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# Experimental study of front-of-package nutrition labels' efficacy on perceived healthfulness of sugar-sweetened beverages among youth in six countries

Karen Hock [a], Rachel B. Acton [a], Alejandra Jáuregui [b], Lana Vanderlee [c], Christine M. White [a], David Hammond [a,*]

[a] School of Public Health Sciences, University of Waterloo, Waterloo, ON N2L 3G1, Canada
[b] Centre for Health and Nutrition Research, National Institute of Public Health, Cuernavaca, MOR 62100, Mexico
[c] School of Nutrition, Université Laval, Quebec, QC G1V 0A6, Canada

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ABSTRACT

Front-of-package (FOP) nutrition labels have been proposed as a strategy to help limit sugar-sweetened beverage (SSB) consumption among youth. However, few studies have examined the efficacy of FOP labels in youth across different countries. A between-group experiment was conducted to examine the impact of FOP labels (no-label control, Health Star Rating, 'High in' Octagon, Guideline Daily Amount (GDA), Traffic Light, or Nutri-Score) on perceived healthfulness of an SSB. The study was conducted online in November-December 2019 with 10,762 children aged 10–17 from six countries: Australia, Canada, Chile, Mexico, the United Kingdom, and the United States. A binary logistic regression model tested the impacts of FOP label condition, country, and sociodemographic characteristics on participants' likelihood of perceiving the SSB to be Unhealthy. Compared to the control condition, participants in each of the five FOP label conditions were significantly more likely to perceive the SSB as Unhealthy ($p < 0.002$). The 'High in' Octagon label had the greatest impact on perceived healthfulness across five out of six countries, whereas the GDA and Nutri-Score labels demonstrated the lowest impact across all six countries. The impact of FOP labels was consistent across sex, age, race/ethnicity, and perceived income adequacy. FOP labels can significantly reduce the perceived healthfulness of SSBs among youth across multiple countries. The current study adds to the evidence that 'high in' labels, which use intuitive symbols such as the octagon 'stop sign', are the most efficacious labels for helping consumers identify foods high in nutrients of concern, including SSBs.

## 1. Introduction

Sugar-sweetened beverage (SSB) consumption among youth is a growing public health concern worldwide (Scharf and DeBoer, 2016). High intake of SSBs, including soda and other beverages with added sugar (von Philipsborn et al., 2019), is associated with an increased risk of adverse health outcomes in youth, including obesity (Keller and Torre, 2015; Ambrosini et al., 2014) and hypertension (Farhangi et al., 2020). SSBs are a primary source of added sugar among youth across many countries (Rosinger et al., 2017; Langlois et al., 2019; Tedstone et al., 2015; Rana et al., 2021). As the World Health Organization (WHO) recommends limiting total daily sugar intake to under 10% of calories consumed (World Health Organization, 2015), there is increasing interest in identifying public health measures that reduce SSB consumption among youth.

Front-of-pack (FOP) nutrition labels have been proposed to help limit consumption of products high in sugars, sodium or saturated fats, including SSBs (World Cancer Research Fund International, 2019). FOP labels appear on fronts of packages (increasing noticeability) and often feature simple and interpretive information, including symbols or

*Abbreviations:* FOP, Front-of-package; GDA, Guideline Daily Amount; HSR, Health Star Rating; IFPS, International Food Policy Study; NFT, Nutrition facts table; SSB, Sugar-sweetened beverage; UK, United Kingdom; US, United States; WHO, World Health Organization.

* Corresponding author at: 200 University Avenue West, School of Public Health, Faculty of Health, University of Waterloo, Waterloo, ON N2L 3G1, Canada.
*E-mail addresses:* k2hock@uwaterloo.ca (K. Hock), rachel.acton@uwaterloo.ca (R.B. Acton), alejandra.jauregui@insp.mx (A. Jáuregui), lana.vanderlee@fsaa.ulaval.ca (L. Vanderlee), c5white@uwaterloo.ca (C.M. White), david.hammond@uwaterloo.ca (D. Hammond).

