

Can nutritional information modify purchase of ultra-processed products? Results from a simulated online shopping experiment

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Abstract

Objective: The aim of the present work was to evaluate the influence of two front-of-pack nutrition information schemes (traffic-light system and Chilean warning system) on consumer purchase of ultra-processed foods in a simulated online grocery store.

Design: Following a between-subjects design, participants completed a simulated weekly food purchase in an online grocery store under one of three experimental conditions: (i) a control condition with no nutrition information, (ii) a traffic-light system and (iii) the Chilean warning system. Information about energy (calories), sugar, saturated fats and salt content was included in the nutrition information schemes.

Setting: Participants were recruited from a consumer database and a Facebook advertisement.

Subjects: People from Montevideo (Uruguay), aged 18–77 years (n 437; 75% female), participated in the study. All participants were in charge of food purchase in the household, at least occasionally.

Results: No significant differences between experimental conditions were found in the mean share of ultra-processed foods purchased by participants, both in terms of number of products and expenditure, or in the mean energy, sugar, saturated fat and salt content of the purchased items. However, the Chilean warning system decreased intended purchase of sweets and desserts.

Conclusions: Results from this online simulation provided little evidence to suggest that the traffic-light system or the Chilean warning system in isolation could be effective in reducing purchase of ultra-processed foods or improving the nutritional composition of the purchased products.

Keywords
Nutritional information
Ultra-processed foods
Traffic-light system
Warning system

The increasing burden of obesity and non-communicable diseases worldwide makes it necessary to develop cost-efficient public policies to reduce their prevalence⁽¹⁾. These policies should take into account the characteristics of the food environment, as it strongly affects food choice and dietary patterns⁽²⁾. In most countries, the food environment is characterized by the large availability and affordability of products with high energy, fat and sugar content, which promote positive energy balance in the population^(3,4). In particular, the replacement of foods prepared from scratch by processed ready-to-eat products with unfavourable nutrient profile has been linked to low diet quality, obesity and other non-communicable diseases^(5–9).

The relationship between the consumption of processed products, nutrient intake and health motivated the development of the NOVA system, which classifies foods based on the extent and purpose of industrial processing⁽¹⁰⁾. This system classifies foods into four groups: unprocessed or minimally processed foods, processed culinary ingredients, processed foods and ultra-processed products. Ultra-processed products are defined as formulations of several ingredients, including salt, sugar, oils and fats, as well as flavourings, colorings, sweeteners, emulsifiers and other additives, which typically have high sugar, salt, sodium and saturated fat content^(11–14). These products are sometimes marketed as healthful, as references to naturalness and health/nutrition claims are

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frequently included on their packages and in advertising campaigns^(15,16). Ultra-processed products have become dominant in the global food system due to their higher commercial profits over fresh or minimally processed foods^(12,17,18). In the specific case of Latin America, the contribution of ultra-processed foods to total daily energy intake has increased markedly in the last 10 years in most countries⁽¹⁹⁾. This situation makes it necessary to develop strategies to inform consumers of the nutritional value of ultra-processed products and to substitute these products by foods and meals made from unprocessed or minimally processed foods (foods that are processed to extend their shelf-life, improve their safety or simplify their preparation, but that do not contain added salt, sugar or fat)^(10,13,17).

The inclusion of nutrition information on packages may raise consumer awareness of the unfavourable nutritional composition of ultra-processed products and, consequently, lead to a decrease in their purchase intention. Given that ultra-processed products have partially replaced meals prepared from scratch^(7,10,17,19), a decrease in consumer purchase intention can be hypothesized to encourage their substitution by unprocessed or minimally processed products. However, conventional nutrition information that is typically found on the back of packages has been extensively reported to cause confusion and to be difficult to find, use and understand^(20–22). For this reason, the inclusion of simplified front-of-pack (FOP) nutrition information has been suggested as an effective way to provide consumers with simple and clear information that can be used in the short time frames usually involved when making their food choices^(23–26).

FOP nutrition information schemes can be classified into three main groups according to the degree to which they guide consumers to infer product healthfulness⁽²⁷⁾. Non-directive systems (e.g. Guideline Daily Amount (GDA) system) include information about nutrient content (per portion or 100 g) and/or as a percentage of the recommended daily intake. Semi-directive systems (e.g. traffic-light system) provide information about the content of key nutrients and indicate whether they are low, medium or high. Finally, directive systems (e.g. health and warning logos) highlight only those products that meet specific criteria in terms of nutrient content. Research has shown that, compared with non-directive systems, directive and semi-directive systems improve consumers' ability to identify and correctly evaluate how healthful products are^(24–26,28–32). In particular, several studies have identified the traffic-light system as the best scheme in terms of understanding and attentional capture^(25,26,29–33). This system uses traffic lights' colour coding (red, yellow and green) to classify the content of key nutrients (sugar, fat, saturated fat and salt) as high, medium or low, respectively⁽³⁴⁾. The red colour of this system, associated with high sugar, fat, saturated fat and/or salt, may convey culturally learned associations with danger and avoidance, which may discourage consumption of

unhealthful products⁽³⁵⁾. Although studies conducted under laboratory settings have shown that the traffic-light system could encourage changes in food choice, in-store observations or consumption data have shown less encouraging results^(30,36–40). However, it is worth highlighting that only a limited number of studies have evaluated the influence of the traffic-light system or other nutrition information schemes on consumer purchase behaviour in real-life settings^(37,38).

