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Impact of sugar taxes and front-of-package nutrition labels on purchases of protein, calcium and fibre

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ABSTRACT

Taxes and front-of-package (FOP) labels can be effective interventions for reducing consumption of sugar, saturated fat, and sodium; however, few studies have examined their impact on intake of 'positive' nutrients. The current study explored the impact of sugar taxes and FOP labels on the protein, calcium and fibre density of snack food purchases. A total of 3584 Canadians aged 13 years and older participated in an experimental marketplace using a 3 × 8 between-within group experiment. Participants received $5 and viewed images of 20 snack food products available for purchase. Participants were randomized to one of five FOP label conditions (*no label*, *high in*, *multiple traffic light*, *health star rating*, or *nutrition grade*) and completed three within-subject purchasing tasks with different sugar tax conditions (*no tax*, *20%*, *tiered*). Upon conclusion, participants received the product and any change from one of the purchasing tasks. The results indicate that participants purchased snack foods with higher fibre density when either sugar tax was applied (+0.1 g/100 kcal) compared to no tax, and when they were assigned to see the *multiple traffic light* (+0.4 g/100 kcal) or *health star rating* (+0.3 g/100 kcal) FOP labels, compared to no FOP label. There were no significant differences in the protein or calcium density of snack foods purchased across the tax or FOP labelling conditions. Overall, the findings suggest that as consumers respond to tax or labelling policies by moving away from sugars, sodium, and saturated fat, there may be no downside—or even an increase—in 'positive' nutrient density.

1. Introduction

The burden from diet-related non-communicable diseases continues to grow worldwide (GBD 2017 DALYs and HALE Collaborators HH et al., 2018; GBD 2017 Causes of Death Collaborators GA et al., 2018). As a result, a number of population-level strategies to improve diets have been proposed, including health-oriented taxes and enhanced front-of-package (FOP) nutrition labelling (World Cancer Research Fund International, 2018a).

Health-oriented taxes have been implemented in various formats around the globe, including taxes on foods high in saturated fats or sodium (Smed et al., 2016; WHO EURO, 2015), caffeinated energy drinks (WHO EURO, 2015; World Cancer Research Fund International, 2016), or sugar-sweetened beverages (SSBs) (Hagenaars et al., 2017). Currently, taxes on SSBs are the most common application of health-oriented food or beverage taxes, but there is also growing interest in taxes on sugary or energy-dense snack foods (World Cancer Research Fund International, 2016; Hagenaars et al., 2017; Scheelbeek et al., 2019; Jensen and Smed, 2017). Among the studies that have explored sugar taxes, most focus on changes in consumption of SSBs, sugars, or calories (Niebylski et al., 2015; Afshin et al., 2017; Redondo et al., 2018). While some studies have explored the potential impacts of SSB taxes on other outcomes (such as protein, fat, sodium, or fruit and vegetable intake), these data come from simulation modelling studies, which make predictions based on assumed effect sizes rather than directly testing changes in behaviour (Cobiac et al., 2017; Ford et al., 2017; Zhen et al., 2014; Caro et al., 2017; Harding and Lovenheim, 2017; Finkelstein et al., 2013). Few studies have used experimental methods to investigate the effects of sugar taxes on consumption of other key nutrients, whether positive (e.g., protein, calcium, fibre) or negative (e.g., sodium, saturated fats) (Acton et al., 2019).

FOP nutrition labels have also been implemented in various countries (World Cancer Research Fund International, 2018b). FOP labels aim to supplement traditional back-of-package nutrition information by providing simple, interpretive information on the front of packages that allows consumers to more easily evaluate and compare the nutritional

Abbreviations: %DV, percent daily value; BMI, body mass index; CEGEP, collège d'enseignement général et professionnel (general and vocational college); CI, confidence interval; FOP, front-of-package; MTL, multiple traffic light; NFt, Nutrition Facts table; RDI, recommended daily intake; SSB, sugar-sweetened beverage

