



Comparing the Effects of Four Front-of-Package Nutrition Labels on Consumer Purchases of Five Common Beverages and Snack Foods: Results from a Randomized Trial

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ABSTRACT

Background Front-of-package (FOP) nutrition labeling systems differ in how they rate food and beverage products. There is a need to examine the implications of these differences, including their focus on nutrients of public health concern.

Objective Our aim was to examine the impacts of 4 common FOP labels on consumers' purchases of products that received conflicting ratings across FOP systems.

Design In an experimental marketplace, participants were randomized to complete a series of purchases under 1 of 5 FOP conditions: no label, "high in" nutrient labels, multiple traffic light, Health Star Rating, or a 5-color nutrition grade.

Participants/setting A final sample of 3,584 Canadians (13 years and older) were recruited from shopping centers in March to May 2018.

Main outcome measures Probability of purchasing was assessed for 5 product categories (100% fruit juice, plain milk, chocolate milk, cheese snacks, and diet beverages), which received conflicting ratings across the FOP conditions.

Statistical analyses Separate generalized linear mixed models estimated the influence of FOP condition on 5 binary outcomes (1 = purchased, 0 = not purchased) corresponding to the product categories.

Results Few differences were observed among the full sample. Among participants who noticed the labels ($n = 1,993$), those in the Health Star Rating condition were 4.5 percentage points (95% CI -7.0 to -1.9) more likely to purchase 100% fruit juice (compared to multiple traffic light) and 3.3 (95% CI 0.4 to 6.2) and 3.0 percentage points (95% CI 0.1 to 6.1) more likely to purchase cheese snacks (compared to no label and "high in"). "High in" labels produced fewer purchases of chocolate milk than no label.

Conclusions Despite some similarities, existing FOP systems differ in the extent to which they promote or dissuade purchases of common product categories. Although the Health Star Rating might encourage purchases of products with certain positive nutritional attributes, "high in" and multiple traffic light systems might more effectively discourage purchases of products contributing nutrients of public health concern.

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AN INCREASING NUMBER OF JURISDICTIONS ARE implementing front-of-package (FOP) nutrition labeling systems, which provide simple nutrition information—often in the form of symbols or ratings—on prepackaged foods and beverages.^{1,2} A growing body of evidence suggests FOP labeling strategies, as part of a comprehensive approach, can improve dietary intake; however, research investigating nuances among different FOP labeling systems is nascent.²⁻⁴

Examples of FOP labeling systems implemented to date include nutrient-specific systems, such as the multiple traffic light (MTL) system used in the United Kingdom or Chile's mandatory "*alto en*" ("high in") warning symbols, as well as summary indicator systems, such as the Australian Health

Star Rating (HSR) and France's Nutri-Score letter grading system.² Similar systems have been proposed in other countries, including a mandatory "high in" nutrient label for sugars, sodium, and saturated fats in Canada.⁵ Given the variety of FOP labeling systems, questions remain as to how they might uniquely influence consumer behavior. For example, 100% fruit juice products and higher-fat or sugary dairy products receive high healthfulness ratings from the HSR system due to their fruit and vegetable or dairy content, but the same products would have a "high in" warning or red traffic light in the systems that emphasize sugar, saturated fat, and sodium content. Similarly, diet beverages are assigned relatively poor ratings under the HSR scheme, but receive either no "high in" symbols or 3 green traffic lights

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under the nutrient-specific systems. Research comparing FOP labels suggests that different systems often elicit different behaviors and that some might be better suited for certain policy objectives than others^{1,2,6}; however, it remains unclear how consumers' purchases of the products noted above might vary across FOP systems. Given the growing interest in FOP nutrition labeling in many countries, it is important for dietitians to understand how they can impact purchasing and consumption behaviors.

The current analysis leveraged data from a large experimental marketplace conducted with Canadian youth and adults. Previously published findings indicated that a "high in" FOP symbol led to purchases of beverages with lower levels of sugars, saturated fats and calories, and snack foods with less sodium and calories compared with no FOP,⁷ without compromising the levels of protein, calcium, and fiber purchased.⁸ Here, in a secondary analysis of data from the original experiment, we examined differences between the FOP systems for the subset of products (100% fruit juice, milk, cheese, and diet beverages) that receive positive ratings under one FOP system but negative ratings under another, to answer the following research question: What are the impacts of 4 FOP nutrition labels on consumers' purchases of products with conflicting ratings across FOP systems?

METHODS

Study Design

Data were drawn from an experimental marketplace study conducted in March to May 2018, in which participants were randomized to 1 of 5 FOP label conditions and completed 8 consecutive purchasing tasks.⁷ Participants 13 years and older were recruited using convenience sampling from 3 shopping centers in Toronto, Waterloo, and Kitchener Ontario. There were no eligibility requirements aside from age. The Office of Research Ethics at the University of Waterloo approved the study and protocol and all participants provided informed consent. Additional consent from a parent or guardian was required for all participants younger than 16 years; if a parent or guardian was not present, the shopper was not permitted to participate.

Participants completed 8 consecutive tasks in which they were provided with \$5 to make a purchase from a selection of 20 beverages or 20 snack food products, which were presented on large printouts resembling a grocery or convenience store shelf. The products were displayed with prices and depicted as they were found in the Canadian food supply at the time of data collection. Each of the 8 tasks presented a different price scenario, with the first 5 tasks displaying the 20 beverage products and the last 3 tasks displaying the 20 snack foods. The price scenarios were investigated in previous analyses, which evaluated the impacts of taxes on purchases of sugary beverages and snack foods.^{7,9} Beverages included both sugary and nonsugary products, such as sodas, sport drinks, vitamin waters, sweetened fruit drinks, 100% fruit juice, milks, and bottled water. Snack food offerings included products with a range of sugars, sodium, and saturated fat contents, such as potato chips, popcorn, crackers, candy, snack bars, energy bars, cookies, nuts, apples, carrots, yogurt, and processed cheese and meat snacks.




















RESEARCH SNAPSHOT

Research Question: What are the impacts of 4 front-of-package nutrition labels on purchases of products with conflicting ratings across labeling systems?

Key Findings: In this experimental marketplace with 3,584 Canadians, minimal differences in purchasing were observed across label conditions, largely explained by limited noticing of the labels. Differences across label conditions were more pronounced among participants who reported noticing the labels, with patterns suggesting that a Health Star Rating might encourage selection of products with certain positive nutritional attributes, while "high in" nutrient labels and multiple traffic light systems may more effectively discourage products contributing nutrients of public health concern.

Participants were randomly assigned by the survey program to 1 of 5 FOP conditions: no label (control); a "high in" warning system labeling foods high in sugars, sodium, or saturated fats, modeled after early iterations proposed by Health Canada¹⁰; an MTL system for sugars, sodium, and saturated fats similar to those in place in the United Kingdom¹¹; an HSR label modeled after the Australian HSR¹²; or a 5-color nutrition grade label similar to the Nutri-Score System first implemented in France.¹³ "High in" and MTL labels were assigned based on nutrient thresholds outlined by Health Canada and the United Kingdom, respectively.^{5,11} However, in 2 cases in which the MTL was incongruent with the "high in" labels, the MTL was adjusted to match the "high in" labels to ensure that any differences in purchasing could be attributed to the labels' visual design and format rather than differences in their product ratings. For the same reason, ratings for the summary indicator labels (HSR and nutrition grade) were assigned based on the Australian HSR algorithm, with nutrition grade letters aligned accordingly (ie, 0.5 to 1 star = E, 1.5 to 2 stars = D, 2.5 to 3 stars = C, 3.5 to 4 stars = B, 4.5 to 5 stars = A). The Australian HSR algorithm calculates ratings by assigning positive points for fruit and vegetable content, dietary fiber, and protein, and negative points for high calorie content, saturated fats, sodium, and total sugars.¹² Labels corresponding to each of the products are presented in Figure 1 (available at www.jandonline.org). The randomly assigned labeling system was displayed accordingly on the beverage and snack food images throughout all 8 tasks, without additional educational materials or explanation. After the purchasing tasks and using an iPad, participants completed a series of survey questions about their sociodemographic characteristics and health behaviors (Figure 2; available at www.jandonline.org). Participants then received the selected beverage or snack food product from 1 of the 8 purchasing tasks and their change from the \$5. Participants did not know which purchase they would receive until the end of the experiment and were instructed to treat all 8 tasks as actual purchases.