Drawing from the health literature and the effectiveness of health warnings in tobacco control campaigns, Chile has recently approved a new directive FOP nutritional labelling scheme to improve consumer ability to identify unhealthful food products⁽⁴¹⁾. According to the Chilean regulation, products with high energy, sodium, sugar and/or saturated fat content must include a separate stop-sign-shaped black warning notice for each nutrient⁽⁴²⁾. Although this system is expected to discourage consumers from buying products with high energy, sodium, sugar and/or saturated fat content, no studies to date have compared this warning notice scheme with other nutrition information schemes.

In this context, the aim of the present work was to evaluate the influence of two FOP nutrition information schemes (traffic-light system and Chilean warning system) on the purchase of ultra-processed foods in a simulated online environment.

Materials and methods

Participants

A total of 437 people from Montevideo (Uruguay) participated in the study. Participants were recruited from the consumer database of the research group who led the study and a Facebook advertisement. To be eligible, participants had to be responsible for food purchase in the household, at least occasionally. The consumer sample did not intend to be representative of the Uruguay population but to include people in charge of food purchase with diversity in terms of gender and age. During recruitment, no information regarding the specific objective of the study was given. Participants were told that they had been invited to participate in a study about perception of food products. All participants gave written informed consent before starting the study and were entered into a raffle for a voucher valued at \$US 100.

Stimuli

A shopping simulation was created using a website that emulated an online grocery store, specifically created for the study. A total of 232 products, grouped into seventeen categories, were included. The categories were selected considering the usual distribution of products in Uruguayan supermarkets and online grocery stores. Products within each category were selected based on

commercial availability and purchase frequency in the country⁽⁴³⁾. For the majority of products, different brands were included. Although the number of products included in the website was markedly lower than the number of products available in most Uruguayan supermarkets, it provided a wide overview of the main product categories commonly purchased by Uruguayan consumers⁽⁴⁴⁾. The number of products included in other studies dealing with shopping simulations ranges between seventy-eight and 273^(30,44).

The nutritional composition and pictures of packaged products were obtained from commercial products available in the Uruguayan marketplace. Each product was labelled with the price and the nutrition information, according to the experimental condition each participant was allocated to. According to Uruguayan legislation, products that are commercialized unpackaged (e.g. meats, fruits and vegetables), mineral water, infusions or spices do not include nutrition information⁽⁴⁵⁾. For this reason, the traffic-light and warning systems were not included in those product categories. A description of the categories and products as well as the percentage of products within each of the categories of the NOVA food classification system⁽¹⁰⁾ are provided in Table 1. Figure 1 shows a screenshot of the online grocery store.

Three experimental conditions were considered: (i) a control condition with no nutrition information; and two nutrition information schemes, namely (ii) a traffic-light system and (iii) the Chilean warning system. Both systems included energy (calorie), saturated fat, sugars and salt

content per portion. The traffic-light system was colour coded and included text descriptors to classify nutrient content as low, medium and high (Fig. 2(a)), whereas the Chilean warning system highlighted only those products with high nutrient content using separate black stop signs for each nutrient (Fig. 2(b)). Conventional nutrition information, which is mandatory nowadays in Uruguay⁽⁴⁵⁾, was not made available across experimental conditions because it is not included on the front of packages and it has been widely reported to be difficult for consumers to understand^(20–21,25,26).

The criteria for classifying nutrient content as high in the traffic-light and warning systems were based on Chilean regulations⁽⁴²⁾. Given that these regulations establish criteria only for high nutrient content, low nutrient content in the traffic-light system was determined based on the criteria from the Food Standards Agency (UK)⁽³⁴⁾. In order to avoid misleading information, the traffic-light system included a classification of energy content only when it was high. The percentage of products with high content of each of the nutrients ranged between 23 and 30% (24% high in energy, 23% high in sugars, 27% high in saturated fat and 30% high in salt).

Experimental procedure

Participants were randomly assigned to one of the three experimental conditions described in the previous section: no nutrition information (n 141), traffic-light system (n 153) or the Chilean warning system (n 143).