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content of products (Kanter et al., 2018). Countries have implemented FOP labelling strategies in a variety of formats, most of which can be categorized as either ‘nutrient-specific’ or ‘summary indicator’ systems (Kanter et al., 2018; Institute of Medicine, 2010). While nutrient-specific FOP systems present information about a product's key nutrients (positive, negative, or both), summary indicator labels use a rating or symbol to summarize the overall nutrient profile of the product (Institute of Medicine, 2010). Examples of nutrient-specific systems include the United Kingdom's voluntary traffic light labels, which use a tri-colour system to indicate high, medium, or low levels of select negative nutrients (UK Department of Health, 2016), as well as Chile's mandatory octagonal ‘high in’ labels that are required on products containing high levels of sugars, sodium, saturated fats, or calories (Center for Science in the Public Interest, 2015). In recent years, countries such as Brazil and Canada have followed the lead of Chile, with similar regulations either proposed or set to be implemented soon (Health Canada, 2016; Culliney, 2018). Whether displayed in the form of a traffic light or a ‘high in’ symbol, nutrient-specific systems usually aim to reduce purchasing and consumption of key ‘negative’ nutrients that are associated with an increased risk of non-communicable disease. Examples of summary indicator labels include Australia and New Zealand's Health Star Rating (Australian Government Department of Health and Ageing, 2016) and France's five-colour Nutri-Score system (World Health Organization, 2017), both of which use unique algorithms to assign ratings based on a product's positive and negative nutritional attributes. While the Health Star Rating assigns ‘health stars’ ranging from 0.5 (least healthful) to 5 (most healthful), the Nutri-Score system assigns colour-coded letter ratings ranging from A (dark green, most healthful) to E (dark orange, least healthful). In contrast to nutrient-specific labels, summary rating systems often aim to improve the overall healthfulness of consumers' purchases, rather than targeting specific nutrients.

Recent research suggests that ‘high in’ FOP labels, such as those proposed in Canada, may be more effective than other label formats in discouraging intake of specific nutrients of public health concern, such as sugar, saturated fat and sodium (Acton et al., 2019; Acton and Hammond, 2018; Khandpur et al., 2018; Machín et al., 2018). However, these labels have also been criticized because they focus exclusively on ‘negative’ nutrients. For example, representatives of the food industry have argued that the ‘high in’ labels proposed in Canada may lead consumers to reduce their intake of foods that provide positive nutrients (Bonnett and Grayson, 2017; Dairy Farmers of Canada, 2018). Alternatively, summary indicator FOP systems that account for both positive and negative nutrients, such as the Health Star Rating or Nutri-Score systems, may be more effective in promoting greater consumption of positive nutrients such as fibre and protein. Studies examining different FOP systems have largely reported on outcomes related to the nutrients presented in the FOP label of interest (Khandpur et al., 2018; Machín et al., 2018; Hersey et al., 2013; Hawley et al., 2013). Little research to date has experimentally tested the effects of nutrient-specific labels on consumption of other positive nutrients, particularly in comparison with other widely-used summary FOP systems.

A previous study led by this research team used an experimental marketplace in Canada to assess and compare the impacts of prominent sugar taxes and FOP labelling systems on the sugars, sodium and saturated fat content of consumers' beverage and snack food purchases (Acton et al., 2019). Results suggested that ‘high in’ nutrient symbols were the most effective FOP label at reducing the sugars, sodium and saturated fat content of participants' purchases, and that all of the sugar taxes tested led to meaningful reductions in sugars and calories purchased. Given the shortage of data examining positive nutrient outcomes in the tax and FOP labelling literature, the authors were motivated to explore the positive nutrient content of participants' purchases from the same experimental marketplace.

The current paper assesses the impacts of sugar taxes and FOP labelling systems on the protein, calcium, and fibre density of individuals' snack food purchases within the abovementioned experimental marketplace. Canada is an ideal setting for this study given that national mandatory FOP regulations are currently under development (Health Canada, 2018), and a federal sugar tax has been considered (Heart and Stroke, 2018; Diabetes Canada, 2016).

2. Methods

2.1. Study design

The current study followed an experimental marketplace design. In an experimental marketplace, participants are provided with a prespecified sum of money and presented with multiple products available for purchase. After selecting a product, participants receive the remainder of the money that they did not spend, along with the product that they purchased. The format of an experimental marketplace provides the opportunity to manipulate price and other variables of interest to assess their influence on consumers' purchases, and the exchange of real products and money is intended to generate more realistic product selections (Epstein et al., 2015; Collins et al., 2014). Complete details of the study procedures are published elsewhere (Acton et al., 2019).

2.2. Study protocol

2.2.1. Participants and recruitment

The study was conducted from March to May 2018. Ethical approval was granted by the Office of Research Ethics at the University of Waterloo (ORE #22494). Participants aged 13 years and older were recruited using convenience sampling from large shopping centres in three cities (Toronto, Kitchener, Waterloo) in Ontario, Canada. Research assistants recruited potential participants from booths in high-traffic areas in the shopping centres. All interested participants were required to provide their age prior to giving written informed consent and beginning the study. Additional written informed consent from a parent or guardian was required for all participants under 16 years; if a parent or guardian was not present, the shopper was not permitted to participate.