Sample size calculations conducted for the original study suggested a total of 2,830 participants (566 per condition) to detect a 0.5-g difference in mean sugar purchased with 80% power, where the mean of the control is 23.1 g, the standard deviation is 3.0 g, and the significance level is .05 for a 2-tailed test.

Product category	Nutrient-Specific Labels		Summary Indicator Labels		Hypotheses
	"High in"	MTL ^a	HSR ^b	Nutrition grade	
100% fruit juice ^c					The summary indicator FOP ^d labels will elicit more purchases compared to the nutrient-specific FOP labels.
Plain milk ^e					
Chocolate milk ^f					
Cheese snacks ^g					
Diet beverages ^h	NA				

NA = not applicable

^aMTL = multiple traffic light.

^bHSR = Health Star Rating.

^c100% fruit juice includes Minute Maid orange juice (Coca-Cola) and Minute Maid apple juice (Coca-Cola) beverages.

^dFOP = front-of-package.

^ePlain milk includes the Neilson 2% milk fat plain (unsweetened) milk beverage (Saputo Inc).

^fChocolate milk includes the Neilson 1% milk fat chocolate (sweetened) milk beverage (Saputo Inc).

^gCheese snacks include Black Diamond Cheestrings (Lactalis Canada) and Mini Babybel Light (Bel Canada) products.

^hDiet beverages include Diet Coke (Coca-Cola), Diet Pepsi (PepsiCo), Diet 7UP (PepsiCo), Gatorade G2 (PepsiCo), and Glaceau Vitaminwater Zero (Coca-Cola) products.

Figure 3. Front-of-package labels and ratings assigned to 5 food and beverage categories receiving conflicting ratings across label conditions in an experimental marketplace and associated hypotheses.

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Outcome Variables

A series of binary outcomes (1 = purchased, 0 = not purchased) was defined to assess the probability of participants purchasing a beverage or snack food from 5 product categories: “100% fruit juice,” “plain milk,” “chocolate milk,” “cheese snacks,” and “diet beverages.” These categories, detailed in Figure 3, were targeted because the “healthfulness” messages communicated were contradictory across the 4 FOP label conditions tested. In particular, the 100% fruit juice beverages, plain milk, chocolate milk, and cheese snacks received high healthfulness ratings from HSR (4 to 5 stars) and nutrition grade (A or B), and the same products were characterized by at least 1 high or red nutrient of concern under the “high in” and MTL conditions. Similarly, diet beverages were assigned poor ratings by HSR (2 stars) and nutrition grade (D), and under the “high in” and MTL conditions, the same products were assigned no “high in” label or 3 green MTL lights. Overall, the summary indicator FOP labels (HSR, nutrition grade) were hypothesized to elicit more purchases of fruit juice, milk beverages, and cheese snacks, and fewer purchases of diet beverages compared to the nutrient-specific FOP labels (“high in” and MTL) (Figure 3).

Analyses

Separate generalized linear mixed models were used to estimate the influence of label condition on each of the binary outcomes outlined above. Generalized linear mixed models were used in these analyses to account for the repeated nature of the purchasing tasks. All models used a compound symmetry covariance matrix, specified tax condition as the repeated measure, and included variables for tax condition and label condition. All statistical analyses were conducted using SPSS software.¹⁴

Although it is informative to investigate these results among the full sample, which provides a sense of the FOP labels’ overall impacts among consumers who are unfamiliar with FOP labels, it is unlikely that a real-world FOP labeling system would be implemented without an accompanying education campaign or media attention.¹⁵⁻¹⁸ It is therefore important to evaluate the purchasing behaviors of those participants who noticed the FOP labels, which might be more reflective of real-world scenarios in which efforts are made to draw attention to the labels. Sensitivity analyses tested the same models, stratified by whether or not participants reported noticing the FOP labels. Participants who noticed the FOP labels included those who responded “yes” to noticing the FOP nutrition labels in their assigned condition (for those assigned to “high in,” MTL, HSR, or nutrition grade) or “no/don’t know” for not noticing an FOP nutrition label (for those assigned to no label) after the purchasing task. The remaining participants were categorized as those who “did not notice the FOP labels.” As reported previously,⁷ 51.5% (n = 1,473) of the 2,858 participants assigned to view products with a FOP label reported noticing the labels, and 71.2% (n = 517) of the 726 participants assigned to no label responded that they did not notice any nutrition symbols or labels on the packages.

Among the subset of participants who noticed the FOP labels, age was unequally distributed across the FOP label condition groups; therefore, all models assessing participants

who noticed the FOP labels included a variable for “age” to control for differences. Age, sex, sugary beverage frequency, ethnicity, education, income adequacy, and body mass index (calculated as kg/m²) classification were equally distributed across the FOP label conditions among the subset of participants who did not notice the FOP labels. Lastly, descriptive statistics were used to report the unadjusted percentages of participants who purchased each individual product category across all purchasing tasks, among the full sample and the subset of participants who reported noticing the labels.

RESULTS

A total of 744, 739, 736, 740, and 743 participants were assigned to the no label, “high in,” MTL, HSR, and nutrition grade FOP label conditions, respectively, and completed the purchasing tasks. After data cleaning, 118 participants (no label n = 18, “high in” n = 25, MTL n = 27, HSR n = 22, nutrition grade n = 26) were removed due to data quality concerns reported by the research assistants (eg, significant cognitive difficulties or distraction, visual impairment, and substantial influence from peers), resulting in a total sample

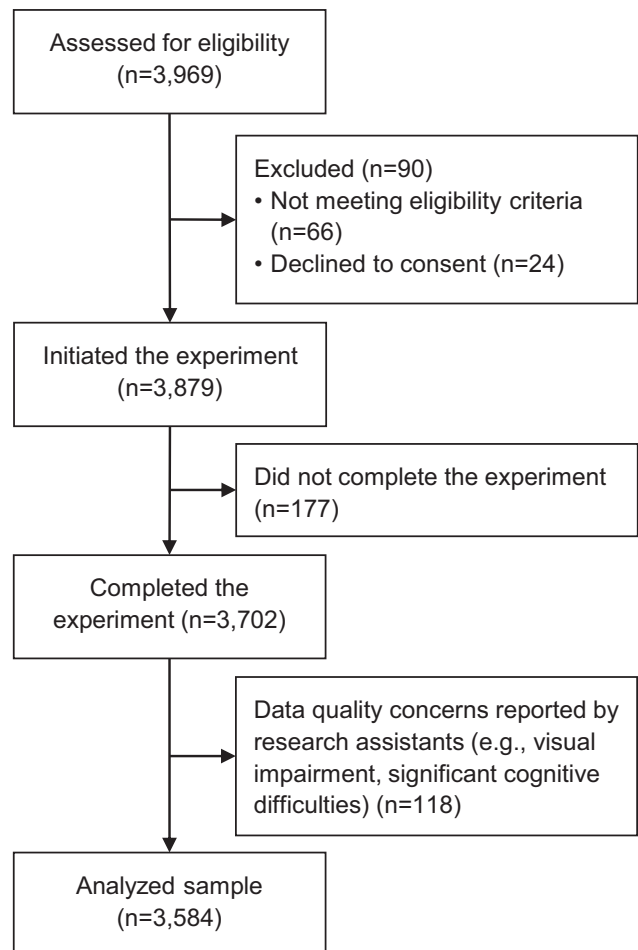


Figure 4. Flow chart of the inclusion process for participants in an experimental marketplace testing the impacts of 4 front-of-package nutrition labels on purchases of products with conflicting ratings across labeling systems.