Table 1 Description of the categories and products included in the simulated online grocery store

Category	Number of products	Description of the products	Percentage of products				
			Including nutrition information*	Natural or minimally processed	Culinary ingredients	Processed	Ultra-processed
Frozen foods/ready-to-eat meals	23	Breaded cheese sticks, corn, spinach, pies, fish nuggets, chicken nuggets, hamburger, lasagne, French fried potatoes, noisette potatoes, pizza	100	9	0	0	91
Oils, dried and canned foods	22	Sunflower oil, olive oil, rice, instant rice, flour, canned green beans, canned corn, canned carrots, canned tuna, instant soups, bouillon cubes	100	9	32	27	32
Beverages	17	Mineral water, sodas, powdered drinks	88	12	0	0	88
Meats	16	Beef, chicken, fish, sausage, breaded steaks	6	94	0	0	6
Snacks	11	Potato chips, cheese snacks, nuts, granola	100	27	0	18	55
Sweets and desserts	11	Powdered milk, desserts, gelatine, jam, sponge cake mixture	100	0	0	0	100
Cold cuts, sausages and cheeses	12	Ham, mortadella, bacon, salami, bologna, sausages, cheeses	100	0	0	25	75
Fruits	8	Banana, plum, peach, strawberry, kiwifruit, mandarin, orange, apple	0	100	0	0	0
Crackers and cookies	23	Crackers, cookies, cereal bars, breakfast cereals, <i>alfajores</i>	100	0	0	0	100
Infusions and cocoa	10	Coffee, tea, mate, cappuccino instant coffee	30	0	0	80	20
Milk and dairy products	22	Milk, butter, margarine, cream, cream cheese, yoghurt, milk desserts, ice creams	100	14	5	0	82
Breads and bakery	10	French bread, pan bread, hamburger buns	100	0	0	30	70
Pastas and pre-made pie crusts	13	Dry pasta, fresh ravioli, pre-made pie crusts	100	0	0	54	46
Condiments and spices	6	Salt, pepper, spices	17	0	83	0	17
Sauces and dressings	10	Mayonnaise, ketchup, mustard, tomato sauce	100	0	0	40	60
Vegetables	18	Spinach, chard, potatoes, sweet potatoes, broccoli, carrots, beetroot, rocket, pumpkin, courgette, lettuce, tomato, onion, aubergine, red and green pepper, squash	0	100	0	0	0
Total	232		77	23	6	14	57

*Following Uruguayan legislation, nutrition information was not included on products that are commercialized unpackaged (e.g. meats, fruits and vegetables), mineral water, infusions and spices⁽⁴⁵⁾.

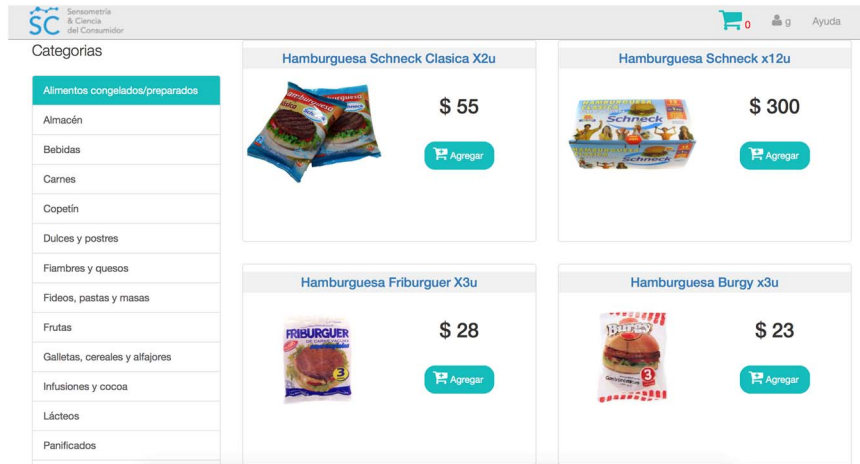


Fig. 1 Screenshot of the online grocery store used in the simulated shopping experiment, showing examples of products as seen by the participants who completed the task without nutrition information. Food categories are shown on the left and some of the products included in one of the categories ('Frozen foods/ready-to-eat meals') are shown on the right using the name of the product, a picture and its price

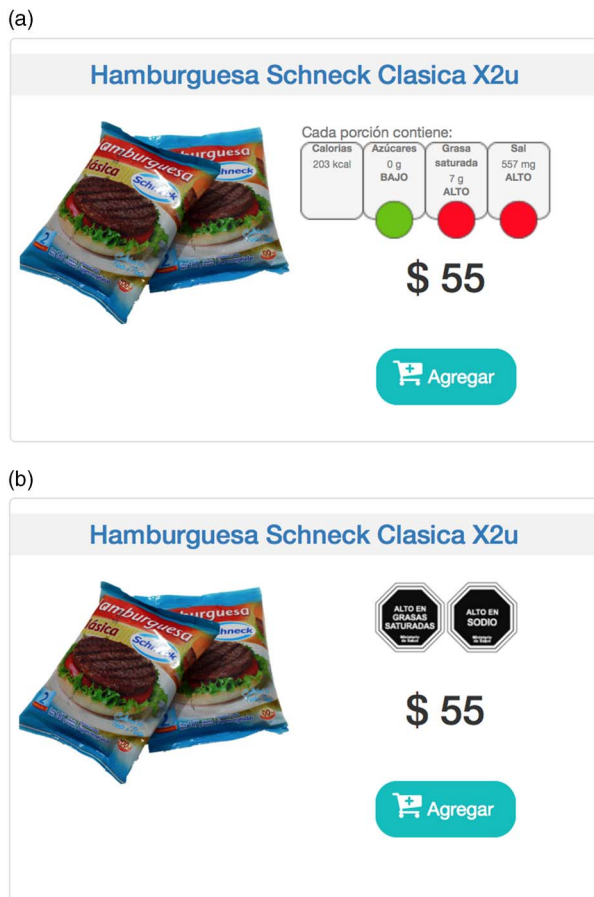


Fig. 2 Example of how nutrition information was presented on the products using the traffic-light system (a) and the Chilean warning system (b)

Randomization was automatically generated by the software and was blinded to the researchers during the study.