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images (Van and Dagevos, 2015). Countries worldwide have implemented different FOP policies, resulting in many label messages, shapes and colours (Kanter et al., 2018). Mandatory 'high in' FOP labels, which often use octagon or 'stop sign' symbols and text to indicate high nutrient levels, have been implemented in multiple countries, most notably Chile and Mexico (Kanter et al., 2018; White et al., 2020). Health Star Ratings (HSRs) voluntarily implemented in Australia and New Zealand provide overall healthfulness ratings of 0.5–5 stars, while Nutri-Score, developed in France and voluntarily implemented across many European countries, uses a five-coloured scale of letters A to E to indicate most to least healthfulness (Kanter et al., 2018). Similarly, voluntary Traffic Lights in the United Kingdom (UK) use red, yellow and green colouring to indicate 'high', 'medium' and 'low' nutrient levels. Products in many countries also feature voluntary, industry-based Guideline Daily Amount (GDA) labels, which convey quantitative nutrient amounts (Kanter et al., 2018). Mexico implemented mandatory FOP GDA labels until 2020, when they were replaced with 'high in' FOP labels (Nacional, 2016).

Interpretative information on FOP labels may be easier to understand than quantitative nutrient information in GDA-based labels or nutrition facts tables (NFTs), which are required on sides or backs of packages in many countries and used less frequently by individuals of low socioeconomic status and education (Campos et al., 2011). A 2017 study among Mexican and United States (US) participants indicated that understanding and use of GDA labels was similar to that of NFTs, while 'high in' labels were associated with greater understanding than NFTs (Nieto et al., 2019).

A recent scoping review of experimental studies found FOP nutrient warnings helped consumers identify products high in nutrients of concern and discouraged their purchases (Taillie et al., 2020); however, less evidence exists on the most effective FOP label format, especially among youth. The majority of FOP labelling studies have involved adults (Grummon et al., 2020), although a considerable proportion of young people use nutrition labels (Haidar et al., 2017; Hobin et al., 2015; Hobin et al., 2016), and evidence suggests children have an important influence on food behaviour within families (Correa et al., 2019). FOP labels using familiar symbols, including octagon 'stop signs', may be especially easy for youth to comprehend given their simple, interpretative design. One study involving youth aged 13–24 reported 'high in' octagonal labels decreased preference for SSBs (Bollard et al., 2016).

Further, few studies have examined whether FOP label impacts vary across countries. One study reported that five FOP labels (HSR, Traffic Lights, Nutri-Score, reference intakes and warning label) significantly increased healthier food selections among adults across 12 countries, with Nutri-Score and Traffic Light labels producing greater impacts overall; a similar pattern was observed across countries (Talati et al., 2019).

The present study examined impacts of five FOP labels on perceived healthfulness of SSBs in youth across six countries. The study had three primary hypotheses: 1) GDA-based labels would be least effective at communicating healthfulness compared to the control (no label), given lower comprehension for quantitative-based information; 2) FOP labels with more intuitive information (e.g., 'high in' labels) would be most effective at communicating healthfulness compared to the control; and 3) similar patterns of findings would occur within countries, except for FOP formats already implemented in participants' country (e.g., higher efficacy of HSRs among Australians). The study also explored differences in perceived SSB healthfulness across sociodemographic groups.

## 2. Materials and methods

### 2.1. Participants

Data were collected as part of the International Food Policy Study (IFPS) Youth Survey, a cross-sectional survey of youth aged 10–17 ($n$ = 11,108) from six countries (Australia, Canada, Chile, Mexico, the UK, and the US), who completed an online questionnaire in November-December 2019. Youth were recruited through parents/guardians enrolled in the Nielsen Consumer Insights Global Panel and their partners' panels. Parents/guardians with a potentially eligible child were informed about the study, and provided consent for their child's participation. Only one child per household was invited. Children were subsequently screened to confirm eligibility, given study information, and provided assent before questionnaire commencement. The target sample size in Canada (3,500) was higher than other countries to provide greater power for subnational tests between provinces unrelated to the current analysis. A total of 750,034 email invitations were sent to a random sample of adult panelists across countries. The American Association for Public Opinion Research cooperation rate #1 was 76.8%, calculated as the percentage of participants who completed the survey (11,108) out of those eligible who accessed the survey link (14,457) (American Association for Public Opinion Research, 2016).