Table 1. Sociodemographic characteristics of participants in an experimental marketplace testing the impacts of 4 front-of-package nutrition labels on participant purchases

Characteristic ^a	Total sample (n = 3,548)	Participants who noticed FOP ^b labels (n = 1,993)	Participants who did not notice FOP labels (n = 1,591)	Test for Differences Between Those Who Noticed and Did Not Notice FOP Labels	
				χ^2	P value
	←————— % —————→				
Age				35.3	<.001
13-18 y	15.3	15.6	14.8		
19-25 y	31.0	32.6	28.9		
26-35 y	20.6	22.6	18.0		
36-45 y	11.9	10.8	13.3		
Older than 45 y	21.3	18.4	24.9		
Sex				0.1	.809
Male	44.0	44.2	43.7		
Female	56.0	55.8	56.2		
Weekly sugary beverage frequency (past week)^c				16.4	.002
0	22.3	19.9	25.2		
1-3	39.4	41.8	36.3		
4-7	24.9	24.7	25.2		
8-14	9.6	9.6	9.6		
More than 14	3.8	3.9	3.7		
Ethnicity				0.3	.859
White	44.9	44.7	45.2		
Other, mixed, not stated	51.8	52.2	51.4		
Indigenous	3.3	3.2	3.4		
Education				0.6	.755
High school or less	26.6	26.7	26.4		
Technical/trade school or college (partial or complete)	11.7	12.0	11.3		
University (partial or complete)	61.7	61.3	62.3		
Income adequacy^d				0.4	.811
Very difficult or difficult	19.5	19.7	19.3		
Neither easy nor difficult	41.4	41.7	41.0		
Easy or very easy	39.1	38.6	39.7		
BMI^e classification				3.5	.482
Underweight (<18.5)	3.3	3.2	3.5		
Normal weight (18.5-24.9)	46.0	46.4	45.5		
Overweight (25.0-29.9)	22.8	22.8	22.9		

(continued on next page)

Table 1. Sociodemographic characteristics of participants in an experimental marketplace testing the impacts of 4 front-of-package nutrition labels on participant purchases (*continued*)

Characteristic ^a	Total sample (n = 3,548)	Participants who noticed FOP ^b labels (n = 1,993)	Participants who did not notice FOP labels (n = 1,591)	Test for Differences Between Those Who Noticed and Did Not Notice FOP Labels	
				χ^2	P value
Obesity (≥ 30.0)	12.1	12.6	11.3		
Not reported	15.8	15.0	16.8		

^aCharacteristics are provided for the total sample, participants who noticed the FOP labels, and participants who did not notice the FOP labels. χ^2 test results indicate differences in the sociodemographic profile of participants who noticed and did not notice the FOP labels.

^bFOP = front-of-package.

^cPrevious 7-day sugary drink consumption was assessed using the following question: "During the PAST 7 DAYS, how many sugary drinks did you have? (This includes pop, fruit drinks, fruit juice, sport drinks, vitamin waters, energy drinks, chocolate milk, tea/coffee with more than 5 teaspoons of sugar, and specialty coffees.) Do NOT count diet or sugar-free drinks. Do NOT include today."

^dPerceived income adequacy was assessed using the following question: "Thinking about your total monthly income, how difficult or easy is it for you to make ends meet?" Response options were "very difficult," "difficult," "neither easy nor difficult," "easy," and "very easy."

^eBMI = body mass index (calculated as kg/m²).

of 3,584. A participant selection flow chart is provided in Figure 4. Table 1 presents characteristics of the total sample, as well for those who did and did not notice the FOP labels. Participants who noticed the labels tended to be younger and more likely to report consuming 1 to 3 sugary beverages in the past week compared to the participants who did not notice the FOP labels.

Effect of FOP Labels on Purchasing of Product Categories

Results from the generalized linear mixed models revealed few differences in purchasing of the key product categories of interest across the labeling conditions (Figure 5). Participants assigned to the HSR condition were 2.2 percentage points less likely to purchase a plain milk product (95% CI -4.3 to -0.1 ; $P = .037$) compared to participants in the no label condition. Participants assigned to view the "high in" labels were 3.6 percentage points (95% CI 0.4 to 6.9 percentage points; $p = .029$) and 3.5 percentage points (95% CI 0.2 to 6.7 percentage points; $P = .038$) more likely to purchase a diet beverage compared to participants in the no label and HSR conditions, respectively. No statistically significant differences in purchases were observed across the labeling conditions for 100% fruit juice, chocolate milk, or cheese snack products.

Sensitivity Analyses

Results from the sensitivity analyses assessing the results stratified by those who noticed the FOP labels compared to those who did not notice the FOP labels are presented in Figure 6 and Figure 7 (available at: www.jandonline.org). Among participants who noticed the FOP labels ($n = 1,993$), a greater number of differences were observed across labeling conditions. Participants assigned to view MTL labels were 4.5 percentage points (95% CI -7.0 to -1.9 percentage points; $P = .001$), 4.0 percentage points (95% CI -6.5 to -1.5 percentage points; $P = .002$), and 2.6 percentage points (95% CI -4.8 to -0.4 percentage points; $P = .020$) less likely to purchase a 100% fruit juice product compared to participants who viewed the HSR, nutrition grade, and no label, respectively.

Participants who viewed products with no label were 4.8 percentage points more likely to purchase chocolate milk (95% CI 1.4 to 8.1 percentage points; $P = .005$) than participants who saw products with the "high in" label. Participants who saw products with the HSR labels, which labeled cheese snacks with 5 stars, were 3.3 percentage points (95% CI 0.4 to 6.2 percentage points; $P = .026$) and 3.0 percentage points (95% CI 0.1 to 6.1 percentage points; $P = .049$) more likely to purchase these snacks than the no label and "high in" conditions, respectively. Lastly, those assigned to the no label condition were 8.2 percentage points (95% CI -12.4 to -4.1 percentage points; $P < .001$), 7.0 percentage points (95% CI -11.4 to -2.6 percentage points; $P = .002$), and 4.9 percentage points (95% CI -9.0 to -0.9 percentage points; $P = .017$) less likely to purchase a diet beverage compared to those who saw the products labeled with the "high in," MTL, or HSR symbols, respectively. There were no significant differences in purchasing of plain milk across the FOP label conditions among those who reported noticing the labels.

In models assessing participants who did not notice the FOP labels ($n = 1,591$), participants assigned to the MTL condition were 2.8 percentage points (95% CI 0.1 to 5.7 percentage points; $p = .049$) more likely to purchase a cheese snack compared to the HSR condition, and those assigned to the no label condition were 5.6 percentage points (95% CI 0.2 to 11.0 percentage points; $p = .042$) and 7.3 percentage points (95% CI 1.9 to 12.7 percentage points; $p = .008$) more likely to purchase a diet beverage than those who viewed the MTL and HSR labels, respectively.

Table 2 (available at: www.jandonline.org) presents the unadjusted percentages of participants who purchased each individual product across all purchasing tasks, among the full sample and the subset of participants who noticed the FOP labels. Notably, the "high in" and MTL conditions led to the most consistently low purchases of products containing "high" levels of sugars, sodium, or saturated fats overall. The pattern of unadjusted results across all product categories also suggests that the increases in purchasing of diet beverages occurred in tandem with shifts away from higher-sugar beverage products.