2.2.2. Purchasing tasks

Experimental purchasing tasks were completed in a 5 (FOP label condition) × 3 (tax condition) between-within group format. The experimental marketplace included purchasing tasks for both beverages and snack foods; however, the current analysis only included the food tasks, given that the beverages contained trivial levels of protein, calcium and fibre.

Participants were randomly assigned to one of five FOP label conditions, within which they completed three consecutive purchasing tasks that each corresponded to a different tax condition. In each purchasing task, participants were shown a selection of 20 different snack food products on a large laminated print-out, which imitated the appearance of grocery or convenience store shelves (Fig. 1). The 20 products were selected to imitate a usual array of snack food items available at a typical Canadian convenience store. Full nutritional information for each product is provided in Supplementary Table 1. A different print-out was shown for each purchasing task to reflect the appropriate label and tax condition for that purchase, and the order of the tax conditions was randomized for each participant. For each task, participants made their selection on an iPad after viewing the large shelf image. Upon survey completion, the survey program randomly selected one of the participants' purchasing tasks. Research assistants gave participants their actual food or beverage product selected in that task, as well as their corresponding change from the $5.00. Participants did not know which purchase selection (and associated change) they would receive until the end of the experiment and were instructed to

Fig. 1. Example product shelf image, showing foods with *high in* FOP labels and *20%* sugar tax.

treat all eight tasks as real purchases.

Research assistants were instructed to not engage in discussion or answer questions about nutrition, diet or food policies. Participants were given clear instructions on the procedure and outcomes of the purchasing tasks, including that the prices may change between purchases; however, research assistants did not highlight the presence of the taxes or FOP labels in any other way.

2.2.3. Experimental conditions

Five FOP label conditions were tested (Fig. 2): *no label* (control); a *high in* labelling system; a multiple traffic light system (*MTL*); a *health star rating* label; and a five-colour *nutrition grade* label.

The *high in* labelling system was modelled after an early design proposed by Health Canada for labelling products high in sugars, sodium and saturated fats (Health Canada, 2018). For these labels, only the nutrient(s) present in high amounts are listed, and the thresholds defining 'high' nutrient levels used in this study were based on Health Canada's proposed guidelines (Health Canada, 2018). If a product's levels of sugars, sodium and saturated fats fell below the thresholds, no label was displayed. The *MTL* labels were loosely modelled after the MTL system introduced in the UK (UK Department of Health, 2016); however, to preserve comparability with the *high in* labels, *MTL* labels were only displayed for sugars, sodium and saturated fats. The *health star rating* label was designed with inspiration from the Australasian Health Star Rating system, and star ratings for products were calculated following the same guidelines (Australian Government Department of Health and Ageing, 2016). Lastly, the *nutrition grade* label was designed to imitate the French NutriScore system (World Health Organization, 2017). *Nutrition grade* scores were assigned to match those of the *health star ratings* for the purposes of this study (i.e., 0.5 to 1 stars = 'E' nutrition grade; 1.5 to 2 stars = 'D'; 2.5 to 3 stars = 'C'; 3.5 to 4 stars = 'B'; 4.5 to 5 stars = 'A'). Most real-world labelling systems do not apply FOP labels to fresh fruits or vegetables (Commonwealth of Australia, 2017; Department of Health, Food Standards Agency, Welsh Government, Food Standards Scotland, 2016; Food and Agriculture Organization of the United Nations, Pan American Health Organization WHO, 2017); therefore, the 'apple' and 'carrot' products in this study did not receive FOP labels under any of the experimental conditions.

The study tested three food-based sugar tax conditions: *no tax* (control), a 20% *ad valorem* tax on high-sugar foods (*20%*), and a tiered specific tax on high-sugar foods (*tiered*). The *20%* tax was assigned to all foods containing > 10 g of total sugars per 100 g. The *tiered* tax, inspired by the tiered SSB tax structure implemented in the UK (UK HM Treasury, 2016), applied a 10% price increase to foods containing 10 to 20 g of total sugars per 100 g, and a 20% price increase to foods containing > 20 g of total sugars per 100 g.

The FOP labels and prices assigned to each of the 20 products are provided in Supplementary Tables 2 and 3.

