Abbreviations:

FOPL, front-of-package label

NFL, nutrition facts label

GDA, guideline daily amount

HSR, Health Star Rating

IFPS, International Food Policy Study

1. INTRODUCTION

Nutrition labelling on foods and beverages is recognized as one potential strategy to improve healthy eating and reduce nutrition-related noncommunicable disease at a population level.[1] In particular, national governments are increasingly implementing standardized front-of-package label (FOPL) systems to communicate the healthfulness of pre-packaged foods to citizens.[2]

Government-endorsed FOPLs can be used to supplement existing mandatory nutrition facts labels (NFLs) that require high literacy levels to interpret[3] and to provide a trusted source of nutrition information amid the 'noise' of package-based marketing (including nutrition claims) used by food companies.[22] Traditionally, nutrition information on food labels in most countries is presented in government-mandated NFLs, typically located on the back or sides of packages.[1] Individuals report frequent use of NFLs, but demonstrate poor objective understanding of the complex information that they display.[3] Further, evidence suggests that the wide array of information that food and beverage companies present to shoppers on packages (such as nutrient content claims, health claims, and imagery of language used to suggest 'healthiness' or 'wellness') is difficult to navigate and can interfere with individuals' ability to assess the healthfulness of a product.[4,5] Interpretive FOPLs (i.e., those that interpret the nutrition information for the individual) have therefore been recommended as a strategy to provide clear nutrition information in a prominent location on food and beverage packages.[1]

A variety of FOPL systems have been implemented globally over the past decade, and more are under development or proposed in several countries.[6,7,8,9] The two main objectives of most FOPL systems to date are to help citizens identify healthier options by informing them of products' nutritional content, and to encourage product reformulation by the food and beverage industry; however, this article will focus on the former. To help individuals identify healthier options, FOPL systems communicate levels of specific nutrients and/or communicate the overall healthfulness of a product using a rating or scoring system.[10] Prominent examples of FOPL systems can be found in the United Kingdom (UK), Australia and New

Zealand, and Mexico, including both industry-developed Guideline Daily Amount (GDA) labels and governmental labelling schemes (see **Figure 1**). In 2013, the UK introduced a voluntary government-endorsed 'traffic light' label that uses a colour-coded system to communicate whether a product contains 'low' (green), 'medium' (amber), or 'high' (red) amounts of sugars, sodium, fats, saturated fats, and calories.[11] In contrast, Australia and New Zealand have used a government-endorsed voluntary Health Star Rating (HSR) FOPL system since 2014, which labels foods and beverages with a star rating (0.5 to 5 stars) based on the product's overall nutrient profile.[12] In 2014, Mexico introduced a mandatory FOPL system proposed by food industry displaying the percent GDAs of key nutrients on packaged products; however, this system was not interpretive (provided no interpretive attributes such as colours or ratings) and employed lenient and non-evidence based thresholds.[13,14] This GDA labelling regulation was replaced in October 2020 by a new mandatory warning FOPL—modelled after FOPLs pioneered in Chile[15]—that uses octagonal warnings to identify products with *exceso* ("high in") sugars, sodium, saturated fats, trans fats, and calories, based on a combination of pre-defined and newly developed nutrition thresholds.[16] Mexico's FOPL system also includes warning legends for added caffeine and non-sugar sweeteners which are not recommended for children,[17,18] numeric warnings for products in packages <40 cm^2, and updates to the mandatory NFL (displaying added sugars and trans fats amounts, and nutrition information per 100 grams or millilitres).[19,20] Similar warning FOPL regulations have recently been adopted elsewhere, including in Canada.[7] Although there is no government-endorsed FOPL system in place in the US, several companies voluntarily display GDA style information ("Facts up Front") on the front of packages for some products,[21] as is also the case in other countries such as Canada and the UK.

[Insert Figure 1]

The existing literature, consisting of both experimental and post-implementation studies, suggests that simple, interpretive FOPL systems are most likely to improve the healthfulness of purchasing and consumption behaviour. In experimental studies of FOPLs, interpretive systems (such as star ratings,

warning symbols, or traffic light systems) are more likely to be used and understood than reductive FOPLs that state nutrient information without any interpretation, such as GDA systems.[22] Evidence from experimental studies also suggests that nutrient-specific systems (e.g., Mexico's "high in" warning labels or the UK's traffic light labels) are more likely to reduce purchasing of nutrients-to-limit (e.g., sugars, sodium, saturated fat), whereas summary rating systems like Australia's HSR may be more effective at communicating the overall healthfulness of a product and helping individuals to compare similar products.[22,23,24,25,26]

Although the body of evidence evaluating the impacts of FOPL systems is growing, the vast majority of the evidence thus far is from experimental studies, with only a small number of post-implementation studies assessing the 'real world' impacts of nationally implemented FOPLs.[23] One such study from 2020 used sales data to compare food purchases in stores that had introduced UK's traffic light system versus stores that had not. The presence of the FOPLs was associated with an improvement in the overall nutritional quality of products purchased.[27] More recently, two studies evaluated beverage purchases and population perceptions, knowledge, and behaviours following implementation of Chile's Law of Food Labeling and Advertising, which includes octagonal warning FOPLs for packaged foods high in energy, sugars, saturated fats, and sodium. While one of these studies found significant reductions in purchases of beverages displaying a warning FOPL post-implementation, the effects of the FOPLs could not be distinguished from the effects of other components of the Law, such as marketing and school sales policies.[28] A second study evaluating the Chilean Law found that mothers of children 2-14 years were aware of the labels, but reported variable levels of use.[29] Lastly, a recent study assessing warning FOPLs in Uruguay observed high awareness and self-reported use of the labels in the first month after implementation.[30] Further post-implementation research is warranted to directly compare relative effectiveness of the many international FOPL systems and to complement the existing evidence from controlled experimental settings.

The current study aimed to: 1) assess the impact of the change in Mexico's FOPL policy from a GDA to a 'high in' warning system in 2020; 2) compare awareness, use and understanding of government-endorsed or mandated FOPLs in Mexico, Australia and the UK; 3) compare awareness, use and understanding for NFLs versus FOPLs; and 4) assess changes over time in awareness, use and understanding of NFLs and FOPLs (in countries where they are present). The study used a natural experimental design to examine changes in self-reported awareness, use, and understanding of NFLs and FOPLs among adults in Australia, Canada, Mexico, the UK, and the US. Annual repeat cross-sectional surveys were conducted in each country in 2018, 2019, and 2020, which captured responses before and after implementation of Mexico's new warning FOPL policy. Of the remaining four countries, two had no government-endorsed FOPL policy at the time of data collection (Canada and the US), and two had government-endorsed voluntary FOPL policies (Traffic Light FOPLs in the UK and HSR FOPLs in Australia) (see Figure 1). In addition to examining FOPLs, self-reported awareness, use and understanding of NFLs were also assessed in each country to directly compare them with similar metrics for FOPLs.