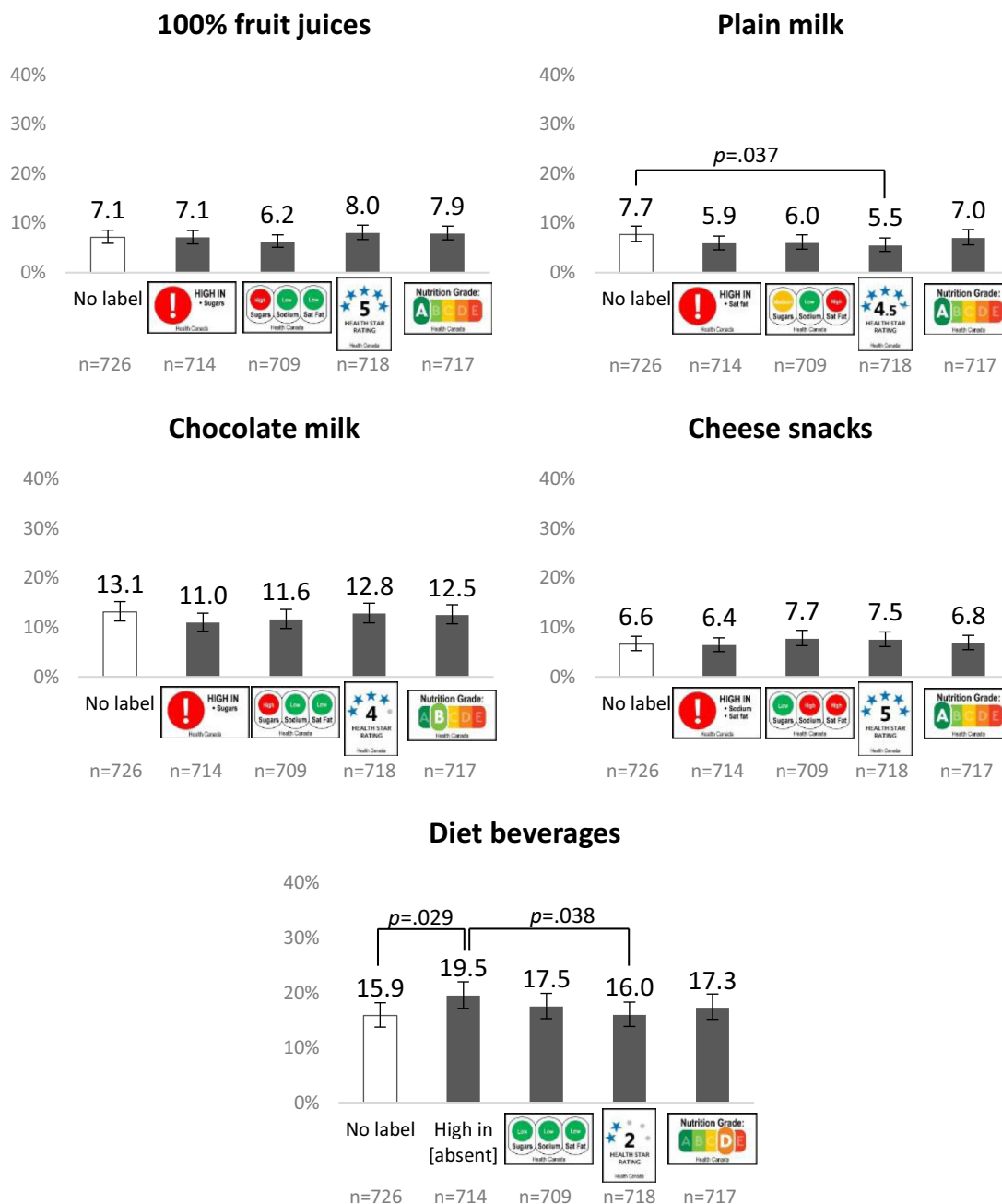


Figure 5. Estimated means for the percentage of participants across the full sample ($n = 3,584$) who purchased a 100% fruit juice, 2% milk fat plain milk, 1% milk fat chocolate milk, cheese snack, or diet beverage product in an experimental marketplace, by front-of-package labeling condition. Significant differences are indicated with brackets. Error bars represent 95% CIs. Products with conflicting ratings across labeling systems were selected for the focus of this analysis. Purchasing patterns for other beverage and snack products included in the experimental marketplace are available in Table 2 (available at: www.jandonline.org).

DISCUSSION

Overall, when investigating participants' purchases of products that receive positive ratings under one FOP system but negative ratings under another, few differences were present across FOP label conditions among the entire sample of participants in an experimental marketplace. Among the full sample, respondents who saw the HSR labels were less likely to purchase plain milk than those who saw no label, and

those who saw products with the "high in" labels were more likely to purchase a diet beverage than respondents in the no label and HSR conditions. These differences, however, were smaller relative to those observed among the subset of participants who reported noticing the labels.

Unsurprisingly, a greater number and magnitude of differences in purchasing behaviors were observed among participants who noticed the labels compared to those who did