2.2.4. Sociodemographic measures

Following the purchasing tasks, participants self-reported their age, sex, ethnicity, education, income adequacy ("Thinking about your total

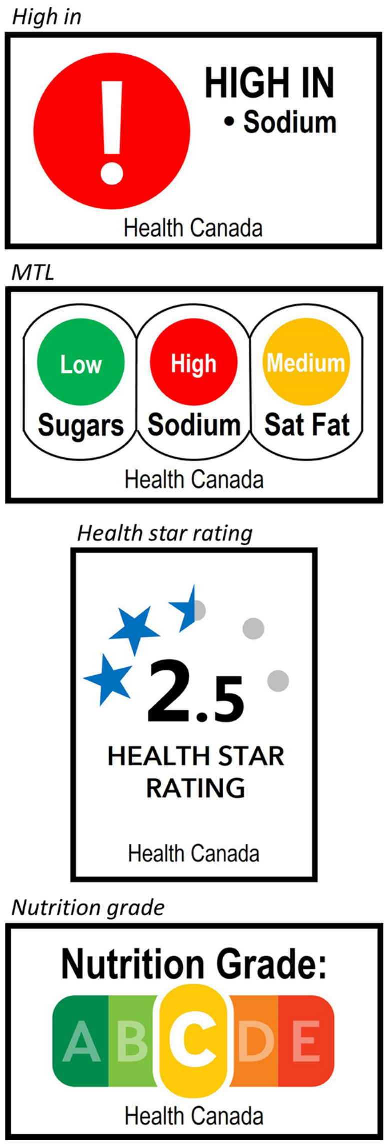

Fig. 2. Images of label conditions, excluding No label (control), as they would appear on the 'salt and vinegar potato chips' product. From top to bottom: High in, MTL, Health star rating, and Nutrition grade.

monthly income, how difficult or easy is it for you to make ends meet?"), and height and weight. Self-reported height and weight were used to calculated body mass index (BMI), which was categorized into "underweight", "normal weight", "overweight" and "obesity" according to World Health Organization (WHO) thresholds (World Health Organization, n.d.-a). BMIs for participants 19 years of age or younger were calculated using growth charts as recommended by the US Centers for Disease Control and Prevention and WHO guidelines (Centers for Disease Control and Prevention, n.d.; World Health Organization, n.d.-b).

2.3. Data analyses

Three primary outcomes were explored: protein density (g/100 kcal), calcium density (mg/100 kcal), and fibre density (g/100 kcal) of snack food items selected for purchase. Nutrient density values reflect the ratio of the nutrient content to the energy content of a food, and provide a more meaningful interpretation of a food's nutrient content than absolute grams or milligrams. Absolute protein and fibre values (in grams) were taken directly from each product's Nutrition

Table 1
Protein, calcium and fibre content and density values for all snack food products included in the experimental purchasing tasks.

Product	Flavour/variety	Serving volume (g)	Calories (kcal)	Protein (g)	Protein density (g/100 kcal)	Calcium (mg)	Calcium density (mg/100 kcal)	Fibre (g)	Fibre density (g/100 kcal)
Potato chips	Lay's Salt & Vinegar	60	320	3	0.9	26	8.3	1	0.3
Potato chips	Lay's Oven Baked Original	32	150	2	1.3	0	0.0	2	1.3
Popcorn	Smartfood White Cheddar	45	250	5	2.0	110	44.0	3	1.2
Popcorn	Skinny Pop	18	100	2	2.0	0	0.0	2	2.0
Crackers/snack	Garden Veggie Straws	28	130	1	0.8	0	0.0	0	0.0
Crackers/snack	Cheddar Goldfish	28	130	3	2.3	44	33.8	1	0.8
Candy gummies	Maynards Gummy Bears	60	200	3	1.5	0	0.0	0	0.0
Chocolate bar	Snickers	47	220	4	1.8	44	20.0	1	0.5
Granola/cereal bar	Quaker Chewy Yogurt Bars	35	150	2	1.3	110	73.3	1	0.7
Power/energy bar	Clif Energy Bar Chocolate Chip	68	250	10	4.0	294	117.6	4	1.6
Cookies	Mrs. Fields	60	270	3	1.1	44	16.3	1	0.4
Nuts	Planters Salted Peanuts	60	390	15	3.8	22	5.6	4	1.0
Nuts	Blue Diamond Salted Almonds	23	140	5	3.6	66	47.1	2	1.4
Fresh fruit	Apple	150	80	0.4	0.5	0	0.0	4	5.0
Fresh vegetable	Baby Carrots Snack Pack	65	25	1	4.0	22	88.0	2	8.0
Yogurt	Beatrice Strawberry Fruit Bottom	175	170	6	3.5	220	129.4	0	0.0
Yogurt	Iögo Fat Free Berry	100	35	3	8.6	110	314.3	0	0.0
Cheese snack	Marbelicious Cheestrings	21	60	6	10.0	110	183.3	0	0.0
Cheese snack	Mini-Babybel, Light	20	45	5	11.1	165	366.7	0	0.0
Meat snack	Schneiders Hot Rods	19	105	4	3.8	11	10.5	0	0.0