2. METHODS

Data were collected as part of the International Food Policy Study (IFPS), an annual repeat cross-sectional survey conducted in five countries: Australia, Canada, Mexico, the UK, and the US. Data were collected via self-completed web-based surveys conducted with adults aged 18-100, who were recruited through the Nielsen Consumer Insights Global Panel and their partners' panels. Email invitations with unique survey access links were sent to a random sample of panelists within each country after targeting for demographics. Panelists known to be ineligible were not invited. Potential respondents were screened for eligibility and quota requirements based on age and sex. Respondents provided consent prior to survey completion. The percentage of participants who completed the survey out of eligible participants who accessed the survey link (the American Association for Public Opinion Research cooperation rate #2) was 69.2% in 2018, 60.1% in 2019, and 62.1% in 2020.[31]

Data collection for the current study occurred in November and December of 2018, 2019 and 2020. Surveys were conducted in English in Australia and the UK, Spanish in Mexico, English or French in Canada, and English or Spanish in the US. Respondents received remuneration in accordance with their panel's usual incentive structure (e.g., points-based or monetary rewards, chances to win prizes). The study was reviewed by and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE# 30829). A full description of the study methodology has been published elsewhere.[32]

2.1 Measures

This study used self-reported measures of awareness, use and understanding, which are key mediators for assessing the impacts of FOPL policies on behaviour change at the population level.[33,34] The extent to which individuals see and attend to a label is the first and arguably most important requirement of an effective FOPL,[33,34,35] and comprehension or understanding of a label is a critical mediator on a label's uptake and use. Evidence from general product labelling and warning labels in other domains demonstrates that self-reported measures of awareness and use are associated with changes in knowledge and behaviour.[22,33,34,36,37] Similarly, self-reported FOPLs understanding is associated with objective measures of nutrition labelling comprehension.[38]

2.1.1 Self-reported awareness and use of nutrition labels

Separate questions were used to assess awareness and use of NFLs in all countries and FOPLs in the three countries in which government-supported FOPLs had been nationally implemented: Australia, the UK and Mexico. Respondents viewed an image of either a NFL or a FOPL from their respective country when responding to questions (see Figure 1 and **Supplementary Figure S1**). *Awareness* was assessed by asking: "How often have you seen this type of food label on packages or in stores?" with the response options on a 5-point scale of "Never / Rarely / Sometimes / Often / All the time". The same response categories were used for *use*, which was assessed by asking those who reported ever seeing the label, "How often do you use this type of food label when deciding to buy a food product?". Respondents who

reported they never saw the label were set to "Never" for the *use* question in this analysis. Both measures were adapted from a 2014 US FDA Health and Diet Survey.[39] Binary versions of the *Awareness* and *Use* variables were analyzed (0=never/rarely/sometimes, 1=often/all the time).

2.1.2 Self-reported understanding of nutrition labels

While viewing the relevant NFL label, participants were asked: "Do you find this information… very hard to understand / hard to understand / neither hard nor easy / easy to understand / very easy to understand?" Participants in Australia, the UK and Mexico were also shown an image of a FOPL from their respective countries (Figure 1) and asked to respond to the same measure of self-reported understanding. The 2020 data collection occurred in parallel with the transition from the GDA to Warning FOPL in Mexico, which was announced in March 2020 and implemented in October 2020.[40] The first warning labels began to appear on products in August, and food and beverage companies were allowed to use provisional stickers between October 2020 and March 2021 to help companies to gradually comply with the new regulation; therefore, both FOPLs were still in circulation during the IFPS 2020 data collection. Thus, respondents in Mexico were asked all three measures for both the GDA and Warning FOPLs (separately). Binary versions of the outcome variable were analyzed for *Label Understanding* (0=very hard/hard/neither, 1=easy/very easy).

2.1.3 Socio-demographic characteristics

Sociodemographic measures included age, sex at birth (male, female), ethnicity, and education. Ethnicity was assessed using country-specific race/ethnicity categories and analysed as a derived variable (majority/minority) to accommodate different measures across countries. Perceived income adequacy was assessed with the question "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).

2.2 Analysis

A total of 65,545 adults completed IFPS surveys across the five countries over the three annual surveys. Respondents were removed due to missing data on the outcome variables (n=99) with further respondents removed due to missing data on income adequacy, ethnicity or education, adding to a total of 1,513 (2.3%) excluded. The final analytic sample included 64,032 participants (2018=22,322; 2019=20,509; 2020=21,201). Post-stratification sample weights were constructed for each country separately based on known population totals by age, sex, region, ethnicity (except in Canada[1]) and education level (except in Mexico[2]). Weights were subsequently rescaled to each sample size.

Descriptive findings are reported for all outcomes, stratified by country. Separate logistic regression models were run using the SURVEYLOGISTIC procedure for each primary outcome: NFL awareness, use and understanding with data from all five countries; and FOPL awareness, use and understanding with data from the countries in which they had been implemented (Australia, the UK, and Mexico). Models were adjusted for age, sex at birth, race/ethnicity, education, and perceived income adequacy, and included indicator variables for country and survey year. Contrasts for all country and year comparisons were tested. A two-way interaction between year and country was added in a subsequent step to test differences between countries over time. Sensitivity analyses were also performed to test the original 5-item scales for awareness, use and understanding treated as continuous (1-5) rather than binary variables.

In the three countries that had implemented FOPL policies, repeated measures models were also conducted to directly compare NFL and FOPL awareness, use, and understanding. Models were stratified by country, only included 2020 data (the authors did not have specific research questions about the comparisons between NFLs versus FOPLs over time in the absence of policy changes), and adjusted for

[1] Ethnicity was not incorporated in the development of weights for Canada due to inconsistent collection methods and response options used in national surveys.
[2] Education was not incorporated in the development of weights for Mexico because the proportion of respondents with lower educational attainment in the survey sample was so much smaller than in population estimates from census data that weights could not be obtained.

the same sociodemographic correlates as described above. A generalized estimating equations model with an unstructured correlation was used to account for the correlation between outcomes for different labels from the same individual using the GENMOD procedure.

All analyses are weighted and 95% confidence intervals are reported for adjusted odds ratios (AOR). For simplicity, only model results where $p<0.05$ are described below. Analyses were conducted using SAS v9.4 (SAS Institute Inc., North Carolina).

3. RESULTS

3.1 Sample characteristics

Table 1 presents sociodemographic characteristics for the sample overall and by country. Mean age of the weighted samples ranged from 40.0 in Mexico to 48.1 in Canada. Approximately half of respondents in each country were female and most identified as a majority ethnicity. Compared to the other countries, the sample of respondents in Mexico consisted of a greater proportion of respondents reporting a 'high' level of education and a greater proportion reporting that it is 'very difficult' or 'difficult' to make ends meet.

[Insert Table 1]

3.2 Nutrition label awareness

3.2.1 NFLs awareness

Figure 2 shows the percentage of respondents who reported seeing NFLs and FOPLs 'often' or 'all the time' on packages or in stores. Across all three years, respondents in the UK were the least likely to report seeing NFLs (all comparisons $p<.001$), and respondents in Canada were most likely (all comparisons $p<.02$). US respondents were more likely to report seeing NFLs than respondents in Australia and Mexico (all comparisons $p<.001$) across all three years.