Participants were asked to imagine that they had to make a weekly food purchase for their household using

the website of an online grocery store. They were explained that products were grouped into categories and that they could go through the products included in each category by making a mouse click on the category name. They were asked to select all the products they would buy by clicking on the 'Add' button of each product. Once they had finished their purchase they were instructed to click on the shopping cart symbol at the top of the website to review the purchase and submit their response.

Data analysis

The minimum number of participants to be included in the study was calculated *a priori* based on the difference between two groups in the percentage of ultra-processed products (which was considered the primary outcome of the study). The effect size, calculated as the ratio between the difference in the average value between two experimental conditions and the standard deviation, was estimated as 0.5. A minimum sample of sixty-four participants for each experimental condition was obtained considering a significance level of 5% (two-sided) and a power level of 80%.

For each participant, the percentage of purchased products within each of the categories of the NOVA food classification system (natural or minimally processed, culinary ingredients, processed products and ultra-processed products) was calculated. The total expenditure in each of the NOVA categories was also calculated for each participant and expressed in US dollars and as a percentage of the total expenditure. For each participant, the total expenditure (expressed in US dollars) in each of the product categories available in the online grocery store (described in the first column of Table 1) was also calculated.

Additionally, the percentage of products containing high content of each of the key nutrients (energy, sugar, saturated fat and salt) purchased by each participant was

also determined, as well as the average content of the key nutrients in 100 g of the products.

Differences in the dependent variables among the experimental groups were evaluated using ANOVA considering a 95% confidence level. When differences were significant, Fisher's test was used for *post hoc* comparison of means. Data analyses were performed in R software⁽⁴⁶⁾.

Results

A description of the sociodemographic characteristics of the participants is shown in Table 2. Compared with the general population of Uruguay, the consumer sample was skewed towards women and young consumers. No significant differences in sociodemographic characteristics were found between the three groups of participants who completed the study using the different experimental conditions ($P=0.725$ for gender, $P=0.114$ for age, $P=0.283$ for educational level, $P=0.887$ for number of people in the household, $P=0.913$ for number of children in the household, $P=0.311$ for responsibility for food purchase in the household).

Simulated purchase of the NOVA food categories

Table 3 shows the mean share of the simulated food purchases of the four NOVA food categories in terms of

Table 2 Sociodemographic characteristics of the participating adults aged 18–77 years (n 437), Montevideo, Uruguay

Characteristic	Number of participants	Percentage of participants
Gender		
Female	328	75
Male	109	25
Age (years)		
18–25	101	23
26–35	157	36
36–50	92	21
≥51	87	20
Educational level		
Primary school/incomplete secondary school	26	6
Secondary school	240	55
Technical education	31	7
University degree	96	22
Postgraduate studies	44	10
Number of people in the household		
1	61	14
2	131	30
3–4	192	44
>4	53	12
Number of children in the household		
0	345	79
1	66	15
2	22	5
3 or more	4	1
Responsibility for food purchase in the household		
Occasionally	52	12
Few times a month	52	12
Once or more a week	333	76

relative number of products and expenditure for the three experimental groups. Ultra-processed products accounted for 34.8–36.6% of the purchased items and 34.8–36.1% of the expenditure. Meanwhile, 40.7–42.9% of the purchased products corresponded to natural and minimally processed products, which accounted for 42.7–43.6% of the expenditure. No significant differences between the three experimental conditions were found in the share of purchased items and expenditure that corresponded to each of the four NOVA categories (Table 3).

When total expenditure for each of the product categories available in the simulated online grocery store was considered, no significant differences were established between the three experimental conditions (for all categories P value was higher than 0.12). The only exception was found for the subgroup 'Sweets and desserts' within the ultra-processed products category. The average total expenditure for this subgroup was significantly lower ($P=0.037$) when the Chilean warning system was considered compared with the control condition (\$US 2.93 *v.* 3.11). Total expenditure for 'Sweets and desserts' in the traffic-light system condition did not significantly differ from that in the control condition and the Chilean warning system (\$US 3.02).

Nutritional composition of the purchased items

As shown in Table 4, the average energy density and the content of sugar, saturated fat and salt of the products selected by participants in the simulated purchase task were not significantly modified by the inclusion of nutrition information. In addition, the percentage of products high in each of the four key nutrients purchased by participants in the simulated task did not differ significantly between the three experimental conditions ($P=0.43$ for products high in energy, $P=0.13$ for products high in sugar, $P=0.52$ for products high in fat, $P=0.88$ for products high in salt). As shown in Fig. 3, approximately 25% of the products purchased by participants were high in energy, saturated fat and/or salt, regardless of whether they completed the simulated purchase task with or without nutrition information. Meanwhile, between 11.2 and 14.0% of the products purchased by participants in the simulated task were high in sugar.