Facts table (NFt) (Government of Canada, 2019). Calcium values were calculated using the percent daily value (%DV) reported in the NFt and converted to milligrams based on Canada's Recommended Daily Intake (RDI) value for calcium at the time of the data collection (Canadian Food Inspection Agency, 2017). For the current study, the absolute nutrient amount values were converted to 'nutrient densities' by dividing the amount of protein, calcium or fibre by the amount of calories per container, and multiplying by a factor of 100. Nutrient content and density values for all snack food products are provided in Table 1.

Chi square tests were used to test for sociodemographic differences between the FOP label experimental conditions. Three repeated-measures ANOVAs (to account for the repeated nature of the purchasing tasks) were run to investigate the effects of labelling and tax on the protein density, calcium density, and fibre density of participants' purchases in the snack food tasks. Each ANOVA included a *tax condition* × *label condition* interaction to assess potential interaction effects between sugar taxes and FOP labelling. In the case that an ANOVA violated the assumption of sphericity (Mauchly, 1940), Greenhouse-Geisser corrections (Greenhouse and Geisser, 1959) were applied to the results. All statistical analyses were conducted using SPSS software (version 25.0; IBM Corp., Armonk, NY; 2017). The significance threshold was set at 0.05 for all tests, with no adjustments for multiple comparisons.

3. Results

Sample characteristics are reported in Table 2. Chi square tests revealed no significant differences in sociodemographic variables between the FOP label experimental conditions (Table 2).

Table 2
Sociodemographic characteristics of sample and test results for differences across experimental conditions (n = 3584).

Characteristic	%	Test for differences
Recruitment city		$\chi^2 = 5.7$ ($p = 0.68$)
Kitchener	17.5	
Toronto	41.2	
Waterloo	41.4	
Age (years)		$\chi^2 = 25.8$ ($p = 0.06$)
13–18	15.3	
19–25	31.0	
26–35	20.6	
36–45	11.9	
> 45	21.3	
Gender		$\chi^2 = 0.8$ ($p = 0.94$)
Male	44.0	
Female	56.0	
Ethnicity		$\chi^2 = 7.3$ ($p = 0.84$)
White	44.9	
Other/mixed	50.3	
Indigenous	3.3	
Not stated	1.6	
Education		$\chi^2 = 1.9$ ($p = 0.99$)
High school or less	26.6	
CEGEP/trade school/college (partial or complete)	11.7	
University (partial or complete)	61.7	
Income adequacy		$\chi^2 = 8.2$ ($p = 0.42$)
'Very difficult' or 'difficult'	19.5	
'Neither easy nor difficult'	41.4	
'Easy' or 'very easy'	39.1	
BMI classification		$\chi^2 = 12.3$ ($p = 0.73$)
Underweight	3.3	
Normal weight	46.0	
Overweight	22.8	
Obesity	12.1	
Not reported	15.8	

CEGEP, Collège d'enseignement général et professionnel (general and vocational college); BMI, body mass index.

3.1. Snack food purchases

Mean protein, calcium, and fibre density values of the products purchased in the snack food tasks are presented in Fig. 3. Repeated-measures ANOVA results are presented in Table 3, including pairwise comparisons between all tax and labelling conditions. There were no significant two-way interactions between tax and labelling condition for any of the three outcomes.

3.1.1. Taxes

There were no differences in the protein density or calcium density of the snack foods that participants purchased across the three tax conditions. However, participants purchased products with higher fibre density in both tax conditions (*20%* and *tiered*) compared to when no sugar tax was present (Table 3).

3.1.2. FOP labelling

No differences were observed in the protein density or calcium density of snack foods purchased across the five FOP label conditions. Participants assigned to the *MTL* or the *health star rating* label conditions purchased products with higher fibre density compared to those in the *no label* control condition (Table 3). Those assigned to the *MTL* also purchased products with greater fibre density than who saw the *high in* or *nutrition grade* label conditions.

4. Discussion

Food industry and other groups have raised concerns that nutrition policies exclusively targeting negative nutrients—such as sugar taxes or some FOP nutrition labels—may have detrimental impacts on positive nutrient intake. In contrast to these concerns, the current study suggests that sugar taxes and FOP nutrition labels do not have a negative impact on the positive nutrient density of consumers' purchases, and in some cases, may improve it.