Surveys were conducted in the primary language(s) spoken in each country. The child's parent/guardian received compensation according to their panel's usual incentive structure (e.g., points-based rewards). The study was reviewed by and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE# 41477). A full description of study methodology is available in the 2019 Youth IFPS Technical Report (http://www.foodpolicystudy.com/methods).

### 2.2. Experimental protocol

A between-group experiment examined FOP labels' impact on perceived healthfulness of a fruit drink. Participants were randomly assigned to view an image of a fruit drink displaying one of six FOP label conditions: no FOP label (control), HSR, 'High in' Octagon, GDA, Traffic Light, or Nutri-Score (see Fig. 1). Assigned images were displayed on screen while participants were asked whether they perceived the drink as healthy or unhealthy (see below). The drink was modelled after packaging of a real sweetened 'fruit punch' that would be classified as an SSB (Centers for Disease Control and Prevention, 2021). The product's packaging referenced "made with real fruit", leaving it ambiguous whether the product constituted 100% fruit juice or a sweetened fruit drink. The package was digitally altered to display a fictional brand name to minimize pre-existing associations with particular brands, and text and units of measure were translated for each country. Product images were otherwise identical in all countries. Participants were not shown an NFT for the product.

### 2.3. Measures

Perceived healthfulness was evaluated with the question *"In your opinion, is this product…"*, with response options *"Very unhealthy*," "*Unhealthy*," "*In the middle*," "*Healthy*," or "*Very healthy*," as well as "*Don't know*" and "*Refuse to answer*". Because the WHO and national public health authorities categorize fruit drinks as SSBs and recommend limiting SSB consumption (World Health Organization, 2015), responses were dichotomized as Unhealthy ("*Unhealthy*" and "*Very Unhealthy*"; defined as the correct response) vs. Other ("*In the middle*," "*Healthy,*" and "*Very healthy*").

Sociodemographic characteristics included age (10–13 years, 14–17 years), sex (male, female), ethnicity (majority, minority/unstated), and perceived income adequacy.

### 2.4. Statistical analysis

A total of 11,108 youth completed the survey across the six countries. Participants with missing data and those responding "*Don't know*" or "*Refuse to answer*" for the primary outcome or perceived income adequacy were removed from analyses. A small number of participants experiencing a technical glitch in the experiment (shown more than one condition) were also excluded, resulting in 346 excluded participants in


**Fig. 1.** Experimental conditions displaying different front-of-package labelling conditions on the sugar-sweetened beverage.

total. A final sample of 10,762 (Australia: 1,386; Canada: 3,575; Chile: 1,204; Mexico: 1,576; UK: 1,461; and US: 1,560) participants were included in analyses.

Chi-square tests evaluated potential differences in sociodemographic profiles across experimental conditions and descriptive tests were conducted, stratified by country. A binary logistic regression model examined impacts of FOP labelling condition on the odds of perceiving the SSB as Unhealthy. The model was adjusted for country, age, sex, ethnicity, and perceived income adequacy. Additional binary logistic regression models evaluated the same outcome, stratified by country. Sensitivity analyses explored whether results differed when perceived healthfulness was analyzed as a continuous outcome variable (1="*Very unhealthy*," 2="*Unhealthy*," 3="*In the middle*," 4="*Healthy*," 5="*Very healthy*"). The $p$ value threshold for significance was set to 0.05 for all tests. Analyses were conducted using SAS v9.4 (SAS Institute Inc., North Carolina).

## 3. Results

Table 1 shows characteristics of the total sample and subsamples across countries. Chi-square tests showed randomization successfully created comparable groups for all measures except age ($p = 0.03$).

### 3.1. Perceived healthfulness

Figure 2 shows the percentage of participants reporting the SSB was Unhealthy by label condition, stratified by country. Percentages of responses across healthfulness ratings are presented in Table S1. Label condition significantly impacted participants' perceived healthfulness of the SSB among the entire sample ($X^2[5] = 341.8$, $p < 0.0001$).

