDA and no label demonstrated that nutrient warnings were most effective in helping consumers to identify products high-in nutrients of concern, to identify a less healthy product, and to increase PME. Moreover, the nutrient warnings led to the lowest likelihood of wanting to purchase the product high in nutrients of concern if it were available and most discouraged participants from wanting to consume a less healthy product. The one exception was that GDA performed better than the nutrient warning at helping participants to identify the high-sugar fruit drink. Overall, the nutrient warnings most consistently performed best in achieving

intended outcomes. Future research is needed to understand the impact of nutrient labels on actual "high in" food and beverage purchases in Colombia.

Supporting information

S1 Checklist. CONSORT 2010 checklist of information to include when reporting a randomised trial*.
(PDF)

S1 Fig. Products used in the experiment.
(DOCX)

S1 Table. Unadjusted means by label type, for single product label reactions.
(DOCX)

S2 Table. Unadjusted proportions and means by label type, for single product assessment task.
(DOCX)

S3 Table. Predicted probabilities between high and low education by outcome and condition.
(DOCX)

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