Discussion

The present study aimed to evaluate the influence of two FOP nutrition information schemes on the purchase of ultra-processed foods in a simulated online grocery store. Results showed no significant effect of the traffic-light system and the Chilean warning system on participants' intended purchase of any of the four NOVA categories or in any parameter related to the nutritional composition of the purchased products. Therefore, directive and semi-directive nutrition information schemes were not efficient

Table 3 Mean share (and 95 % CI) of simulated purchase of the four NOVA food categories, in terms of number of products and expenditure, for participants who completed the task in the control condition (without nutrition information) and with two front-of-pack nutrition information schemes (traffic-light system and Chilean warning system)

NOVA food category	Experimental condition	Share of simulated purchase in terms of number of products (%)		Share of simulated purchase in terms of expenditure (%)	
		Mean	95 % CI	Mean	95 % CI
Natural and minimally processed	Control condition (<i>n</i> 141)	40.7	6.2	42.7	6.6
	Traffic-light system (<i>n</i> 153)	42.1	5.8	43.6	6.2
	Chilean warning system (<i>n</i> 143)	42.9	6.2	43.4	6.4
	<i>P</i> value*		0.69		0.94
Culinary ingredients	Control condition (<i>n</i> 141)	8.6	2.8	8.6	3.4
	Traffic-light system (<i>n</i> 153)	8.1	2.8	8.7	3.6
	Chilean warning system (<i>n</i> 143)	8.9	3.0	9.6	4.0
	<i>P</i> value*		0.83		0.81
Processed products	Control condition (<i>n</i> 141)	14.5	3.6	13.0	3.8
	Traffic-light system (<i>n</i> 153)	15.2	3.6	13.2	3.6
	Chilean warning system (<i>n</i> 143)	13.0	3.2	12.0	3.4
	<i>P</i> value*		0.31		0.69
Ultra-processed products	Control condition (<i>n</i> 141)	36.6	6.8	36.1	6.8
	Traffic-light system (<i>n</i> 153)	34.8	6.6	34.8	6.6
	Chilean warning system (<i>n</i> 143)	35.6	6.2	35.5	6.8
	<i>P</i> value*		0.83		0.91

*The *P* value for the comparison of experimental conditions using ANOVA is shown. Mean values for a NOVA food category within a column were not significantly different according to ANOVA ($P > 0.05$).

Table 4 Mean nutritional composition (and 95 % CI) of the products purchased by participants who completed the task in the control condition (without nutrition information) and with two front-of-pack nutrition information schemes (traffic-light system and Chilean warning system)

Experimental condition	Energy density (kcal/100 g)		Sugars (%)		Sugars (%)		Salt (mg/100 g)	
	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI
Control condition (<i>n</i> 141)	201	28	8.8	2.4	2.9	0.6	2095	480
Traffic light system (<i>n</i> 153)	196	20	8.0	2.0	2.8	0.8	1827	420
Chilean warning system (<i>n</i> 143)	198	30	8.7	2.4	2.8	0.6	1954	440
<i>P</i> value*		0.23		0.36		0.41		0.57

To convert energy density to kJ/100g, multiply kcal/100 g values by 4.184.

*The *P* value for the comparison of experimental conditions using ANOVA is shown. Mean values within a column were not significantly different according to ANOVA ($P > 0.05$).

at reducing intended purchase of ultra-processed products in this online simulation. This suggests that nutrition information may not be suited to cause drastic changes in purchasing patterns by encouraging replacement of ultra-processed products by natural or minimally processed products. However, in the present study, the traffic-light system and the Chilean warning system were also unable to encourage minor shifts in the nutritional composition of the products purchased in the online simulation. The only effect of the inclusion of nutrition information was related to a decrease in participants' expenditure in one specific food category, 'Sweets and desserts', which was significantly lower when the Chilean warning system was included compared with the control condition.

Results from the present work are in agreement with those from other experimental studies that showed lack of influence of FOP nutrition information on intended food consumption^(24,30,36,39,40). These findings are similar to those by Sacks *et al.*, which suggested that consumer food purchase of ready meals and sandwiches did not decrease

4 weeks after implementation of the traffic-light system in the UK⁽³⁷⁾.

Two possible explanations for the lack of effect of nutrition information on consumer purchase of ultra-processed products and the nutritional profile of the purchased products can be considered. First of all, nutrition information is only one of several product characteristics that influence consumer food choices⁽⁴⁷⁾, who can prioritize other product characteristics over healthfulness. In the specific case of ultra-processed products, convenience, tastiness, price, as well as emotional associations with the brand can be more relevant than their nutritional profile in shifting consumers' intention to purchase. In particular, middle-income people in Uruguay have been reported to favour convenience over health-related factors, even if convenient products are perceived as less healthful and tasty than home-made products⁽⁴⁸⁾. Similarly, Grunert and Willis argued that the inclusion of FOP nutrition information is unlikely to discourage consumers from eating products they like, as