Table 2 presents results from the binary logistic regression model for perceived healthfulness across label conditions, countries, and sociodemographic groups. Complete pairwise comparisons between label conditions and countries are provided in Table S2. Across all countries, participants in each of the five FOP label conditions were significantly

**Table 1**
Sociodemographic characteristics among the overall sample and across countries (N = 10,762).

| | **Overall** (N = 10,762) % (N) | **Australia** (n = 1,386) % (n) | **Canada** (n = 3,575) % (n) | **Chile** (n = 1,204) % (n) | **Mexico** (n = 1,576) % (n) | **UK** (n = 1,461) % (n) | **US** (n = 1,560) % (n) |
|---|---|---|---|---|---|---|---|
| **Age** | | | | | | | |
| 10–13 y | 52.0 (5,602) | 54.0 (748) | 51.2 (1,829) | 53.0 (638) | 52.9 (833) | 52.2 (762) | 50.8 (792) |
| 14–17 y | 48.0 (5,160) | 46.0 (638) | 48.8 (1,746) | 47.0 (566) | 47.1 (743) | 47.8 (699) | 49.2 (768) |
| **Sex** | | | | | | | |
| Male | 52.4 (5,637) | 54.6 (757) | 52.2 (1,866) | 52.6 (633) | 56.5 (890) | 49.2 (719) | 49.5 (772) |
| Female | 47.6 (5,125) | 45.4 (629) | 47.8 (1,709) | 47.4 (571) | 43.5 (686) | 50.8 (742) | 50.5 (788) |
| **Ethnicity** | | | | | | | |
| Majority | 79.0 (8,506) | 83.0 (1,150) | 74.8 (2,673) | 86.4 (1,040) | 83.8 (1,321) | 89.1 (1,302) | 65.4 (1,020) |
| Minority/Unstated | 21.0 (2,256) | 17.0 (236) | 25.2 (902) | 13.6 (164) | 16.2 (255) | 10.9 (159) | 34.6 (540) |
| **Perceived Income Adequacy**[a] | | | | | | | |
| Not enough money | 4.2 (452) | 5.3 (74) | 3.0 (106) | 5.6 (67) | 3.3 (52) | 5.1 (74) | 5.1 (79) |
| Barely enough money | 20.3 (2,188) | 20.4 (283) | 14.4 (515) | 24.1 (290) | 24.4 (384) | 22.7 (332) | 24.6 (384) |
| Enough money | 62.0 (6,673) | 62.2 (862) | 62.1 (2,219) | 65.8 (792) | 66.2 (1,043) | 62.1 (907) | 54.5 (850) |
| More than enough money | 13.5 (1,449) | 12.1 (167) | 20.6 (735) | 4.6 (55) | 6.2 (97) | 10.1 (148) | 15.8 (247) |

[a] Perceived income adequacy was assessed with the question "*Does your family have enough money to pay for things your family needs?*", with response options "*Not enough money*," "*Barely enough money*," "*Enough money*," "*More than enough money*," "*Don't know*," and "*Refuse to answer*".