In Canada and the US, awareness of NFLs decreased from 2018 to 2019 (Canada: AOR=0.86, 0.75-0.99, p=.042; US: AOR=0.84, 0.74-0.97, p=.014) and from 2018 to 2020 (Canada: AOR=0.87, 0.75-1.00, p=.048; US: AOR=0.81, 0.70-0.92, p=.002). In Australia and the UK, awareness of NFLs increased from 2018 to 2019 (Australia: AOR=1.15, 1.02-1.30, p=.022; UK: AOR=1.20, 1.08-1.33, p<.001) and from 2018 to 2020 (Australia: AOR=1.12, 1.00-1.26, p=.045; UK: AOR=1.14, 1.03-1.25, p=.010). In Mexico, awareness of NFLs increased between 2018 and 2020 (AOR=1.24, 1.09-1.40, p<.001).

[Insert Figure 2]

3.2.2 FOPL awareness

Across all three years, respondents in Mexico were more likely to report seeing their country's FOPL (GDA) than respondents in Australia for the HSR (AOR=2.76, 2.57-2.95, p<.001) and respondents in the UK for the Traffic Light FOPL (AOR=1.27, 1.20-1.35, p<.001). Awareness of FOPLs was lower for the HSR FOPL in Australia compared to the Traffic Light FOPL in the UK (AOR=0.46, 0.43-0.48, p<.001).

In Australia, awareness of the HSR FOPL increased from 2018 to 2019 (AOR=1.25, 1.13-1.38, p<.001) and from 2018 to 2020 (AOR=1.27, 1.15-1.40, p<.001). In the UK, awareness of the Traffic Light FOPL increased between 2018 and 2020 (AOR=1.17, 1.06-1.29, p=.002). Awareness of Mexico's GDA FOPL increased from 2018 to 2020 (AOR=1.44, 1.27-1.63, p<.001) and from 2019 to 2020 (AOR=1.30, 1.15-1.47, p<.001), and was higher for the new Warning FOPL in 2020 than the GDA FOPL in 2018 (AOR=1.98, 1.73-2.25, p<.001) and 2019 (AOR=1.79, 1.57-2.03, p<.001). Results from *year x country* interactions indicate that the increase in awareness between the GDA FOPL in 2019 and the Warning FOPL in 2020 among Mexican respondents was greater than changes in awareness of FOPLs in Australia and the UK (p<.001 for all comparisons).

3.2.3 Comparisons between NFL & FOPL awareness

Results from repeated measures models indicate that in 2020, respondents in Australia were less likely to report seeing the HSR FOPL compared to NFLs (AOR=0.27, 0.25-0.29, p<.001). In contrast, UK respondents were more likely to see the Traffic Light FOPL than NFLs (AOR=1.18, 1.10-1.27, p<.001). In Mexico, respondents were more likely to report seeing the new Warning FOPL compared to both the NFL (AOR=1.23, 1.09-1.38, p<.001) and the GDA FOPL (AOR=1.36, 1.22-1.52, p<.001). Mexico respondents were less likely to report seeing the GDA FOPL compared to NFLs (AOR=0.90, 0.82-0.99, p=.026).

3.3 Use of nutrition labels

3.3.1 NFL use

Figure 3 shows the percentage of respondents who reported using NFLs and FOPLs 'often' or 'all the time' in deciding what to eat or buy. Across all three years, respondents in the UK were least likely to report using NFLs (p<.001 for all comparisons), and respondents in Mexico were less likely to report using NFLs than those in Canada, the US and Australia (p<.001 for all comparisons). Respondents in Australia were also less likely to report using NFLs than those in Canada and the US (p<.001 for both).

NFL use decreased from 2018 to 2020 in Canada (AOR=0.88, 0.80-0.98, p=.015) and between 2019 and 2020 in Australia (AOR=0.91, 0.82-1.00, p=.046). NFL use increased between 2018 and 2019 in the UK (AOR=1.11, 1.00-1.24, p=.045) and Mexico (AOR=1.12, 1.01-1.25, p=0.39). There were no changes in NFL use across the three years in the US.

[Insert Figure 3]

3.3.2 FOPL use

Across the three years, respondents in Australia were less likely to report using their country's FOPL than respondents in the UK for the Traffic Light FOPL and those in Mexico for the GDA FOPL (p<.001 for all

comparisons). FOPL use was higher for the Traffic Light FOPL in the UK than the GDA FOPL in Mexico (AOR=1.08, 1.01-1.16, p=.020).

In Australia, FOPL use increased between 2018 and 2019 (AOR=1.15, 1.02-1.29, p=.020) and between 2018 and 2020 (AOR=1.19, 1.06-1.33, p=.003). There were no differences in FOPL use across years in the UK. Use of Mexico's GDA FOPL increased between 2018 and 2020 (AOR=1.13, 1.01-1.27, p=.027), and use was higher for Mexico's new Warning FOPL in 2020 than for the GDA FOPL in 2018 (1.38, 1.24-1.54, p<.001) and 2019 (1.29, 1.16-1.44, p<.001). Results from *year x country* interactions indicate that the increase in use between the 2019 GDA FOPL and the 2020 new warning FOPL among Mexican respondents was greater than changes in use of FOPLs in Australia and the UK (p<.01 for all comparisons).

3.3.3 Comparisons between NFL & FOPL use

Results from repeated measures models indicate that in 2020, respondents in Australia were less likely to use the HSR FOPL compared to NFLs (AOR=0.47, 0.43-0.51, p<.001), while UK respondents were more likely to use the Traffic Light FOPL than NFLs (AOR=1.14, 1.07-1.22, p<.001). In Mexico, respondents were more likely to use the new Warning FOPL compared to NFLs (AOR=1.21, 1.12-1.31, p<.001) and the GDA FOPL (AOR=1.22, 1.12-1.32, p<.001), with no difference between the NFL and GDA FOPL.

3.4 Understanding nutrition labels

3.4.1 NFL understanding

Figure 4 shows the unadjusted percentages of respondents who reported that NFLs and FOPLs are 'easy' or 'very easy' to understand. Across the three years, respondents in the UK were least likely to report NFLs to be easy or very easy to understand compared to all other countries, while those in the US were most likely (p<.001 for all comparisons). Differences in NFL understanding were observed between all countries (p<.001 for all).

There were no changes in NFL understanding across the three years in Canada, the US or Australia. In the UK, NFL understanding increased between 2018 and 2020 (AOR=1.12, 1.02-1.23, p=.013). In Mexico, NFL understanding increased between 2018 and 2020 (AOR=1.15, 1.04-1.28, p=.008) and between 2019 and 2020 (AOR=1.13, 1.02-1.26, p=.023).

[Insert Figure 4]

3.4.2 FOPL understanding

Across the three years, respondents in Mexico were least likely to report that their country's FOPL (GDA) was easy or very easy to understand, compared to respondents in Australia for the HSR FOPL and in UK for the Traffic Light FOPL (p<.001 for all comparisons). There were no differences in FOPL understanding between Australia and the UK.