In this study, neither a *20%* nor a *tiered* sugar tax produced any differences in the protein or calcium density of consumers' snack food selections. Further, both tax formats led consumers to purchase snack foods with up to 6% higher fibre density (+0.1 g/100 kcal) compared to when no tax was applied, suggesting that sugar taxes do not have a negative impact on nutrient density and indeed may improve it.

The FOP nutrition labels tested in this study showed a similar pattern of results to the taxes. Of particular interest, the nutrient-specific FOP labels that exclusively target sugar, sodium and saturated fat (*high in* and *MTL*) had no detrimental effects on positive nutrient density; in fact, the *MTL* system resulted in participants purchasing snack foods with 25% higher fibre density (+0.4 g/100 kcal) relative to no FOP labels. These results may be explained by the fact that the snack food products containing particularly high levels of nutrients of concern (i.e., displaying more than one 'red' traffic light) also had low fibre densities (0.4 g/100 kcal on average). By discouraging participants' purchases of products with high sugars, sodium or saturated fats, the *MTL* labels at the same time shifted participants towards products with higher fibre densities. The summary FOP labels that account for positive nutrients in their labelling systems (*health star rating* and *nutrition grade*) also led to no reductions in positive nutrient density. While the *health star rating* improved fibre density relative to no FOP label (+17%, +0.3 g/100 kcal), it performed no better than the *high in* or *MTL* formats despite its broader nutrient focus. While it is encouraging that none of the FOP labels in this study reduced the protein, calcium or fibre density of participants' purchases, the minimal improvements in positive nutrient density may suggest deficiencies in the *health star rating* and *nutrition grade*'s abilities to promote purchasing of nutrient-dense products, at least in the limited context of this study.

It is important to note that although the changes in fibre density observed may appear small, the magnitude of these effects are likely to be meaningful when extrapolated to the larger population and over