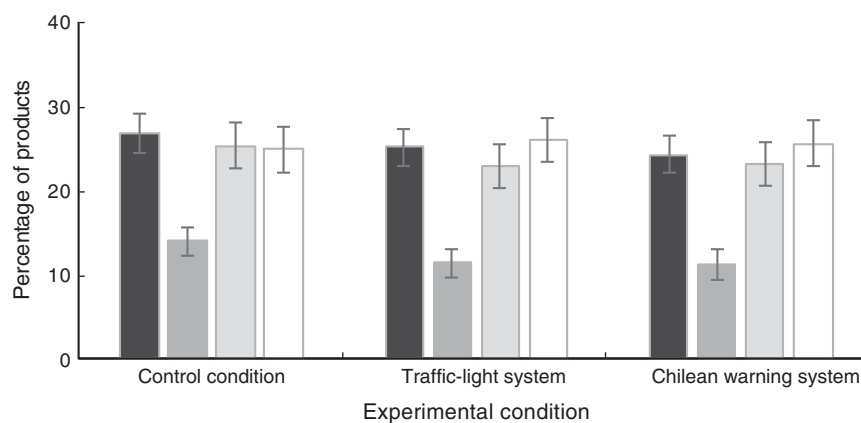


Fig. 3 Mean percentage of products high in key target nutrients (■, high in energy (calories); ■, high in sugar; □, high in saturated fat; □, high in salt) for participants who completed the task in the control condition (without nutrition information) and with two front-of-pack nutrition information schemes (traffic-light system and Chilean warning system). Vertical bars correspond to Tukey's honestly significant differences ($P = 0.05$)

hedonic aspects of food consumption have a large influence in shaping food choices⁽²¹⁾. Therefore, even if directive and semi-directive nutrition information schemes can positively improve consumer understanding of the nutritional characteristics of products, they do not necessarily lead to a change in consumer intention to purchase. In this sense, it is important to stress that although former research has shown that self-reported use of nutrition information has been associated with more healthful dietary patterns, the casual relationship between these two variables has not been established yet^(49–51).

A second potential explanation for the lack of influence of nutrition information on consumer purchase of ultra-processed foods in the simulated online grocery store is related to fact that they may not be accustomed to using this information when making their food choices⁽²¹⁾. Considering that most of our daily decisions are based on repetitive and automatic behaviours, FOP nutrition information may not change consumer choices during the first exposure. People may find it difficult to understand FOP nutrition information schemes upon first exposure without any previous explanation. In addition, people may need repeated exposures to this information to incorporate it in their decision-making strategies. For these reasons, the use of educational campaigns during the implementation of FOP information may be necessary to encourage consumers to search for this information on food packages and take it into account when making their food purchase decisions.

Despite these results, the lack of effect of FOP nutrition information on consumer food purchases does not mean that it should not be included on packages. Directive and semi-directive schemes have been extensively reported to increase consumer ability to find and understand nutrition information on food packages^(20–22,30), which in turn can enable them to make more informed choices. In this sense, it is important to highlight that few comprehensive studies have examined the effect of FOP nutrition

information on consumers' food choices⁽³⁷⁾ and none has evaluated the impact of the Chilean warning system. Besides, the implementation of directive and semi-directive nutritional labelling schemes can encourage food companies to reformulate their products so as to differentiate themselves in the marketplace, as highlighted by Borgmeier and Westenhofer⁽³⁰⁾. In addition, FOP nutrition information may have a larger effect on consumers' food choices when combined with other public policies, such as regulations on the use of health claims, restrictions on food advertising, taxes on products with high sugar and fat content, as well as communication campaigns highlighting those policies⁽⁵²⁾. The evaluation of the potential synergistic effect of these public policies deserves further attention to support decision making.

Limitations of the study

The limitations of the present work should be highlighted. First, the application of a simulated grocery store for studying consumer behaviour, and particularly the influence of nutrition information on food choice, is incipient^(30,44). The present study involved a simulated purchase situation in a virtual environment, which may not realistically depict a real shopping situation in which participants would have to eat the products they purchase. In particular, the reduced number of foods considered in the virtual grocery store could have contributed to the lack of influence of the nutrition information schemes, and there is a possibility that a wider selection of products could have led to differences between the experimental treatments. The assessment of the influence of nutrition information on consumer food choices should involve consumers' repeated purchase of real products over an extended period of time using, for example, experimental grocery stores. This type of study could provide more rigorous information about the potential influence of FOP nutrition labelling schemes on consumers' eating patterns.

Second, the study involved a consumer sample that was mostly composed of well-educated female participants and therefore the influence of sociodemographic characteristics on consumer reaction towards nutrition information could not be evaluated. Further studies aimed at evaluating the influence of different nutrition information schemes on specific gender, age, educational level and income groups, as well as consumer segments differing in other motivational and attitudinal variables, may provide valuable information.

Conclusions

Results from the present study provided little evidence to suggest that the traffic-light system or the Chilean warning system in isolation could be effective in reducing the purchase of ultra-processed foods, encouraging their substitution by natural or minimally processed products, or in improving the nutritional composition of food purchases. Further research is needed to confirm and extend the findings from the present work to other consumer populations.