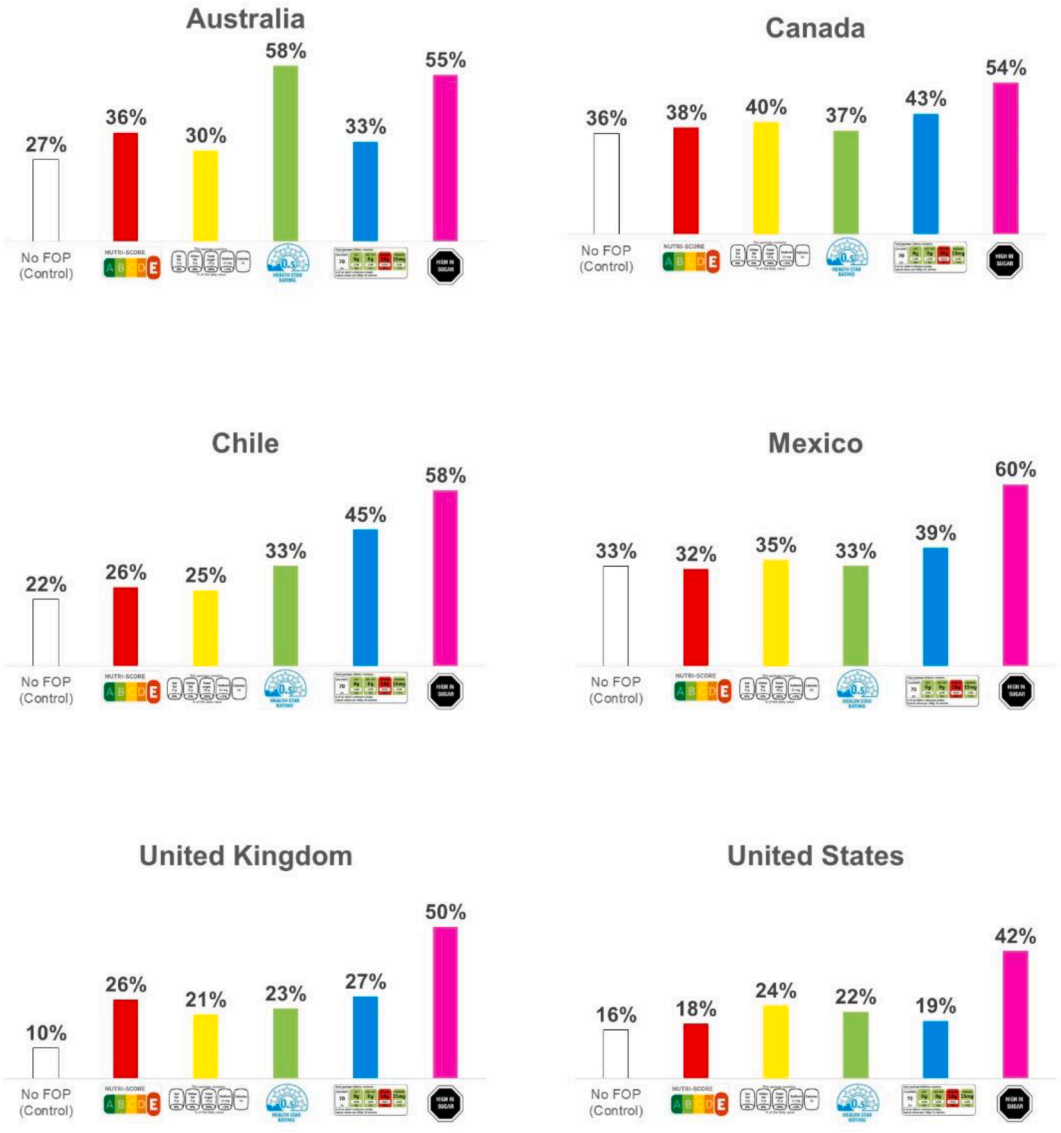


**Fig. 2.** Youth perceptions of the SSB as Unhealthy by front-of-package labelling condition and country (N = 10,762).

**Table 2**
Odds of youth perceiving a sugar-sweetened beverage as Unhealthy vs. Other (binary logistic regression; N = 10,762).

| | Odds of perceiving an SSB as Unhealthy (vs. Other) | |
|---|---|---|
| | OR (95% CI) | *p* level |
| **Label Condition**[b] | | |
| Control | Ref | – |
| Nutri-score | 1.26 (1.09–1.46) | 0.002 |
| GDA | 1.32 (1.14–1.53) | <0.001 |
| Health Star Rating | 1.50 (1.30–1.74) | <0.001 |
| Traffic Light | 1.57 (1.36–1.81) | <0.001 |
| 'High in' Octagon | 3.33 (2.89–3.84) | <0.001 |
| **Country**[b] | | |
| US | Ref | – |
| UK | 1.15 (0.97–1.37) | 0.103 |
| Chile | 1.81 (1.53–2.15) | <0.001 |
| Mexico | 2.18 (1.86–2.56) | <0.001 |
| Australia | 2.25 (1.91–2.65) | <0.001 |
| Canada | 2.35 (2.05–2.70) | <0.001 |
| **Age** | | |
| 10–13 y | Ref | – |
| 14–17 y | 1.26 (1.16–1.36) | <0.001 |
| **Sex** | | |
| Male | Ref | – |
| Female | 1.22 (1.13–1.33) | <0.001 |
| **Ethnicity** | | |
| Majority | Ref | – |
| Minority/Unstated | 0.93 (0.84–1.03) | 0.174 |
| **Perceived Income Adequacy** | | |
| Barely enough money | Ref | – |
| Not enough money | 1.19 (0.96–1.47) | 0.120 |
| Enough money | 0.97 (0.88–1.08) | 0.610 |
| More than enough money | 1.19 (1.03–1.37) | 0.021 |