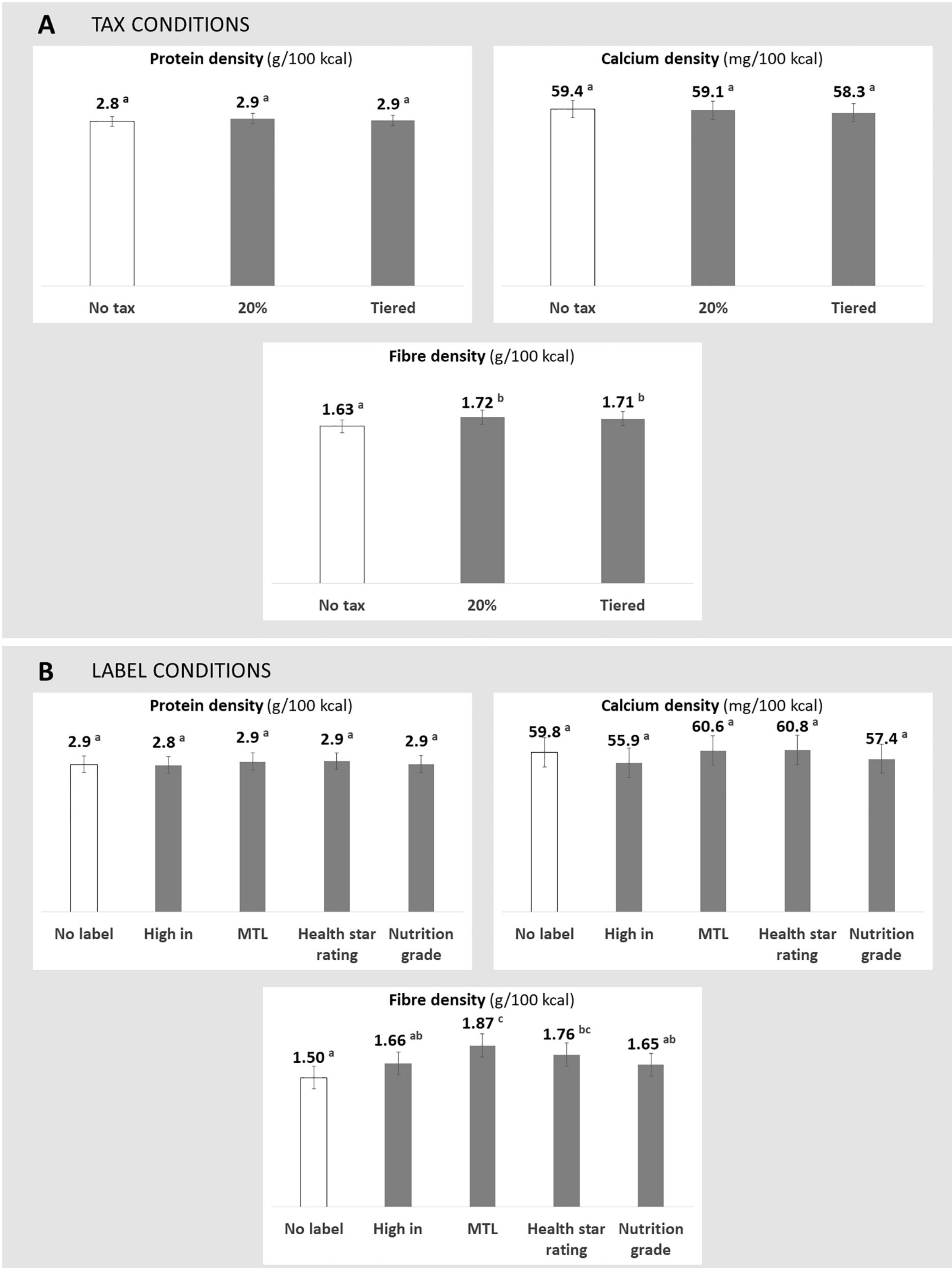

Fig. 3. Protein, calcium and fibre densities of foods purchased within an experimental marketplace in which (A) tax conditions and (B) FOP label conditions varied (n = 3584). Error bars represent 95% confidence intervals for the mean estimates. a, b, c Values with differing superscript letters indicate tests for which $p < 0.05$ in a repeated-measures ANOVA.

Table 3
Repeated-measures ANOVA results for protein, calcium and fibre densities of foods purchased within an experimental marketplace with varied tax and FOP label conditions (n = 3584).

	Protein density			Calcium density			Fibre density		
Main effects model statistics									
Tax condition		*F* (2, 7141) = 0.57;	*p* = 0.57		*F* (2, 7143) = 0.28;	*p* = 0.75		*F* (2, 7158) = 4.47;	***p* = 0.01**
Label condition		*F* (4, 3579) = 0.18;	*p* = 0.95		*F* (4, 3579) = 1.69;	*p* = 0.67		*F* (4, 3579) = 4.24;	***p* = 0.002**
Tax condition × label condition		*F* (8, 7141) = 0.29;	*p* = 0.97		*F* (8, 7143) = 0.26;	*p* = 0.98		*F* (8, 7158) = 0.31;	*p* = 0.96
Pairwise comparisons: Tax conditions	g/100 kcal	*Mean difference* (95% CI)	*p* value	mg/100 kcal	*Mean difference* (95% CI)	*p* value	g/100 kcal	*Mean difference* (95% CI)	*p* value
No tax–20%	−0.05	(−0.14, 0.04)	0.28	0.35	(−2.67, 3.37)	0.82	−0.09	(−0.16, −0.03)	**0.007**
No tax–tiered	−0.02	(−0.11, 0.07)	0.70	1.15	(−1.88, 4.17)	0.46	−0.08	(−0.15, −0.02)	**0.01**
20%–tiered	0.03	(−0.06, 0.12)	0.51	0.79	(−2.33, 3.92)	0.62	0.01	(−0.06, 0.08)	0.77
Pairwise comparisons: Label conditions	g/100 kcal	*Mean difference* (95% CI)	*p* value	mg/100 kcal	*Mean difference* (95% CI)	*p* value	g/100 kcal	*Mean difference* (95% CI)	*p* value
No label–high in	0.02	(−0.21, 0.25)	0.85	3.91	(−3.81, 11.64)	0.32	−0.16	(−0.35, 0.02)	0.09
No label–MTL	−0.06	(−0.29, 0.18)	0.64	−0.77	(−8.51, 6.97)	0.85	−0.38	(−0.56, −0.19)	**< 0.001**
No label–health star rating	−0.06	(−0.29, 0.17)	0.61	−0.96	(−8.67, 6.76)	0.81	−0.27	(−0.45, −0.08)	**0.006**
No label–nutrition grade	−0.01	(−0.24, 0.22)	0.93	2.40	(−5.32, 10.12)	0.54	−0.15	(−0.34, 0.04)	0.12
High in–MTL	−0.08	(−0.31, 0.16)	0.51	−4.68	(−12.45, 3.09)	0.24	−0.21	(−0.40, −0.02)	**0.03**
High in–health star rating	−0.08	(−0.31, 0.15)	0.49	−4.87	(−12.61, 2.88)	0.22	−0.10	(−0.29, 0.09)	0.30
High in–nutrition grade	−0.03	(−0.26, 0.20)	0.79	−1.51	(−9.26, 6.24)	0.70	0.01	(−0.18, 0.20)	0.89
MTL–health star rating	−0.01	(−0.24, 0.23)	0.97	−0.19	(−7.94, 7.57)	0.96	0.11	(−0.08, 0.30)	0.25
MTL–nutrition grade	0.05	(−0.19, 0.28)	0.70	3.17	(−4.59, 10.93)	0.42	0.22	(0.04, 0.41)	**0.02**
Health star rating–nutrition grade	0.05	(−0.18, 0.28)	0.67	3.36	(−4.38, 11.09)	0.40	0.11	(−0.07, 0.30)	0.23