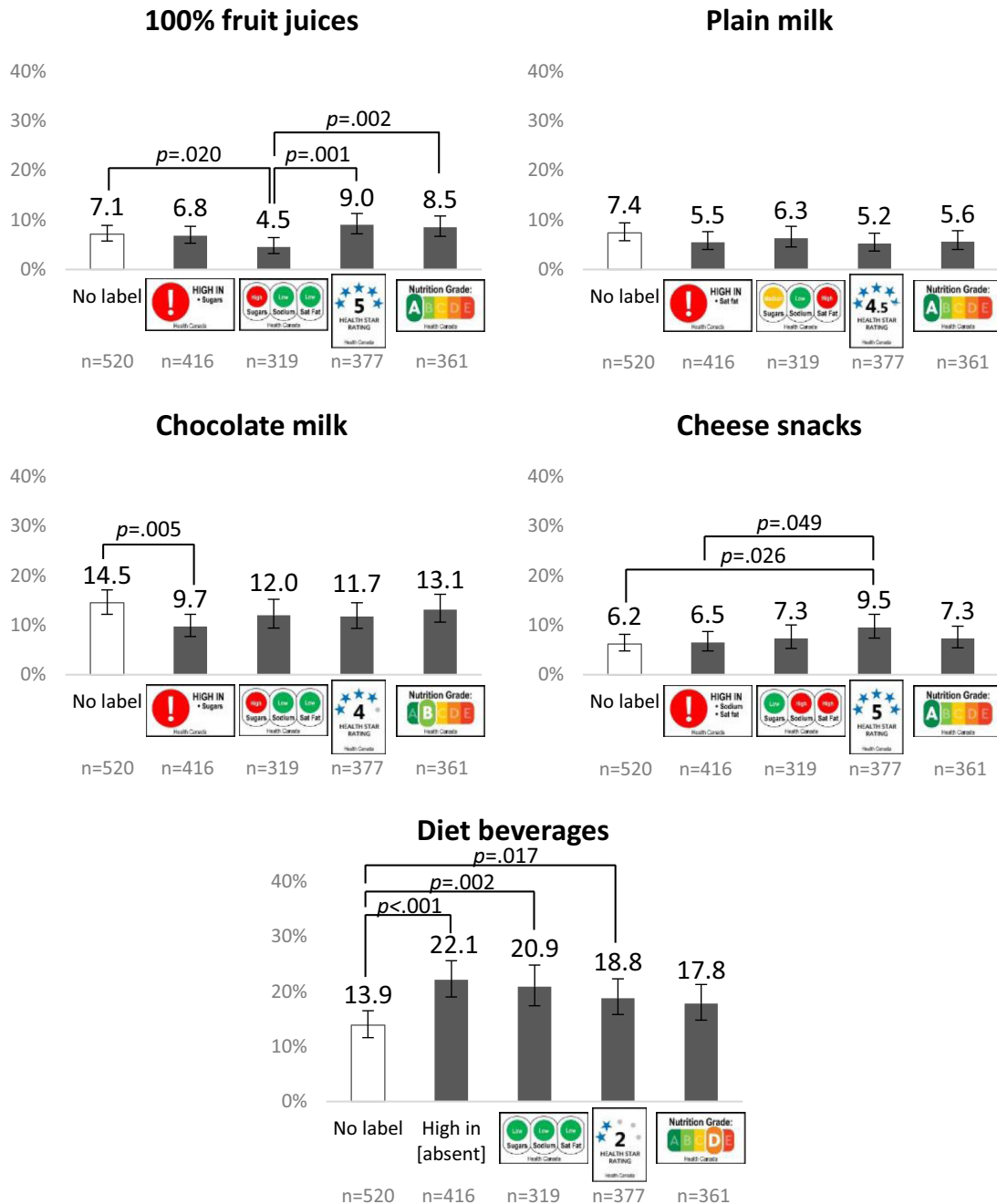


Figure 6. Estimated means for the percentage of participants who noticed a front-of-package nutrition label ($n = 1,993$) and who purchased a 100% fruit juice, 2% milk fat plain milk, 1% milk fat chocolate milk, cheese snack, or diet beverage product in an experimental marketplace, by FOP labeling condition. Significant differences are indicated with brackets. Error bars represent 95% CIs. Products with conflicting ratings across labeling systems were selected for the focus of this analysis. Purchasing patterns for other beverage and snack products included in the experimental marketplace are available in Table 2 (available at: www.jandonline.org).

not. In fact, results for diet beverage purchases were reversed between the 2 subsamples: among respondents who noticed the FOP labels, a greater proportion of those in any of the FOP label conditions selected a diet beverage compared to those who saw no label, and the opposite was true among respondents who did not notice the labels. In addition, presumably due to the high star ratings displayed on these

products, exposure to the HSR condition led to more purchases of 100% fruit juice (compared to the MTL) and cheese snacks (compared to no label and “high in”) among those who noticed the FOP labels. Although the differences may appear small, they are likely to translate to substantial impacts at a population level. For example, the 4.5 percentage points (50.0%) difference in likelihood of purchasing 100%

fruit juice between the HSR and MTL conditions—if applied to the most recent estimates of 100% fruit juice consumption in Canada (34 kcal per capita per day¹⁹)— translates to an average reduction of 17 kcal per capita per day. Simulation modeling work has estimated that a 17 kcal average reduction in per capita daily energy intake would translate to the prevention of more than 12,000 cancer cases, 36,000 cases of ischemic heart disease, 4,800 strokes, and 138,000 cases of type 2 diabetes over 25 years in Canada.²⁰ This is, of course, an oversimplification and assumes that reductions in purchases would directly translate to reductions in consumption.

The high star ratings assigned to 100% fruit juice products in particular have been raised as a key criticism of Australia's FOP system due to the high sugar content found in these products,^{21,22} and in the system's 5-year review, these ratings were cited as a recommended area for improvement to more clearly distinguish water and other low-calorie beverages from high-calorie drinks.²³ Notably, Canada's 2019 Food Guide (implemented after the current study was conducted) recommends replacing sugary drinks (including 100% fruit juice) with water or whole fruit.²⁴ Interestingly, the HSR condition did not have the same effect on 4.5-star rated 2% plain milk products among the entire sample or the subsample of participants who noticed the labels. It is possible that the 4.5-star rating, although seemingly high on its own, was a deterrent to participants when observed in the context of other 5-star rated beverages, such as water or fruit juice. Recent declines in consumption and preferences for cow's milk over the past several years in Canada might also offer an explanation for the direction of effects seen here.^{25,26}

Results for the “high in” labels among those who noticed the FOP labels provide some insight into the potential effects of similar FOP labels proposed in Canada. Those who were exposed to and noticed the “high in” labels were 4.8 percentage points (33.1%) and 3.0 percentage points (31.6%) less likely to purchase 1% milk fat chocolate milk (compared to no label) and cheese snacks (compared to HSR), respectively; both of these products displayed at least one “high” nutrient of concern. Unadjusted purchase data for all 20 beverages and 20 snack food products suggest that participants who noticed the labels in the “high in” condition purchased fewer products contributing “high” nutrients of concern overall compared to those in the no label condition, and to a lesser extent compared to HSR. These results are consistent with evidence from several recent studies, which suggest that nutrient warning labels discourage product selection.^{27–35}

Some of the most substantial differences among participants who noticed the labels were seen in the diet beverage category; however, only with respect to the no label control. Diet beverages—which were rated relatively poorly by the HSR and nutrition grade, but displayed no “high in” labels and 3 green traffic lights under the MTL condition—were purchased more frequently in all of the FOP label conditions relative to no label. It is likely that the higher levels of diet beverage purchases compared to the control condition were driven by participants shifting away from the other high-sugar beverages that displayed the poorest ratings, as reflected in the unadjusted purchase data for the individual product categories. Given current disagreement and limited evidence on the recommended intake of artificially

sweetened beverages,^{36,37} the potential for consumers to substitute this product category for others should be a key consideration for policymakers implementing an FOP system.

Collectively, the results reinforce previous research suggesting that different FOP labeling systems might be better suited for certain policy goals than others.^{1,2,6} As expected, our analyses suggest that “high in” nutrient labels might be better at discouraging consumption of products containing high levels of nutrients of concern, such as fruit juice and sugary milk beverages, 2 of the most frequently consumed beverages and top contributors to sugar and calorie consumption in Canada.³⁸ In contrast, a summary indicator system, such as Australia's HSR, might be less likely to deter purchases of such products, particularly if fruit or dairy content are valued highly in their rating algorithms. Results from previous analyses of this experimental marketplace also suggest that the summary indicator systems were no better at encouraging purchases of protein, calcium, or fiber from snack foods compared to the nutrient-specific labels.⁸

In addition, our results stratified by those who noticed the FOP labels compared to those who did not notice the labels reinforce the importance of consumer awareness and salience of FOP labels. Long-established best practices from labeling research in other domains emphasize that awareness and salience are key predictors of the extent to which consumers will attend to a label, and subsequently respond to it.³⁹ This concept was reflected in the current study, with more notable differences observed across FOP label conditions among participants who noticed the labels. FOP labeling systems in the real world should be implemented alongside strong information campaigns to maximize label awareness and subsequent use—such as those associated with the Australian Health Star Ratings and Chile's “*alto en*” labels^{40,41}—and future research should investigate the independent effects of such campaigns.

Strengths and Limitations

Strengths of the current study include the between-subject experimental design and the use of real products and actual monetary exchange in the purchase tasks. Limitations include the use of a convenience sample, which limits the sample's representativeness of the larger Canadian population; however, the sample provided good variability across socio-demographic characteristics and health behaviors. The product categories assessed are important given their conflicting ratings across FOP systems, but they represent only a small portion of the broader food supply. In particular, the current study did not include a low-fat, unsweetened milk beverage option, and therefore omitted a key beverage alternative that would have displayed no “high in” symbols or red traffic lights. In addition, it is likely that some participants may have reported noticing the FOP labels when they did not, and vice versa. The current study did not explore the potential impacts of brand familiarity; however, given that real brands were used, the behaviors produced by these brands are likely to be similar to that of real-world scenarios. Other factors that might have influenced purchasing intentions, such as dietary preferences, dietary restrictions and health consciousness, were not measured. The experimental marketplace also included price scenarios that were not analyzed in this study (including scenarios with regular

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market prices and tax scenarios); however, given that all participants were exposed to the same prices, these would be unlikely to impact the current findings across FOP label conditions. Furthermore, the multiple tests conducted raise the possibility of detecting false positives. The smaller sample sizes provided by the subsample of participants analyzed in the sensitivity analyses might also have offered insufficient power to detect meaningful differences in the outcomes of interest. Similarly, the subsample of participants who noticed the labels produced slight group imbalances (ie, participants in the “high in” label condition were more likely to notice the labels and therefore made up a greater proportion of the subsample than other FOP conditions), leading to potential imbalances in power to detect differences across the experimental groups.