In Australia, self-reported FOPL understanding increased between 2018 and 2020 (AOR=1.11, 1.00-1.22, p=.045). In the UK, FOPL understanding increased between 2019 and 2020 (AOR=1.12, 1.01-1.24, p=.027). Understanding of Mexico's GDA FOPL increased between 2018 and 2020 (AOR=1.16, 1.04-1.29, p=.006) and between 2019 and 2020 (AOR=1.15, 1.03-1.28, p=.010), and understanding was substantially higher for the new Warning FOPL in Mexico in 2020 than the GDA FOPL in 2018 (AOR=4.23, 3.75-4.77, p<.001) and 2019 (AOR=4.19, 3.72-4.72, p<.001). Results from *year x country* interactions indicate that the increase in understanding for the new FOPL warning in Mexico was greater than changes in FOPL understanding in Australia and the UK (p<.001 for all).

3.4.3 Comparisons between NFL & FOPL understanding

Results from repeated measures models indicate that in 2020, respondents in Australia and the UK reported greater understanding of the HSR and Traffic Light FOPLs, respectively, compared to NFLs

(Australia: AOR=1.26, 1.17-1.36, p<.001; UK: AOR=1.61, 1.50-1.72, p<.001). In Mexico, respondents reported greater understanding of the new Warning FOPL compared to NFLs (AOR=3.37, 3.05-3.72, p<.001) and the GDA FOPL (AOR=3.61, 3.27-3.98, p<.001). Mexico respondents reported lower understanding of the GDA FOPL than for NFLs (AOR=0.93, 0.87-1.00, p=.045).

3.5 Sensitivity Analyses

Sensitivity analyses assessing the primary outcomes as continuous variables found the overall pattern of results to be the same as the original 5-item scales (see **Supplementary Tables S1-S3**).

4. DISCUSSION

This study provides evidence of adults' self-reported awareness, use and understanding of nutrition labels in five countries, including before and after implementation of Mexico's new warning FOPL system. In this study, Mexico's Warning FOPL was reported to be seen more, used more, and easier to understand than Mexico's previous GDA FOPL, Australia's HSRs, and the UK's traffic light labels. Within countries, FOPLs were reported to be more easily understood than traditional back-of-package NFLs, with the exception of the GDA FOPLs in Mexico.

Awareness of NFLs was relatively high in all countries, ranging from about two thirds in the UK to over 80% of respondents in Canada and the US reporting that they saw NFLs "often" or "all the time." These results are consistent with the long-standing use of NFLs in these countries,[41] and, given the reported value that people place on nutrition information,[42,43] reflects substantial societal benefits. Reported use and understanding of NFLs were also lowest in the UK compared to the other countries. It is unclear why NFL awareness, use and understanding were lowest among UK respondents; however, it may be that the quantitative information displayed in the UK's traffic light FOPLs (introduced in 2013) make UK citizens less likely to seek information in the back-of-package NFL. In addition, the format of NFLs differs

between countries in terms of the size, font, portion size and information elements of labels. In Canada and the US, nutrition information is expressed 'per serving' and includes a percent daily value (%DV), while in the UK (and Mexico, as of 2020) this is typically per 100 g or ml and voluntarily expressed per serving, and in Australia values are required per serving and per 100 g or ml. Some studies have explored how these elements may contribute to differentials in label understanding,[44,45] but their impact on label use has seldom been explored in the literature.[46]

In terms of FOPLs, relatively low rates of awareness and using the HSR labels were reported in Australia compared to FOPLs in the other countries, which likely reflects the lower levels of uptake of the voluntary HSR labels in Australia. As of 2019, only an estimated 41% of eligible food and beverage products in Australia displayed a HSR.[47] Australia's HSR was the only FOPL for which ratings of 'easy' or 'very easy' understanding (59-62%) were higher than its ratings of awareness (seeing 'often' or 'very often'; 43-49%). These findings, coupled with results of previous studies,[48,49,50] suggest that there is potential for the label to add more value and have larger impacts if it is more widely implemented. In contrast, reported awareness and use of the UK's traffic light FOPLs—which is also voluntary—were higher. This may be explained by more widespread presence of traffic light FOPLs in the UK. Although manufacturers display traffic light FOPLs on products in several different formats in the UK (including hybrid forms of traffic lights accompanied by Reference Intakes or GDA information), the recognition of the traffic light label in general may be higher overall.[51,52] Evidence from previous surveys in the UK demonstrate widespread reported use and awareness of the traffic light FOPLs. In 2016, a nationally representative survey of individuals in the UK found over 80% of respondents reported looking at FOPLs, and a survey in Northern Ireland in 2020 reported that 91% of respondents recognized the traffic light FOPL, and 56% reported using it when shopping.[53,54] The lower magnitude of reported use and awareness in our study is partially explained by the fact we analyzed awareness and use 'often' or 'all the time', while the referenced surveys asked about any use of the FOPL, regardless of frequency. When including additional responses for 'rarely' and 'sometimes', 96% of UK respondents in this study reported 'any'

awareness and 90% of UK respondents reported 'any' use of the traffic light FOPL across all three years (data not shown).

Importantly, our results show that self-reported awareness, use and understanding were higher for Mexico's newly implemented Warning FOPL than for the previous GDA FOPL. The differences between Mexico's Warning and GDA FOPLs for reported awareness (81% vs. 76%, respectively) and use (41% vs. 37%) were modest, but still meaningful: a 4-5 percentage point increase in awareness and use of FOPLs has the potential to have significant impacts on food purchasing decisions and resulting health outcomes at a population level.[55] These increases in awareness and use are particularly telling given the recency of the warning label's implementation, and the fact that, at the time of data collection, no communication campaign had yet been implemented to promote awareness or use of the warning labels, nor had other components of the policy (e.g., banning the use of cartoon characters on the front of packages) been implemented. Rates of reported understanding for the Warning FOPL, however, were substantially higher (at 79%) than the GDAs and all other FOPLs and NFLs in Canada, US, Australia, and the UK. Again, the very high level of understanding of the Warning FOPL is particularly noteworthy given that FOPL had been on packages for only a few months and full implementation of the warning labels was not until December 2020. By contrast, the GDA system—with substantially lower rates of understanding at 52%—had been present in the food supply for six years, and relatively large investments had been made to promote them.[56] The findings related to Warning FOPLs observed in this study reflect the growing evidence, including post-implementation data from Chile and Uruguay, that 'warning' style FOPLs are effective at communicating simplified nutrition information,[22,28,29,49,57] even without an associated communication campaign.[30] These results are particularly important from a policymaking perspective, and further research on the downstream impacts on label use and public health outcomes should be prioritized.