CI, Confidence Interval; GDA, Guideline Daily Amount; OR, Odds Ratio; UK, United Kingdom; US, United States.
[b] All pairwise contrasts shown in Table S1.

more likely to perceive the SSB as Unhealthy compared to the control (no label) condition ($p \leq 0.002$). The 'High in' Octagon led to higher odds of perceiving the SSB as Unhealthy compared to the other four FOP label conditions ($p < 0.001$). Additionally, participants in the Traffic Light condition were more likely to perceive the SSB as Unhealthy compared to those in the GDA or Nutri-Score condition ($p \leq 0.015$), while those in the HSR condition were more likely to perceive the SSB as Unhealthy compared to those in the Nutri-Score condition ($p \leq 0.015$).

Significant differences in perceived healthfulness were observed between countries ($p \leq 0.024$). Participants in Australia, Canada, Chile, and Mexico were more likely to perceive the SSB as Unhealthy compared to those in the US or UK ($p < 0.001$). Participants in Chile were less likely to perceive the SSB as Unhealthy compared to those in Australia, Canada or Mexico ($p \leq 0.024$).

Perceived healthfulness also differed by age group, sex, and perceived income adequacy (response percentages across label condition, country, and sociodemographic group are presented in Table S3). Female participants and youth aged 14–17 were more likely than male participants and youth aged 10–13 to perceive the SSB as Unhealthy, respectively ($p < 0.001$). Additionally, participants who reported having "*More than enough money*" were more likely than those reporting "*Barely enough money*" to perceive the SSB as Unhealthy ($p = 0.021$). In contrast, ethnicity was not associated with significant differences in perceived healthfulness. In a sensitivity analysis exploring perceived healthfulness as a linear outcome variable, the overall pattern of results did not differ substantially (Table S4 reports results from the linear model).

### 3.2. Country-specific models

Table S5 reports results from models stratified by country. As shown in Table S5, the 'High in' Octagon condition led to higher odds of perceiving the SSB as Unhealthy compared to every other label condition in all countries ($p < 0.005$), except Australia. In Australia, the 'High in' Octagon and HSR conditions both led to higher odds of perceiving the SSB as Unhealthy compared to the control, Nutri-Score, and GDA, and Traffic Light conditions ($p < 0.0001$). Additionally, compared to the control condition, higher odds of perceiving the SSB as Unhealthy were observed in the Nutri-Score condition in Australia ($p = 0.042$); the Nutri-Score, Traffic Light, GDA, and HSR conditions in the UK ($p < 0.001$); the GDA condition in the US ($p = 0.022$); and the HSR condition in Chile ($p = 0.009$). The Traffic Light condition led to higher odds of perceiving the SSB as Unhealthy compared to the control, Nutri-Score, HSR, and GDA conditions in Chile ($p < 0.027$), as well as the control and HSR conditions in Canada ($p < 0.029$).

## 4. Discussion

This study examined impacts of five FOP labels on perceived healthfulness of an SSB among youth in six countries. Overall, each FOP label impacted perceived SSB healthfulness, although efficacy varied substantially across formats. Contrasting hypothesis 1, GDA labels were least effective at communicating healthfulness compared to the control in only three countries (Australia, Chile, and the UK). In line with hypothesis 2, 'High in' Octagon labels had the greatest impact across all countries, except in Australia, where they were among the most effective labels (along with the HSR). In line with hypothesis 3, the patterns of findings were largely similar across countries; however, higher efficacies of already implemented label formats were only observed for HSRs among Australians and 'High In' labels among Chileans.