Regarding the comparison of the traffic-light system and the Chilean warning system, although results from the present work suggest no clear superiority of one over the other, the Chilean system led to a small change in consumer intended purchase of one unhealthful food category. This suggests that the Chilean system may be a promising alternative to the traffic-light system. Further research comparing these two systems in terms of consumers' ability to find and understand nutrition information is necessary.

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References

- World Health Organization (2014) *Global Status on Non-Communicable Diseases 2014*. Geneva: World Health Organization.
- Story M, Kaphingst KM, Robinson-O'Brien R *et al.* (2008) Creating healthy food and eating environments: policy and environmental approaches. *Annu Rev Public Health* **29**, 253–272.
- Zobel EH, Wansan TW, Rossing P *et al.* (2016) Global changes in food supply and the obesity epidemic. *Curr Obes Rep* **5**, 449–455.
- Popkin BM, Adair LS & Ng SW (2012) Global nutrition transition and the pandemic of obesity in developing countries. *Nutr Rev* **70**, 3–21.
- Juul F & Hemmingsson E (2015) Trends in consumption of ultra-processed foods and obesity in Sweden between 1960 and 2010. *Public Health Nutr* **18**, 3096–3107.
- Rauber F, Campagnolo PD, Hoffman DJ *et al.* (2015) Consumption of ultraprocessed food products and its effects on children's lipid profiles: a longitudinal study. *Nutr Metab Cardiovasc Dis* **25**, 116–122.
- Moubarac J-C, Martins AP, Claro RM *et al.* (2013) Consumption of ultra-processed foods and likely impact on human health. Evidence from Canada. *Public Health Nutr* **16**, 2240–2248.
- Louzada ML, Baraldi LG, Steele EM *et al.* (2015) Consumption of ultra-processed foods and obesity in Brazilian adolescents and adults. *Prev Med* **81**, 9–15.
- Tavares LF, Fonseca SC, Garcia Rosa ML *et al.* (2012) Relationship between ultra-processed foods and metabolic syndrome in adolescents from a Brazilian Family Doctor Program. *Public Health Nutr* **15**, 82–87.
- Monteiro CA, Cannon G, Levy R *et al.* (2016) NOVA. The star shines bright. *World Nutr* **7**, 28–38.
- Martínez Steele E, Baraldi LG, Louzada ML *et al.* (2016) Ultra-processed foods and added sugars in the US diet: evidence from a nationally representative cross-sectional study. *BMJ Open* **6**, e009892.
- Luiten C, Steenhuis IHM, Eyles H *et al.* (2016) Ultra-processed foods have the worst nutrient profile, yet they are the most available packaged products in a sample of New Zealand supermarkets. *Public Health Nutr* **19**, 530–538.
- Pan American Health Organization (2016) *Pan American Health Organization Nutrient Profile Model*. Washington, DC: PAHO.
- Giménez A, de Saldamando L, Curutchet MR *et al.* (2016) Package design and nutritional profile of foods targeted at children available in supermarkets in Montevideo, Uruguay. *Cad Saude Publica* (In the Press).
- Colby SE, Johnson L, Scheett A *et al.* (2010) Nutrition marketing of food labels. *J Nutr Educ Behav* **42**, 92–98.
- Schermel A, Emrich TE, Arcand J *et al.* (2013) Nutrition marketing on processed food packages in Canada: 2010 Food Label Information Program. *Appl Physiol Nutr Metab* **38**, 666–672.
- Monteiro CA, Moubarac JC, Cannon G *et al.* (2013) Ultra-processed products are becoming dominant in the global food system. *Obes Rev* **14**, 21–28.
- Ludwig DS & Nestle M (2008) Can the food industry play a constructive role in the obesity epidemic? *JAMA* **300**, 1808e–1811e.
- Pan American Health Organization (2015) *Ultra-Processed Food and Drink Products in Latin America: Trends, Impact on Obesity, Policy Implications*. Washington, DC: PAHO.
- Cowburn G & Stockley L (2005) Consumer understanding and use of nutrition labelling: a systematic review. *Public Health Nutr* **8**, 21–28.
- Grunert KG & Wills JM (2007) A review of European research on consumer response to nutrition information on food labels. *J Public Health* **15**, 385–399.
- Sharf M, Sela R, Zentner G *et al.* (2012) Figuring out food labels. Young adults' understanding of nutrition information