Reported understanding was found to be higher for all of the FOPLs compared to NFLs, aside from Mexico's GDA labels. The nearly identical rates of reported understanding between NFLs and GDA FOPLs in Mexico underscore the overall agreement in the FOPL literature that GDA-style FOPLs do not provide any assistive value to citizens beyond that of the traditional NFL,[22,58,59,60,61] and reflect evidence from Mexico suggesting that the previously mandated GDA labels were difficult for individuals to understand and used less frequently than the NFL.[14,62,63] In a parallel analysis of the IFPS Youth survey (respondents aged 10-17), results demonstrated similar patterns of higher understanding among FOPLs compared to NFLs.[64]

Some changes were observed across the three years of data collection for awareness, use and understanding. In particular, reported awareness and use of NFLs decreased modestly over time in Canada and the US, while awareness increased over time for NFLs in Australia, UK and Mexico, and awareness and use increased for most FOPLs. The reasons for decreasing awareness and use of NFLs in Canada and US are unclear. Both countries recently introduced minor adjustments to their respective NFLs, which might be expected to increase, even slightly, NFL awareness; however, information campaigns to raise awareness of the changes were limited or non-existent at the time of data collection. Further, increasing awareness of NFLs in Australia, UK and Mexico could be linked to the increasing presence of FOPLs in these countries: it may be that FOPLs cue individuals to revisit the back-of-package NFLs. The general trend upwards in awareness, use and understanding for FOPLs could be explained by a gradual increase in products displaying the FOPL and, therefore, a gradual increase in awareness among the population. Reported understanding of the NFLs and FOPLs was more stable, aside from modest increases in the UK and Mexico. The relatively small changes over time observed among adult participants in this study for all measures are in contrast to patterns observed for the same nutrition labelling indicators among youth. In the parallel analysis of the IFPS Youth survey, more prominent increases in reported use and understanding of NFLs were observed in the US and Australia between 2019 and 2020, as well as for the HSR FOPL.[64]

4.1 Strengths and Limitations

Strengths of this study include the multiple years of data, large sample size, and the 'natural experiment' format, which allowed us to explore changes in awareness, use and understanding of on-pack labelling systems over time, before and/or after implementation of FOPL schemes (particularly Mexico's new warning FOPLs), and in comparison to countries with no government-endorsed FOPL scheme. This study is subject to limitations common to survey research. Respondents were recruited using non-probability-based sampling; therefore, the findings do not provide nationally representative estimates. For example, although the data were weighted by age group, sex, region, education (except in Mexico), and ethnicity (except in Canada), the Mexico sample had notably higher levels of education compared to national benchmark estimates consistently across the three years. There is vast literature indicating that highly educated people are more aware, use more frequently and have a better understanding of nutrition information,[3,65,66] as is also reflected in our results (data not shown). Thus, estimates of label awareness, use and understanding may be over-estimated for Mexico. However, the sample in Mexico also included a greater proportion of respondents reporting lower income adequacy compared to the other countries. Similar to education, lower income has been associated with lower awareness, use, and understanding of nutrition labels,[3,65,66] making the high understanding of Mexico's new warning FOPLs even more striking. Further, education and perceived income adequacy were controlled for in all models. This study relies on self-reported measures of awareness, use and understanding, and thus does not measure FOPL's intended downstream impacts of improving healthy eating and reducing nutrition-related noncommunicable disease at a population level. However, different measures of these indicators across countries and over time, such as purchasing and consumption data, will be important to confirm the conclusions made in this study. Further, this study did not evaluate all major FOPL systems. In particular, IFPS does not include survey respondents from any countries that use the Nutri-Score label, which is one of the most prominent FOPL systems used in seven European countries since 2017.[67] The study also did not display updated images of Mexico's NFLs corresponding to the 2020 nutrition labelling regulation changes in 2020.

Although the changes to the NFLs were minor, respondents' reported awareness, use and understanding of NFLs in Mexico in 2020 may not be a precise representation of the new NFLs. Lastly, the final wave of data collection in this study was collected in the midst of the global COVID-19 pandemic, which had notable impacts on individuals' interaction with food and their food environments[68]. The results from 2020 should be considered within the context of the pandemic.

4.2 Conclusions

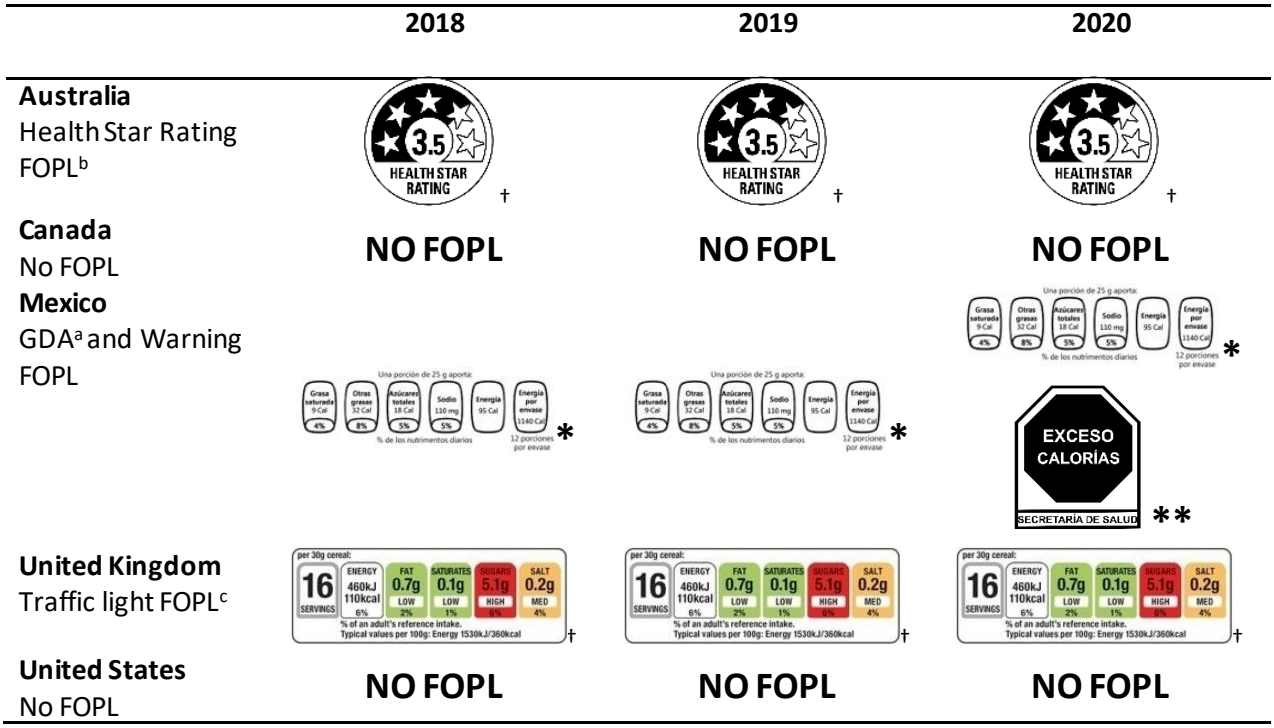
Results from this study provide valuable insights into individuals' perceptions of government-endorsed nutrition labelling in five countries from 2018 to 2020, including before and after implementation of Mexico's Warning FOPL policy. Greater awareness, use and understanding of Mexico's new Warning FOPL compared to the country's previous GDA FOPL emphasizes the effectiveness of simple, interpretive FOPLs over information-heavy GDA formats, which performed no better in this study than the existing back-of-package NFL. Awareness and use were relatively low for the HSR FOPL in Australia, likely a reflection of its voluntary nature and incomplete industry uptake, reinforcing the importance of advocating for mandatory FOPL regulations where possible. Some modest changes in awareness, use and understanding were observed over time for NFLs and FOPLs in most countries, but were relatively consistent across the three years. Overall, this study provides evidence supporting the effectiveness of simple, interpretive FOPLs, compared to NFLs and non-interpretive FOPLs such as GDA-based systems. Warning-style FOPLs may be particularly successful due to their simplicity and ease of understanding. Future research is warranted to explore how citizens use FOPLs when making purchasing and consumption decisions (e.g., the extent to which they are used to help choose products within the same category, or to avoid specific categories of products) and to evaluate the impact of FOPL policies on purchasing patterns and dietary intake.