The magnitude of the 'High in' Octagon labels' impact was substantial: about twice as many participants exposed to these labels correctly identified the SSB as Unhealthy compared to the control across all countries, while the magnitude in the UK was approximately five times greater. 'High in' Octagon labels may have been more easily understood by youth given their use of a simple, recognizable symbol. This finding is consistent with focus groups and surveys conducted to develop Chile's FOP label system, where the 'high in' label was associated with the greatest level of understanding among low-middle income women and youth (Reyes et al., 2019). Research in other countries, including Brazil and Uruguay, also suggests that 'high in' labels may be more effective in mediating perceived healthfulness than GDA and Traffic Light labels (Arrúa et al., 2017; Khandpur et al., 2018). Similarly, studies conducted after 'high in' FOP labels were implemented in Chile indicate positive impacts (Quintiliano Scarpelli Dourado et al., 2021; Taillie et al., 2020). In a survey involving Chilean families with children < 14 years, 'high in' FOP labels led nearly half of participants to report they stopped purchasing certain foods (Quintiliano Scarpelli Dourado et al., 2021). An analysis of household food expenditures estimated that purchases of 'high in' beverages decreased by nearly 24% after implementation of Chile's 'high in' label; however, this effect cannot be attributed to FOP labels alone, as the FOP label policy was implemented alongside other measures, including marketing restrictions and school sales bans (Taillie et al., 2020).

Results from this study suggest FOP labels' impact may be influenced by consumer familiarity (Taillie et al., 2020). Although the current study did not test respondents' familiarity with the FOP labels, it may be assumed that youth living in countries with a FOP labelling system are more likely to be familiar with that labelling system than youth in other countries. As hypothesized, the HSR had among the greatest efficacies in Australia, likely due to participant familiarity, as the system had been implemented since 2014 (Australian Government, 2020); outside of Australia, HSRs had similar efficacy to Traffic Light, Nutri-Score, and GDA labels. In contrast, there was little evidence that Traffic Light and GDA labels had greater efficacy among UK and Mexican youth relative to other FOP formats, respectively, despite their presence on products in each country. Notably, while HSRs outperformed most other FOP label

formats in Australia, the 'High in' Octagon label had similar efficacy levels, despite being novel to Australians. Likewise, the 'High in' Octagon label outperformed FOP label formats implemented in Mexico and the UK. Thus, 'high in' FOP labels appear intuitive, with high comprehension levels even in the absence of prior exposure or public education campaigns.

Although GDA and Nutri-Score labels led more participants to perceive the SSB as Unhealthy compared to the control, they had the least impact compared to other FOP labels across countries. The lower efficacy for GDA labels is consistent with previous research, including an experimental study that reported Brazilian children aged 9–12 were more likely to rate processed foods and beverages with GDA labels as healthier than children in Traffic Light and 'high in' label conditions (Lima et al., 2017). Notably, GDA labels were no more effective than the control in Mexico, despite their presence on packaged foods since 2015. These findings align with evidence from Mexico's National Health and Nutrition Survey, indicating GDA labels were ineffective (and thus were recently replaced with 'high in' labels) (Tolentino-Mayo et al., 2018). Previous studies evaluating Nutri-Score labels have generally produced positive findings among European adults, but to a somewhat lesser extent in other countries (Temple, 2019; Andreeva et al., 2021). The authors are unaware of studies evaluating Nutri-Score's impact among children or youth. Additionally, similar to the current findings, an experimental study found a hexagonal 'high in' label significantly reduced Uruguayan children's selection of orange juice as their preferred product (Arrúa et al., 2017), while Traffic Light labels had limited effects on product choice (Arrúa et al., 2017; Ares et al., 2016).

This study also demonstrated differences in perceived healthfulness across countries and sociodemographic groups. US and UK youth overall were substantially less likely to identify the SSB as Unhealthy relative to participants in other countries. Differences across sociodemographic groups were more modest, with female and older participants (14–17 years) more likely to perceive the SSB as Unhealthy. These results are unsurprising, as older youth are likely more educated about SSBs, and females historically report greater attention to nutrition and health than males (Wardle et al., 2004). Healthfulness perceptions across income adequacies in this study were less consistent, and there were no notable differences across ethnicities. These results highlight FOP labels' potential to improve diet quality among youth of varying sociodemographic conditions across countries.