CONCLUSIONS

Overall, this analysis suggests that despite some similarities, existing FOP systems differ in the extent to which they promote or dissuade purchases of key food categories, such as 100% fruit juice or dairy products. Although a star rating system might encourage purchases of products with certain positive nutritional attributes, a “high in” or MTL system might be more effective at discouraging purchases of products containing high levels of sugars, sodium, or saturated fats.

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STATEMENT OF POTENTIAL CONFLICT OF INTEREST

David Hammond has provided paid expert testimony on behalf of public health authorities in response to legal challenges from the food and beverage industry. No potential conflict of interest was reported by the remaining authors.

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AUTHOR CONTRIBUTIONS

R. B. Acton, S. I. Kirkpatrick, and D. Hammond formulated the research questions. R. B. Acton conducted research, performed statistical analysis, and wrote initial draft of manuscript. S. I. Kirkpatrick and D. Hammond contributed significantly to the manuscript. All authors have read and approved the final manuscript.

Table 2. Mean percent of sample who purchased each product across all purchasing tasks, among the full sample and the subset of participants who noticed the front-of-package labels in an experimental marketplace

Variable	Full Sample (n = 3,584)					Participants Who Noticed the FOP ^a Labels (n = 1,993)				
	No label (n = 726)	"High in" (n = 714)	MTL ^b (n = 709)	HSR ^c (n = 718)	Nutrition grade (n = 717)	No label (n = 520)	"High in" (n = 416)	MTL (n = 319)	HSR (n = 377)	Nutrition grade (n = 361)
Beverages										
1 Coca-Cola (Coca-Cola)	4.2	3.1	3.7	3.9	4.8	4.5	3.1	3.0	3.7	4.1
2 Diet Coke (Coca-Cola)	3.5	5.7	4.4	5.1	5.0	3.8	5.7	5.0	5.9	5.3
3 Pepsi (PepsiCo)	1.3	1.6	1.3	1.4	1.2	1.3	1.8	0.4	1.0	1.1
4 Diet Pepsi (PepsiCo)	2.2	1.1	2.3	2.1	2.3	2.2	0.7	2.6	1.8	2.7
5 7UP (PepsiCo)	2.9	2.2	2.8	2.2	2.1	2.7	2.1	3.0	2.3	2.9
6 Diet 7UP (PepsiCo)	1.0	1.9	2.3	1.1	1.9	0.9	1.8	1.9	1.0	1.4
7 Orange Crush (Canada Dry Mott's Inc)	2.8	2.0	2.5	2.2	2.1	3.4	2.2	2.2	2.0	2.4
8 Gatorade, lemon lime (PepsiCo)	2.5	2.1	1.8	2.5	2.3	2.5	2.0	1.4	1.4	2.0
9 Gatorade, fruit punch (PepsiCo)	1.9	1.5	1.5	2.1	1.7	2.1	1.4	1.9	2.0	1.8
10 Gatorade G2, fruit punch (PepsiCo)	3.3	4.2	3.8	2.4	3.5	3.3	5.0	4.9	3.4	3.8
11 Glaceau Vitamin Water, XXX (Coca-Cola)	3.6	3.7	3.2	3.1	3.1	3.0	4.3	3.6	2.9	3.3
12 Glaceau Vitaminwater, energy (Coca-Cola)	2.7	1.2	1.7	1.7	1.7	2.7	1.5	2.3	2.0	1.4
13 Glaceau Vitaminwater Zero, XOXOX (Coca-Cola)	5.9	6.8	6.4	5.3	4.9	3.9	9.0	6.8	6.9	4.5
14 Nestea (Coca-Cola)	6.8	8.9	8.2	6.4	7.0	7.2	9.1	8.2	5.5	6.4
15 Minute Maid lemonade (Coca-Cola)	2.2	2.0	2.1	2.7	2.6	2.1	1.8	1.8	2.5	2.4
16 Minute Maid apple juice (Coca-Cola)	3.3	3.2	3.0	3.5	3.2	3.5	2.8	2.3	4.3	3.7
17 Minute Maid orange juice (Coca-Cola)	4.4	3.8	3.4	4.8	5.1	4.2	4.0	2.5	4.9	5.6
18 Neilson 2% milk fat plain milk (Saputo Inc)	7.7	6.0	6.5	5.8	6.9	8.1	5.6	6.8	5.8	5.5
19 Neilson 1% mil fat chocolate milk (Saputo Inc)	13.1	10.8	11.0	13.1	12.7	14.3	10.2	12.5	12.3	13.9
20 Real Canadian Natural Spring Water (Loblaw Companies Ltd)	24.6	28.2	28.1	28.7	26.1	24.3	25.9	26.9	28.5	25.8

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Table 2. Mean percent of sample who purchased each product across all purchasing tasks, among the full sample and the subset of participants who noticed the front-of-package labels in an experimental marketplace (*continued*)

Variable	Full Sample (n = 3,584)					Participants Who Noticed the FOP ^a Labels (n = 1,993)				
	No label (n = 726)	“High in” (n = 714)	MTL ^b (n = 709)	HSR ^c (n = 718)	Nutrition grade (n = 717)	No label (n = 520)	“High in” (n = 416)	MTL (n = 319)	HSR (n = 377)	Nutrition grade (n = 361)
Snack foods										
1 Lay’s salt and vinegar potato chips (PepsiCo)	6.1	5.0	5.0	5.2	6.5	6.8	4.6	5.7	4.5	6.6
2 Lays oven baked potato chips (PepsiCo)	6.2	5.2	4.2	5.9	3.9	6.4	7.0	3.7	6.3	3.9
3 Smartfood white cheddar popcorn (PepsiCo)	9.4	8.7	8.8	7.6	9.0	10.5	7.2	7.8	6.7	7.9
4 Skinny Pop (Amplify Snack Brands)	5.3	5.7	5.5	4.9	5.2	4.3	7.1	6.5	5.5	5.7
5 Veggie Straws (Hain-Celestial Canada)	6.2	5.5	5.4	6.7	5.6	5.4	6.1	7.1	6.8	6.3
6 Pepperidge Farm Goldfish crackers (Campbell Soup Company)	1.9	2.4	2.4	2.4	2.6	2.2	2.3	2.5	2.0	2.0
7 Maynards Original Gummies (Mondelez International)	5.1	5.9	5.2	4.5	4.9	5.1	5.5	5.4	3.5	4.6
8 Snickers candy bar (Mars Wrigley)	7.9	6.9	5.8	6.1	6.4	7.1	8.0	5.0	7.2	6.4
9 Quaker chewy yogurt granola bar (PepsiCo)	1.8	2.2	1.6	1.9	1.9	1.6	2.1	1.4	2.6	2.7
10 Clif Bar (Clif Bar & Co.)	6.8	4.5	5.1	6.3	6.2	7.4	3.2	7.1	6.1	6.6
11 Mrs Fields cookie (Famous Brands International)	4.6	4.1	5.4	3.8	4.8	4.4	3.3	4.4	3.4	3.7
12 Planters salted peanuts (Johnvince Foods)	0.8	0.8	1.1	2.1	1.4	0.8	1.1	1.6	2.4	1.2
13 Blue Diamond lightly salted almonds (Blue Diamond Growers)	7.7	9.6	6.6	6.7	8.7	8.4	9.4	6.2	6.5	10.0
14 Apple, generic	11.1	13.4	15.4	14.0	12.9	10.8	12.9	14.9	11.5	13.2
15 Bolthouse Farms baby cut carrots (Campbell Soup Company)	3.9	4.8	6.9	6.0	5.0	3.5	4.2	7.3	6.8	4.6