AUTHOR CONTRIBUTIONS

Rachel B Acton: Writing – Original draft preparation, Visualization. **Vicki L Rynard:** Formal data analysis, Writing – Review and editing. **Jean Adams:** Writing – Review and editing. **Jasmin Bhawra:** Writing – Review and editing. **Adrian J Cameron:** Writing – Review and editing. **Alejandra Contreras-Manzano: Writing** – Review and editing. **Rachel E Davis:** Writing – Review and editing. **Alejandra Jáuregui:** Writing – Review and editing. **Gary Sacks:** Writing – Review and editing. **James F Thrasher:** Writing – Review and editing. **Lana Vanderlee:** Conceptualization, Methodology, Writing – Review and editing. **Christine M White:** Conceptualization, Methodology, Project administration, Data curation, Writing – Review and editing. **David Hammond:** Conceptualization, Methodology, Funding acquisition, Supervision, Writing – Review and editing. All authors have reviewed and approved the final article.

FIGURES

Figure 1. Mandatory and voluntary government-endorsed front-of-package labelling systems present in Australia, Canada, Mexico, the United Kingdom, and the United States from 2018-2020



* =Mandatory policy; **=Revised mandatory policy; †=Government-endorsed voluntary policy

[a] The GDA FOPL system in Mexico was originally implemented in 2014.

[b] The Health Star Rating FOPL system in Australia was originally implemented in 2014.

[c] The Traffic light FOPL system in the UK was originally implemented in 2013.

GDA, guideline daily amount; FOPL, front-of-package label.

Figure 2. Unadjusted percentages of adult respondents who reported having seen nutrition labels (awareness) on packages or in stores 'often' or 'all the time', by country and year (N=64,032)

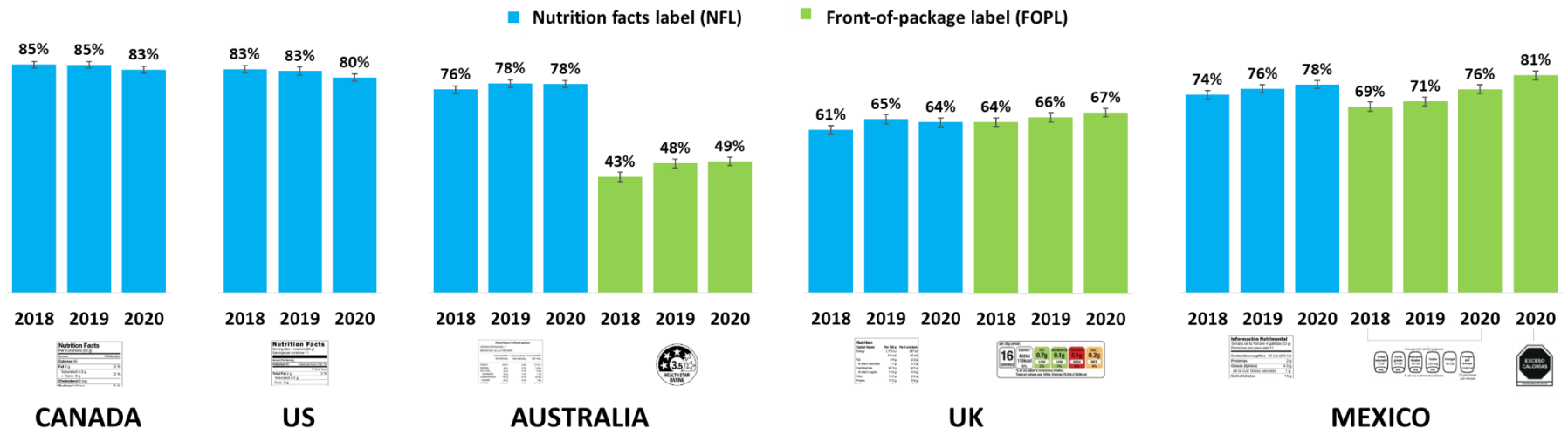


Figure 3. Unadjusted percentages of adult respondents who reported using nutrition labels 'often' or 'all the time' when deciding to buy a food product, by country and year (N=64,032)

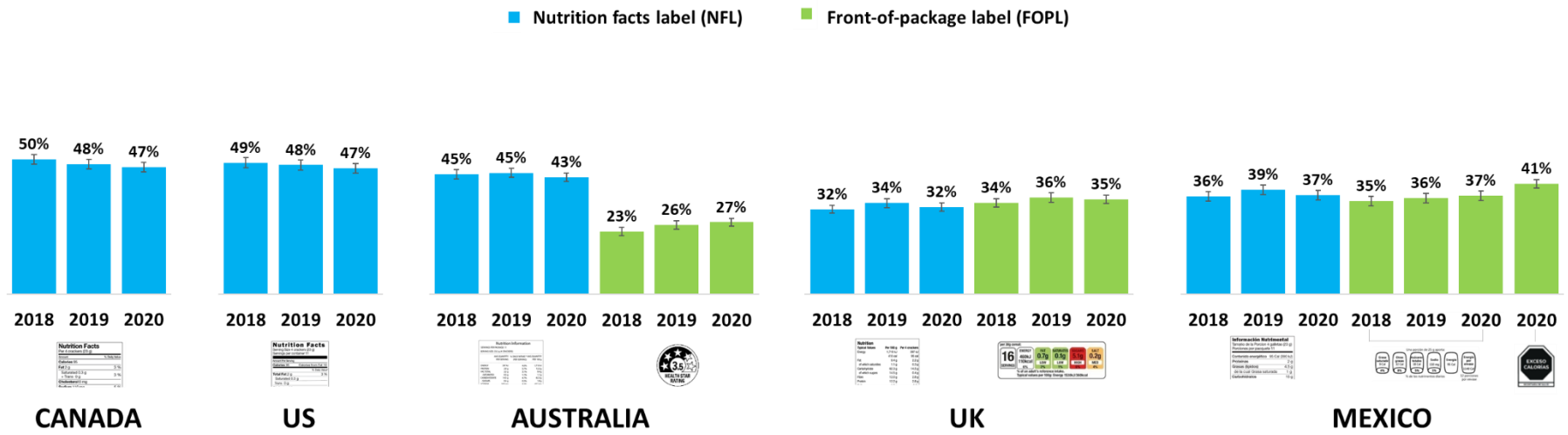
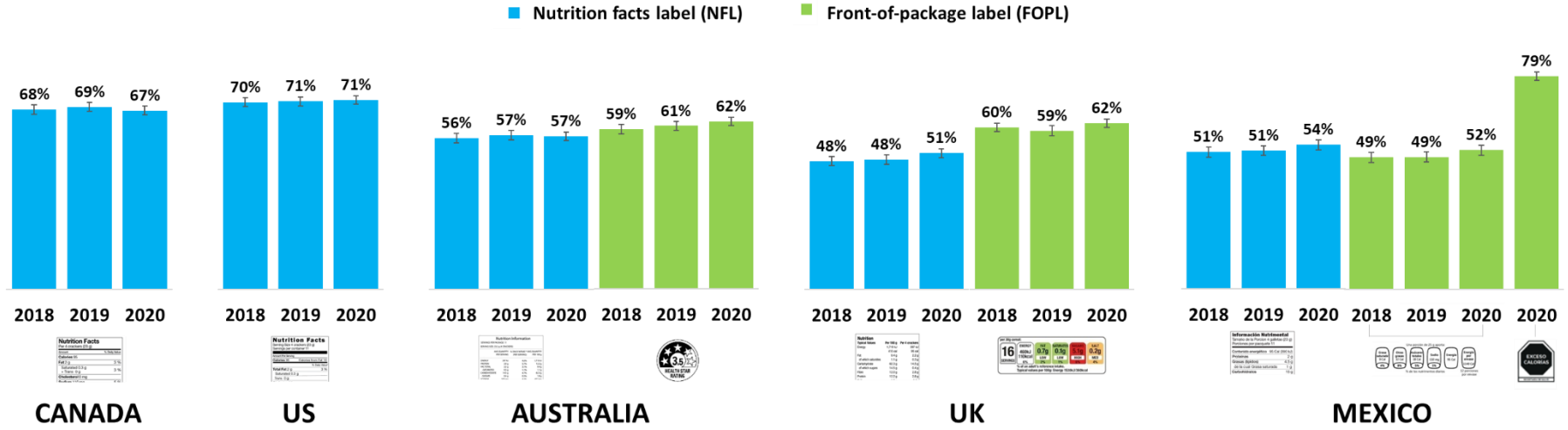