- presented on food labels is inadequate. *Appetite* **58**, 531–534.
23. Hawley KL, Roberto CA, Bragg MA *et al.* (2013) The science on front-of-package food label. *Public Health Nutr* **16**, 430–439.
 24. Feunekes GJJ, Gortemaker IA, Willems AA *et al.* (2008) Front-of-pack nutrition labelling: testing effectiveness of different nutrition labelling formats front-of-pack in four European countries. *Appetite* **50**, 57–70.
 25. Ares G, Giménez A, Bruzzone F *et al.* (2012) Attentional capture and understanding of nutrition labelling: a study based on response times. *Int J Food Sci Nutr* **63**, 679–688.
 26. Jones G & Richardson M (2007) An objective examination of consumer perception of nutrition information based on healthiness ratings and eye movements. *Public Health Nutr* **10**, 238–244.
 27. Hodgkins C, Barnett J, Wasowicz-Kirylo G *et al.* (2012) Understanding how consumers categorize nutritional labels: a consumer derived typology for front-of-pack nutrition labelling. *Appetite* **59**, 806–817.
 28. Roberto CA, Shivaram M, Martinez O *et al.* (2012) The Smart Choices front-of-package nutrition label. Influence on perceptions and intake of cereal. *Appetite* **58**, 651–657.
 29. Kelly B, Hughes C, Chapman K *et al.* (2009) Consumer testing of the acceptability and effectiveness of front-of-pack food labelling systems for the Australian grocery market. *Health Promot Int* **24**, 120–129.
 30. Borgmeier I & Westenhoefer J (2009) Impact of different food label formats on healthiness evaluation and food choice of consumers. A randomised-controlled study. *BMC Public Health* **9**, 184.
 31. Antúnez L, Giménez A, Maiche A *et al.* (2015) Influence of interpretation aids on attentional capture, visual processing, and understanding of front-of-package nutrition labels. *J Nutr Educ Behav* **47**, 292–299.
 32. Aschemann-Witzel J, Grunert KG, van Trijp HCM *et al.* (2013) Effects of nutrition label format and product assortment on the healthfulness of food choice. *Appetite* **71**, 63–74.
 33. Gorton D, Ni Mhurchu C, Chen M *et al.* (2009) Nutrition labels. A survey of use, understanding and preferences among ethnically diverse shoppers in New Zealand. *Public Health Nutr* **12**, 1359–1365.
 34. Food Standards Agency (2007) *Front-of-Pack Traffic Light Signpost Labelling. Technical Guidance. Issue 2*. London: FSA.
 35. Genschow O, Reutner L & Wänke M (2012) The color red reduces snack food and soft drink intake. *Appetite* **58**, 699–702.
 36. Hieke S & Wills JM (2012) Nutrition labelling. Is it effective in encouraging healthy eating? *CAB Rev* **7**, 1–7.
 37. Sacks G, Rayner M & Swinburn B (2009) Impact of front-of-pack 'traffic-light' nutrition labelling on consumer food purchases in the UK. *Health Promot Int* **24**, 344–352.
 38. Sacks G, Tikellis K, Millar L *et al.* (2011) Impact of 'traffic-light' nutrition information on online food purchases in Australia. *Aust N Z J Public Health* **35**, 122–126.
 39. Dodds P, Wolfenden L, Chapman K *et al.* (2014) The effect of energy and traffic light labelling on parent and child fast food selection: a randomised controlled trial. *Appetite* **73**, 23–30.
 40. Ni Mhurchu C, Volkova E, Jiang Y *et al.* (2017) Effects of interpretive nutrition labels on consumer food purchases: the Starlight randomized controlled trial. *Am J Clin Nutr* **105**, 695–704.
 41. Corvalán C, Reyes M, Garmendia ML *et al.* (2013) Structural responses to the obesity and non-communicable diseases epidemic: the Chilean law of food labelling and advertising. *Obes Rev* **14**, 79–87.
 42. Ministerio de Salud (2015) *Decreto número 13, de 2015*. Santiago: Ministerio de Salud.
 43. Bove MI & Cerruti F (2008) *Los alimentos y bebidas en los hogares: ¿Un factor de protección o de riesgo para la salud y el bienestar de los uruguayos? Encuesta nacional de gastos e ingresos de los hogares 2005–2006*. Montevideo: Instituto Nacional de Estadística.
 44. Muller L & Ruffieux B (2012) Modification des achats en réponse à l'apposition de différents logos d'évaluation nutritionnelle sur la face avant des emballages. *Cab Nutr Diet* **47**, 171–182.
 45. Poder Ejecutivo (2006) *Decreto 117/006*. Montevideo: IMPO.
 46. R Core Team (2014) *R: A Language and Environment for Statistical Computing*. Vienna: R Foundation for Statistical Computing.
 47. Köster EP (2003) The psychology of food choice. Some often encountered fallacies. *Food Qual Prefer* **14**, 359–373.
 48. Ares G, Machín L, Girona A *et al.* (2016) Comparison of motives underlying food choice and barriers to healthy eating between low and medium income consumers in a Uruguay. *Cad Saude Publica* (In the Press).
 49. Satia JA, Galanko JA & Neuhouser ML (2005) Food nutrition label use is associated with demographic, behavioral, and psychosocial factors and dietary intake among African Americans in North Carolina. *J Am Diet Assoc* **105**, 392–402.
 50. Neuhouser ML, Kristal AR & Patterson RE (1999) Use of food nutrition labels is associated with lower fat intake. *J Am Diet Assoc* **99**, 45–53.
 51. Kreuter MW, Brennan LK, Scharff DP *et al.* (1997) Do nutrition label readers eat healthier diets? Behavioral correlates of adults' use of food labels. *Am J Prev Med* **13**, 277–283.
 52. Capacci S, Mazzocchi M, Shankar B *et al.* (2012) Policies to promote healthy eating in Europe. A structured review of instruments and their effectiveness. *Nutr Rev* **70**, 188–200.