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Table 2. Mean percent of sample who purchased each product across all purchasing tasks, among the full sample and the subset of participants who noticed the front-of-package labels in an experimental marketplace (*continued*)

Variable	Full Sample (n = 3,584)					Participants Who Noticed the FOP ^a Labels (n = 1,993)				
	No label	"High in"	MTL ^b	HSR ^c	Nutrition grade	No label	"High in"	MTL	HSR	Nutrition grade
	(n = 726)	(n = 714)	(n = 709)	(n = 718)	(n = 717)	(n = 520)	(n = 416)	(n = 319)	(n = 377)	(n = 361)
16 Beatrice fruit on the bottom strawberry yogurt (Lactalis Canada Inc)	2.0	1.5	1.9	2.1	1.5	1.9	1.3	1.6	1.9	1.0
17 Iögo 0% mixed berry yogurt (Ultima Foods)	4.6	4.9	4.5	4.2	4.2	4.4	5.2	3.1	4.5	3.9
18 Black Diamond Cheestrings (Lactalis Canada)	3.0	4.3	4.2	3.5	4.2	3.0	4.5	3.1	4.9	4.9
19 Mini Babybel light (Bel Canada)	3.6	2.0	3.5	4.0	2.6	3.3	1.9	4.2	4.6	2.4
20 Schneiders Hot Rod meat sticks (Maple Leaf Foods)	2.3	2.3	1.8	2.0	2.5	2.6	3.0	1.2	2.2	2.0

^aFOP = front-of-package

^bMTL = multiple traffic light.

^cHSR = Health Star Rating.

Variable		"High in" Label			MTL ^a Label			HSR ^b	Nutrition grade ^c
		Sugar	Sodium	Sat fat	Sugar	Sodium	Sat fat		
	Beverages								
1	Coca-Cola (Coca-Cola)	●			High	Low	Low	★	E
2	Diet Coke (Coca-Cola)				Low	Low	Low	★★	D
3	Pepsi (PepsiCo)	●			High	Low	Low	★	E
4	Diet Pepsi (PepsiCo)				Low	Low	Low	★★	D
5	7UP (PepsiCo)	●			High	Low	Low	★	E
6	Diet 7UP (PepsiCo)				Low	Low	Low	★★	D
7	Orange Crush (Canada Dry Mott's Inc)	●			High	Low	Low	★	E
8	Gatorade, lemon lime (PepsiCo)	●			High	Low	Low	★1/2	D
9	Gatorade, fruit punch (PepsiCo)	●			High	Low	Low	★1/2	D
10	Gatorade G2, fruit punch (PepsiCo)				Low	Low	Low	★★	D
11	Glacéau Vitaminwater, XXX (Coca-Cola)	●			High	Low	Low	★1/2	D
12	Glacéau Vitaminwater, energy (Coca-Cola)	●			High	Low	Low	★1/2	D
13	Glacéau Vitaminwater Zero, XOXOX (Coca-Cola)				Low	Low	Low	★★	D
14	Nestea (Coca-Cola)	●			High	Low	Low	★1/2	D
15	Minute Maid lemonade (Coca-Cola)	●			High	Low	Low	★1/2	D
16	Minute Maid apple juice (Coca-Cola)	●			High	Low	Low	★★★★★	A
17	Minute Maid orange juice (Coca-Cola)	●			High	Low	Low	★★★★★	A
18	Neilson 2% milk fat plain milk (Saputo Inc)			●	Medium	Low	High	★★★★1/ 2	A

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Figure 1. Front-of-package labels and ratings corresponding to label conditions for all beverage and snack food products in the purchasing tasks in an experimental marketplace testing the impacts of 4 front-of-package nutrition labels on participant purchases. Source: Acton R.B., Jones A.C., Kirkpatrick S.I., Roberto C.A., Hammond D. Taxes and front-of-package labels improve the healthiness of beverage and snack purchases: A randomized experimental marketplace. *Int J Behav Nutr Phys Act.* 2019;16(1):46..

Variable		"High in" Label			MTL ^a Label			HSR ^b	Nutrition grade ^c
		Sugar	Sodium	Sat fat	Sugar	Sodium	Sat fat		
19	Neilson 1% milk fat chocolate milk (Saputo Inc)	●			High	Low	Low	★★★★	B
20	Real Canadian natural spring water (Loblaw Companies Ltd)				Low	Low	Low	★★★★★	A
	Snack Foods								
	Product								
1	Lay's salt and vinegar potato chips (PepsiCo)		●		Low	High	Medium	★★1/2	C
2	Lays oven baked potato chips (PepsiCo)				Medium	Medium	Medium	★★★★	B
3	Smartfood white cheddar popcorn (PepsiCo)		●	●	Low	High	High	★★	D
4	Skinny Pop (Amplify Snack Brands)				Low	Medium	Medium	★★★★	B
5	Veggie Straws (Hain-Celestial Canada)		●		Low	High	Medium	★★1/2	C
6	Pepperidge Farm Goldfish crackers (Campbell Soup Company)		●		Low	High	Medium	★★	D
7	Maynards Original Gummies (Mondelēz International)	●			High	Low	Low	★★	D
8	Snickers candy bar (Mars Wrigley)	●		●	High	Medium	High	★	E
9	Quaker chewy yogurt granola bar (PepsiCo)	●		●	High	Medium	High	★1/2	D
10	Clif Bar (Clif Bar & Co.)	●			High	Medium	Medium	★★1/2	C
11	Mrs Fields cookie (Famous Brands International)	●		●	High	Medium	High	★	E

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Figure 1. (continued) Front-of-package labels and ratings corresponding to label conditions for all beverage and snack food products in the purchasing tasks in an experimental marketplace testing the impacts of 4 front-of-package nutrition labels on participant purchases. Source: Acton R.B., Jones A.C., Kirkpatrick S.I., Roberto C.A., Hammond D. Taxes and front-of-package labels improve the healthiness of beverage and snack purchases: A randomized experimental marketplace. *Int J Behav Nutr Phys Act.* 2019;16(1):46..

Variable		"High in" Label			MTL ^a Label			HSR ^b	Nutrition grade ^c
		Sugar	Sodium	Sat fat	Sugar	Sodium	Sat fat		
12	Planters salted peanuts (Johnvince Foods)			●	Low	Medium	High	★★★★	B
13	Blue Diamond lightly salted almonds (Blue Diamond Growers)				Low	Medium	Medium	★★★★★	A
14	Apple, generic	NA ^d	NA	NA	NA	NA	NA	NA	NA
15	Bolthouse Farms baby cut carrots (Campbell Soup Company)	NA	NA	NA	NA	NA	NA	NA	NA
16	Beatrice fruit on the bottom strawberry yogurt (Lactalis Canada Inc)	●		●	High	Low	High	★★1/2	C
17	lögo 0% mixed berry yogurt (Ultima Foods)				Low	Low	Low	★★★★1/2	A
18	Black Diamond Cheestrings (Lactalis Canada)		●	●	Low	High	High	★★★★★	A
19	Mini Babybel Light (Bel Canada)		●	●	Low	High	High	★★★★★	A
20	Schneiders Hot Rod meat sticks (Maple Leaf Foods)		●	●	Medium	High	High	1/2	E

^aMTL = multiple traffic light.
^bHSR = Health Star Rating.
^cNutrition grades: E = 0.5 to 1 star; D = 1.5 to 2 stars; C = 2.5 to 3 stars; B = 3.5 to 4 stars; A = 4.5 to 5 stars.
^dNA = not applicable.