Figure 4. Unadjusted percentages of adult respondents who reported finding nutrition labels 'easy' or 'very easy' to understand, by country and year (N=64,032)



607 **TABLES**

608 **Table 1.** Sociodemographic characteristics among the overall sample and across countries, 2018-2020 (weighted % and means; unweighted n)
609

	Overall (n=64,032) % (n)	Australia (n=12,418) % (n)	Canada (n=12,441) % (n)	Mexico (n=12,353) % (n)	UK (n=13,627) % (n)	US (n=13,193) % (n)
Age (years)						
Mean (SD)	46.1 (16.8)	46.7 (16.9)	48.1 (17.1)	40.0 (14.1)	48.4 (17.1)	46.9 (16.9)
Sex						
Male	48.8 (31,639)	49.1 (6,114)	49.5 (6,101)	47.9 (6,379)	48.8 (6,714)	48.8 (6,331)
Female	51.2 (32,393)	50.9 (6,304)	50.5 (6,340)	52.1 (5,974)	51.2 (6,913)	51.2 (6,862)
Ethnicity						
Majority	77.4 (52,442)	74.8 (10,552)	79.6 (9,919)	79.4 (10,317)	88.9 (12,353)	64.1 (9,301)
Minority	22.6 (11,590)	25.2 (1,866)	20.4 (2,522)	20.6 (2,036)	11.1 (1,274)	35.9 (3,892)
Education[a]						
Low	42.9 (19,249)	42.0 (4,388)	42.0 (3,345)	21.5 (2,569)	50.3 (4,368)	56.9 (4,579)
Medium	21.9 (17,418)	32.4 (4,287)	33.5 (4,934)	13.3 (1,536)	21.4 (3,804)	9.9 (2,857)
High	35.2 (27,365)	25.6 (3,743)	24.5 (4,162)	65.2 (8,248)	28.3 (5,455)	33.1 (5,757)
Perceived Income Adequacy[b]						
Very difficult	8.8 (5,005)	7.3 (877)	8.2 (877)	12.8 (1,422)	6.1 (701)	9.7 (1,128)
Difficult	21.6 (13,143)	18.6 (2,269)	19.4 (2,205)	32.9 (3,953)	17.1 (2,156)	20.7 (2,560)
Neither easy nor difficult	37.6 (23,610)	39.1 (4,756)	38.6 (4,734)	38.1 (4,790)	37.5 (4,901)	34.9 (4,429)
Easy	21.1 (14,506)	24.1 (3,067)	22.1 (2,961)	12.9 (1,750)	25.0 (3,657)	20.8 (3,071)
Very easy	10.9 (7,768)	11.0 (1,449)	11.6 (1,664)	3.3 (438)	14.3 (2,212)	13.9 (2,005)

SD, standard deviation; UK, United Kingdom; US, United States.

[a] Participants were asked, "What is the highest level of formal education that you have completed?" Responses were categorized as 'low' (completed secondary school or less), 'medium' (some post-secondary qualifications), or 'high' (university degree or higher) according to country-specific criteria.

[b] Respondents were asked, "Thinking about your total monthly income, how difficult or easy is it for you to make ends meet?"

610

Supplementary Material

Supplemental Table S1. Sensitivity analyses assessing awareness of nutrition labelling among respondents from the International Food Policy Study (2018-2020) using a continuous variable

	NFL awareness Mean (SE)			FOPL awareness Mean (SE)		
	2018	**2019**	**2020**	**2018**	**2019**	**2020**
	n=22,322	n=20,509	n=21,201	n=13,511	n=12,396	n=12,491
Australia	4.09 (.02)	4.19 (.02)	4.14 (.02)	3.21 (.02)	3.35 (.02)	3.36 (.02)
Canada	4.38 (.02)	4.39 (.02)	4.35 (.02)	-	-	-
Mexico	3.98 (.02)	4.01 (.02)	4.07 (.02)	GDA: 3.91 (.02)	GDA: 3.93 (.02)	GDA: 4.04 (.02) WL: 4.07 (.02)
UK	3.71 (.02)	3.80 (.02)	3.78 (.02)	3.77 (.02)	3.84 (.02)	3.88 (.02)
US	4.38 (.02)	4.38 (.02)	4.30 (.02)	-	-	-

FOPL, front-of-package label; GDA, guideline daily amount; NFL, nutrition facts label; SE, standard error; UK, United Kingdom; US, United States; WL, warning label.

Respondents were asked, "How often have you seen this type of food label on packages or in stores?" Responses were assessed using a 5-point Likert scale (1=never, 2=rarely, 3=sometimes, 4=often, 5=all the time) and analysed as a continuous variable (1-5), with higher values indicating greater awareness.

Supplemental Table S2. Sensitivity analyses assessing use of nutrition labelling among respondents from the International Food Policy Study (2018-2020) using a continuous variable

	Use of NFL Mean (SE)			Use of FOPL Mean (SE)		
	2018	**2019**	**2020**	**2018**	**2019**	**2020**
	n=22,322	n=20,509	n=21,201	n=13,511	n=12,396	n=12,491
Australia	3.27 (.02)	3.30 (.02)	3.26 (.02)	2.64 (.02)	2.70 (.02)	2.76 (.02)
Canada	3.40 (.02)	3.37 (.02)	3.35 (.02)	-	-	-
Mexico	3.01 (.02)	3.07 (.02)	3.01 (.02)	GDA: 2.98 (.02)	GDA: 3.03 (.02)	GDA: 3.05 (.02) WL: 3.10 (.02)
UK	2.92 (.02)	3.00 (.02)	2.94 (.02)	2.98 (.02)	3.06 (.02)	3.04 (.02)
US	3.41 (.02)	3.40 (.02)	3.35 (.02)	-	-	-

FOPL, front-of-package label; GDA, guideline daily amount; NFL, nutrition facts label; SE, standard error; UK, United Kingdom; US, United States; WL, warning label.