The findings reinforce the need for FOP labels to help youth identify SSBs as less healthy beverages, as only 10–36% of those in the no-label control condition across countries perceived the SSB as Unhealthy. Despite national dietary guidelines discouraging SSB consumption, approximately one-third of youth in the no-label control condition perceived the SSB as "*Healthy*" or "*Very healthy*" (Australian Government National Health and Medical Research Council, 2015; Health Canada, 2019; de Salud, 2016). This relatively high perception of SSB healthfulness might have resulted in part from the use of a fruit drink, as fruit juices have been considered by youth as healthier alternatives to other beverages (Battram et al., 2016; Brownbill et al., 2020) and fruit drinks may feature potentially misleading nutrition claims (Duffy et al., 2021). Thus, strategies are needed to educate youth on potential health impacts of SSB consumption, particularly regarding fruit drinks, which may in turn help decrease their intake.

### 4.1. Study limitations and strengths

The current study represents one of the largest evaluations of FOP labels among youth to date. The cross-country comparisons and between-group experimental design are notable strengths. However, some limitations should be noted. First, participants were recruited using nonprobability-based sampling; therefore, findings may not be nationally representative. However, the sample included varied perceived income adequacies and a relatively wide age range. Second, the primary outcome (perceived healthfulness) was dichotomized into Unhealthy versus Other from its original 5-level format; however, sensitivity analysis indicated the same pattern of findings with a continuous outcome in a linear model, demonstrating that findings across FOP label conditions are robust to outcome classification. Third, the study had limited power to detect significant differences within countries. Despite this limitation, significant contrasts were observed when the data were stratified by country. Fourth, the study did not examine potential impacts of other label features, including cartoons or marketing tactics, nor how participants' nutrition knowledge and attitudes towards SSBs impacted perceived healthfulness, which should be evaluated in future research. As the effect of FOP labels may also differ based on product category and brand (Lim et al., 2020), future research should include a variety of food and drink products to further strengthen the overall understanding of FOP labels and generalizability of findings.

Finally, this study evaluated perceived healthfulness of an SSB; however, behavioural endpoints (such as food purchase and intake) must be significantly impacted by FOP labels for public health outcomes to be improved (Taillie et al., 2020). A majority of research on FOP labels to date has focused on consumer healthfulness perceptions or purchase intentions (Taillie et al., 2020), with meta-analyses determining that FOP labels significantly reduce healthfulness perceptions of SSBs, as well as purchase or consumption intentions of food and drinks (Grummon et al., 2020; Clarke et al., 2020). However, as a majority of these studies have been conducted online, findings may not be generalized to real-world settings (Grummon et al., 2020; Clarke et al., 2020). While perceived healthfulness has been observed as a mediating factor in the association between FOP labels and purchase intentions (Temmerman et al., 2021), future studies should directly evaluate their impact on actual behavioural responses (Taillie et al., 2020). Among the few studies that have evaluated behavioural outcomes associated with FOP labels, results are generally consistent with the findings of the current study in highlighting the effectiveness of simple dissuasive labels, such as the 'high in' label (Machín et al., 2019; Acton et al., 2019; Lima et al., 2019). Additionally, because determining actual behavioural outcomes is challenging in an online environment (Taillie et al., 2020), future research should be conducted in real-world settings, such as grocery stores or cafeterias (Grummon et al., 2020).

## 5. Conclusion

FOP labels significantly impact perceived healthfulness of SSBs among youth across countries. Although all FOP formats had greater efficacy than the no-label control, the current study adds to the growing evidence that 'high in' labels, which use intuitive symbols such as octagonal 'stop signs', are the most effective format for helping consumers identify foods high in nutrients of concern, including SSBs. The current study extends previous research by demonstrating the superiority of 'high in' FOP labels among youth across six countries with different nutrition labelling policies and food environments.

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## CRediT authorship contribution statement

**Karen Hock:** Formal analysis, Writing – original draft, Visualization. **Rachel B. Acton:** Formal analysis, Writing – review & editing, Visualization. **Alejandra Jáuregui:** Writing – review & editing. **Lana**

**Vanderlee:** Conceptualization, Methodology, Writing – review & editing. **Christine M. White:** Conceptualization, Methodology, Data curation, Writing – review & editing. **David Hammond:** Conceptualization, Methodology, Formal analysis, Writing – review & editing, Visualization, Supervision.

## Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

David Hammond has provided paid expert testimony on behalf of public health authorities in response to legal challenges from the food and beverage industry.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2021.101577.

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