Figure 1. (continued) Front-of-package labels and ratings corresponding to label conditions for all beverage and snack food products in the purchasing tasks in an experimental marketplace testing the impacts of 4 front-of-package nutrition labels on participant purchases. Source: Acton R.B., Jones A.C., Kirkpatrick S.I., Roberto C.A., Hammond D. Taxes and front-of-package labels improve the healthiness of beverage and snack purchases: A randomized experimental marketplace. *Int J Behav Nutr Phys Act.* 2019;16(1):46..

Domain/variable	Survey item ^a
Age	[Asked verbally] "Can you please tell me your age?"
Sex	[Recorded by research assistant]
Previous 7-day sugary drink consumption	During the PAST 7 DAYS, how many sugary drinks did you have? (This includes pop, fruit drinks, fruit juice, sports drinks, vitamin waters, energy drinks, chocolate milk, tea/coffee with more than 5 teaspoons of sugar, and specialty coffees.) Do NOT count diet or sugar-free drinks. Do NOT include today. [open text response]
Ethnicity	Are you an Aboriginal person, that is, First Nations (North American Indian), Métis or Inuit (Inuk)? Yes No [Not asked for respondents who identified as an Aboriginal person:] People living in Canada come from many different cultural and racial backgrounds. Are you... (Select all that apply) White Chinese South Asian (eg, East Indian, Pakistani, Sri Lankan) Black Filipino Latin American Southeast Asian (eg, Cambodian, Indonesian, Laotian, Vietnamese) Arab West Asian (eg, Afghan, Iranian) Japanese Korean Other → Please specify: [open text]
Education	[age 17 y+] What is the highest level of formal education that you have completed? Grade 10 or lower Grade 11 Grade 12 (completed high school) Technical or trade school or college Some university, no degree Completed university degree Postgraduate degree (eg, Master's or PhD, professional programs) [age <17 y] What is the highest level of formal education that you have completed? Grade 5 or lower Grade 6 Grade 7 Grade 8 Grade 9 Grade 10 Grade 11 Grade 12 or high school diploma or equivalent

(continued on next page)

Figure 2. Survey questions assessing sociodemographic characteristics and health behaviors in an experimental marketplace testing the impacts of 4 front-of-package nutrition labels on participant purchases.

Domain/variable	Survey item ^a
Perceived income adequacy	Thinking about your total monthly income, how difficult or easy is it for you to make ends meet? Very difficult Difficult Neither easy nor difficult Easy Very easy
Body mass index classification	[Calculated based on self-reported height and weight]
^a Response options “don’t know” and “refuse to answer” were available for all survey items completed by participants.	

Figure 2. (continued) Survey questions assessing sociodemographic characteristics and health behaviors in an experimental marketplace testing the impacts of 4 front-of-package nutrition labels on participant purchases.

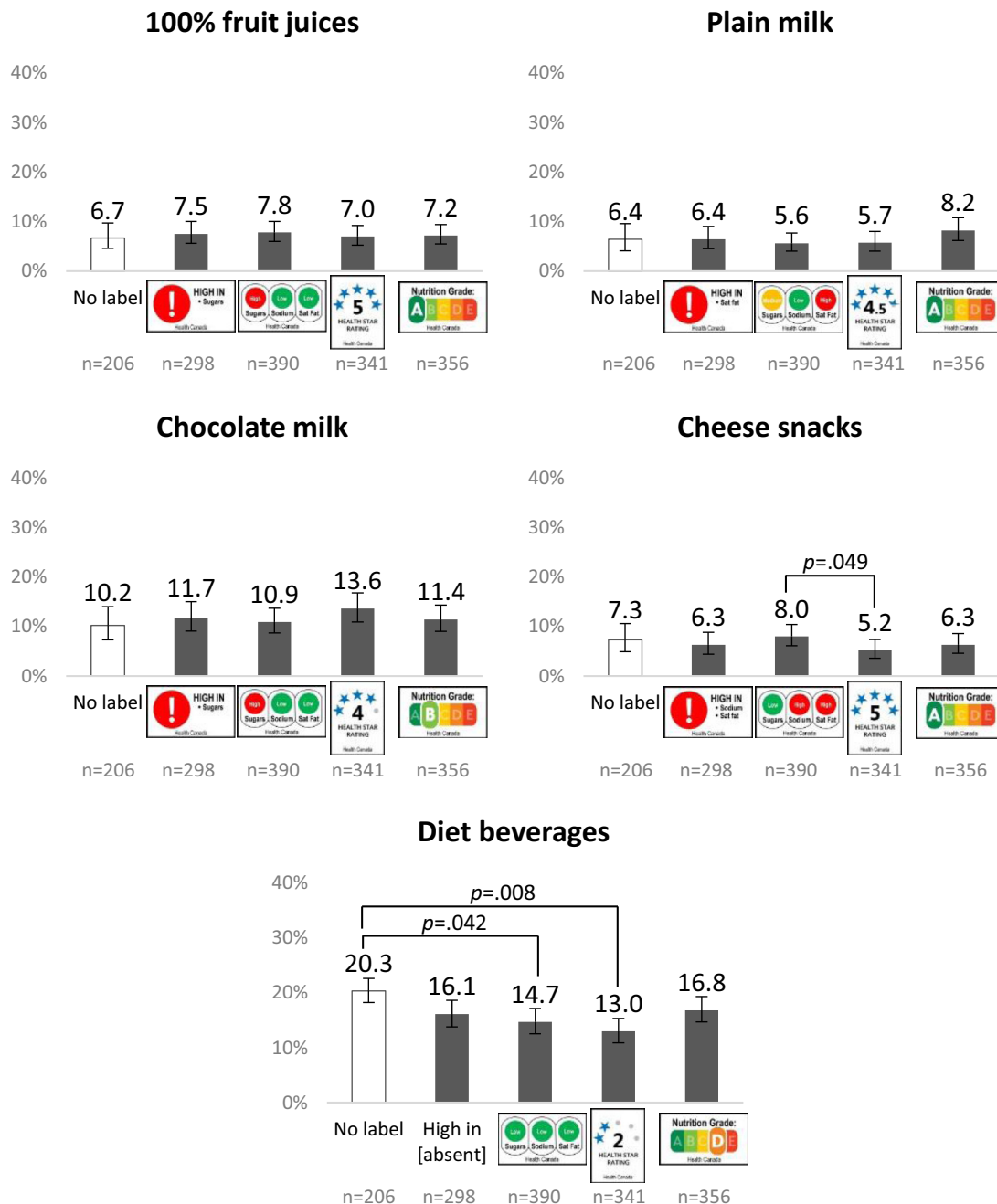


Figure 7. Estimated means for the percentage of participants who did not notice front-of-package (FOP) nutrition labels ($n = 1,591$) and who purchased a 100% fruit juice, 2% milk fat plain milk, 1% milk fat chocolate milk, cheese snack, or diet beverage product in an experimental marketplace, by FOP labeling condition. Significant differences are indicated with brackets. Error bars represent 95% CIs. Products with conflicting ratings across labeling systems were selected for the focus of this analysis. Purchasing patterns for other beverage and snack products included in the experimental marketplace are available in Table 2 (available at: www.jandonline.org).