95% CI = 95% confidence interval; MTL = multiple traffic light.
Bold text indicates significant results at a level of $p < 0.05$.

time. A crude calculation tells us that if an individual consuming 2000 kcal per day increased their fibre intake by 0.1 to 0.4 g/100 kcal consistently, they would consume an additional 2 to 8 g of fibre per day. Given that most Canadians only consume about half the recommended 25 to 38 g of fibre daily (Government of Canada, n.d.), an increase of even 2 g may be impactful, particularly at a population level.

The current findings should be interpreted in the context of previous research, including results from the same experimental marketplace, which suggest that sugar taxes are effective at reducing purchased sugars (up to 19% less), calories (up to 18% less), and even sodium and saturated fat (up to 9% less) (Acton et al., 2019). The same study also found the *high in* labels to be superior at reducing negative nutrients relative to other label formats: participants viewing the *high in* labels purchased beverages with less sugar (−11%), saturated fat (−18%), and calories (−12%), and snack foods with less sodium (−8%) and calories (−5%) compared to those who saw no FOP label (Acton et al., 2019). Taken together, results from these two studies suggest less benefit from the summary indicator FOP systems, which appear to be less effective at reducing intake of negative nutrients, and no better than nutrient-specific labels at improving positive nutrient density in snack food purchases. Given that the health burden from dietary intake is largely driven by excess consumption of negative nutrients (Health Canada, 2019), the current results suggest that policymakers may reasonably prioritize strategies that target sugars, sodium and saturated fat, without concern that the policies will reduce the positive nutrient density of consumers' diets.

Correlations between the nutrient densities across the foods in this study should be noted. Importantly, the correlation coefficient of the protein density and calcium density for the snack products in this study is 0.9; therefore, the similar results found for these two nutrients in this study are unsurprising. On the other hand, there is little correlation between the 'positive' (protein, calcium, fibre) and 'negative' (sugars, sodium, saturated fats) nutrients contained in the snack foods, suggesting that the questions investigated in this study provide a unique and important perspective in addition to the previous analyses.

The current study is subject to several limitations. The study used non-systematic convenience sampling; therefore, the sample may not accurately reflect the characteristics of the larger Canadian population. However, the sample provided a large age range and good variability across sociodemographic characteristics. A separate study by the authors exploring differences in the tax and label effects by individual-level characteristics identified few moderating effects of participant characteristics on negative nutrients purchased (manuscript under review). The study's experimental marketplace design used real products and money to replicate authentic purchasing behaviours as closely as possible; however, the simulated purchasing tasks may not represent how consumers interact with price and labels in real world settings and using their own money. The study also included a limited selection of 'snack' foods. In real-world scenarios, individuals' dietary intake is derived from a range of foods much larger than those presented in this study, including many other nutrient-dense options. Future research should assess the impact of these policy strategies on overall diet quality using a more comprehensive selection of food and beverage products. Strengths of the study include the high internal validity of an experimental design, combined with the behavioural outcomes and real monetary consequences of actual purchase tasks.

5. Conclusions

The results of this study provide a more comprehensive view into how sugar taxes and FOP nutrition labels may impact dietary intake, and suggest that these policies may lead to purchases of snack foods with higher fibre, but similar protein and calcium densities. These results should also be considered in conjunction with previous work, which has demonstrated the potential for these policies to significantly reduce consumption of sugars, sodium, saturated fat and calories. At the same time as these strategies help to reduce intake of negative nutrients, they may also promote foods with greater nutrient density. It would appear that the FOP labels that are most effective in reducing negative nutrients may be at least equally effective at promoting foods with greater nutrient density as those that provide summary indicators of overall nutrient content.

CRediT author contribution statement

Rachel B Acton: Conceptualization, Project administration, Investigation, Methodology, Data curation, Formal analysis, Writing – original draft, Visualization. David Hammond: Conceptualization, Funding acquisition, Resources, Writing – review & editing, Supervision.

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Declaration of competing 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. All remaining authors declare that they have no competing interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ypmed.2020.106091.

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