Respondents were asked, "How often do you use this type of food label when deciding to buy a food product?" Responses were assessed using a 5-point Likert scale (1=never, 2=rarely, 3=sometimes, 4=often, 5=all the time) and analysed as a continuous variable (1-5), with higher values indicating more frequent use.

Supplemental Table S3. Sensitivity analyses assessing self-reported understanding of nutrition labelling among respondents from the International Food Policy Study (2018-2020) using a continuous variable

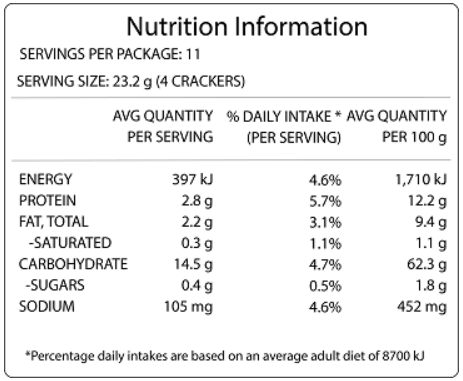
	Understanding of NFL Mean (SE)			Understanding of FOPL Mean (SE)		
	2018	**2019**	**2020**	**2018**	**2019**	**2020**
	n=22,322	n=20,509	n=21,201	n=13,511	n=12,396	n=12,491
Australia	3.49 (.02)	3.51 (.02)	3.50 (.02)	3.61 (.02)	3.63 (.02)	3.68 (.02)
Canada	3.79 (.02)	3.79 (.02)	3.78 (.02)	-	-	-
Mexico	3.34 (.02)	3.35 (.02)	3.40 (.02)	GDA: 3.29 (.02)	GDA: 3.30 (.02)	GDA: 3.34 (.02) WL: 4.01 (.02)
UK	3.31 (.02)	3.34 (.02)	3.36 (.02)	3.58 (.02)	3.60 (.02)	3.63 (.02)
US	3.86 (.02)	3.89 (.02)	3.86 (.02)	-	-	-

FOPL, front-of-package label; GDA, guideline daily amount; NFL, nutrition facts label; SE, standard error; UK, United Kingdom; US, United States; WL, warning label.

Respondents were asked, "Do you find this information…", with response options assessed using a 5-point Likert scale (1=very hard to understand, 2=hard to understand, 3=neither hard nor easy, 4=easy to understand, 5=very easy to understand) and analysed as a continuous variable (1-5), with higher values indicating greater self-reported understanding.

Supplemental Figure S1. Nutrition facts labels from five countries assessed in the International Food Policy Study

Australia



Nutrition Information

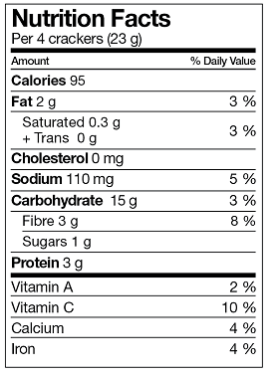
SERVINGS PER PACKAGE: 11

SERVING SIZE: 23.2 g (4 CRACKERS)

	AVG QUANTITY PER SERVING	% DAILY INTAKE * (PER SERVING)	AVG QUANTITY PER 100 g
ENERGY	397 kJ	4.6%	1,710 kJ
PROTEIN	2.8 g	5.7%	12.2 g
FAT, TOTAL	2.2 g	3.1%	9.4 g
-SATURATED	0.3 g	1.1%	1.1 g
CARBOHYDRATE	14.5 g	4.7%	62.3 g
-SUGARS	0.4 g	0.5%	1.8 g
SODIUM	105 mg	4.6%	452 mg

*Percentage daily intakes are based on an average adult diet of 8700 kJ

Canada



Nutrition Facts

Per 4 crackers (23 g)

Amount	% Daily Value
Calories 95	
Fat 2 g	3 %
Saturated 0.3 g + Trans 0 g	3 %
Cholesterol 0 mg	
Sodium 110 mg	5 %
Carbohydrate 15 g	3 %
Fibre 3 g	8 %
Sugars 1 g	
Protein 3 g	
Vitamin A	2 %
Vitamin C	10 %
Calcium	4 %
Iron	4 %

Mexico[a]

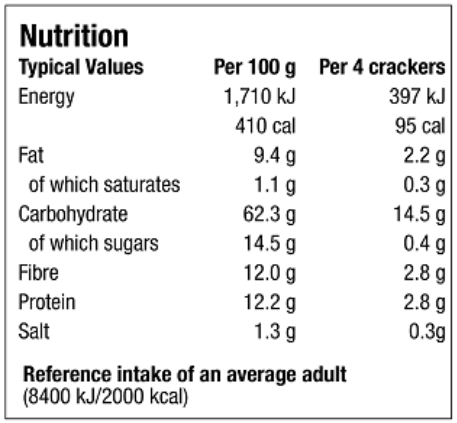
Información Nutrimental

Tamaño de la Porcion 4 galletas (23 g)

Porciones por pacquete 11

Contenido energético	95 Cal (390 kJ)
Proteínas	2 g
Grasas (lipidos)	4.5 g
de la cual Grasa saturada	1 g
Carbohidratos	15 g
de la cual Azúcares	1 g
Fibra Dietética	3 g
Sodio	110 mg

United Kingdom

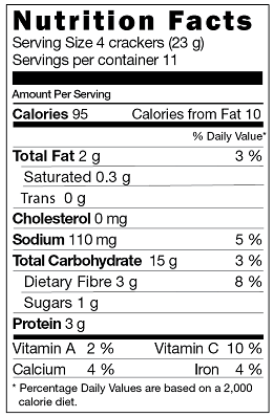


Nutrition

Typical Values	Per 100 g	Per 4 crackers
Energy	1,710 kJ	397 kJ
	410 cal	95 cal
Fat	9.4 g	2.2 g
of which saturates	1.1 g	0.3 g
Carbohydrate	62.3 g	14.5 g
of which sugars	14.5 g	0.4 g
Fibre	12.0 g	2.8 g
Protein	12.2 g	2.8 g
Salt	1.3 g	0.3g

Reference intake of an average adult (8400 kJ/2000 kcal)

United States



Nutrition Facts

Serving Size 4 crackers (23 g)

Servings per container 11

Amount Per Serving

Calories 95 Calories from Fat 10

% Daily Value*

Total Fat 2 g	3 %
Saturated 0.3 g	
Trans 0 g	
Cholesterol 0 mg	
Sodium 110 mg	5 %
Total Carbohydrate 15 g	3 %
Dietary Fibre 3 g	8 %
Sugars 1 g	
Protein 3 g	

Vitamin A 2 % Vitamin C 10 %

Calcium 4 % Iron 4 %

* Percentage Daily Values are based on a 2,000 calorie diet.

[a] Changes were made to the Mexican nutrition facts label in 2020 (declaration of nutrient values per 100 grams or milliliters, and mandatory display of added sugars and trans fats values) which were not reflected in the International Food Policy Study 2020 questionnaire.

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