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Article

Which Front-of-Package Labels Help Indian Consumers Identify and Reduce Unhealthy Food Purchases? A Randomized Field Experiment

S.K. Singh[1]* and Lindsey Smith Taillie,[2]*, Ashish Gupta[3], Maxime Bercholz[4], Barry Popkin[2], Nandita Murukutla[3]

[1] Department of Survey Research and Data Analytics; International Institute for Population Sciences, Deemed University; sksingh@iipsindia.ac.in
[2] Department of Nutrition, Gillings School of Global Public Health; Carolina Population Center; University of North Carolina at Chapel Hill; taillie@unc.edu; popkin@unc.edu
[3] Vital Strategies; agupta@vitalstrategies.org; nmurukutla@vitalstrategies.org
[4] Carolina Population Center; University of North Carolina at Chapel Hill; bercholz@email.unc.edu
* Denotes co-first authors and co-corresponding authors. Correspondence to: sksingh@iipsindia.ac.in for SKS and taillie@unc.edu for LST.

Abstract: Policies to require front-of-package labels (FOPLs) on foods may help Indian consumers better identify foods high in nutrients of concern including sugar, saturated fat, and sodium, and discourage their consumption, outcomes critical for preventing rises in diet-related non-communicable disease. The objective was to test whether FOPLs helped Indian consumers identify 'high-in' foods and reduce intentions to purchase them. We conducted an in-person randomized experiment (n=2,869 adults between ages 18 and 60 years old) in six states of India in 2022. Participants were randomized to one of five FOPLs: a control label (barcode), warning label (octagon with "High in [nutrient]"), Health Star Warning (HSR), Guideline Daily Amount (GDA), or traffic light label. Participants then viewed a series of foods high in sugar, saturated fat, or sodium with the assigned FOPL, and rated product perceptions and label reactions. Fewer than half of participants in the control group (39.1%) correctly identified all products high in nutrient(s) of concern. All FOPLs led to an increase in this outcome, with the biggest differences observed for the warning label (60.8%, p<0.001) followed by the traffic light label (54.8%, p<0.001), GDA (55.0%, p<0.001), and HSR (45.0%, p<0.01). Relative to the control, only the warning label led to a reduction in intentions to purchase the products. The results suggest that warning labels are the most effective FOPL to help Indian consumers identify and avoid unhealthy foods.

Keywords: warning labels; Health Star Rating; Nutriscore; GDA; food policy; obesity prevention; non-communicable diseases

1. Introduction

Over the past several decades, with the emergence of the epidemiological transition, India has experienced a growing problem of overweight and obesity and all the major nutrition-related noncommunicable diseases, especially diabetes and hypertension[1-3]. According to the latest National Family Growth study, nearly 1 in 4 adults and 1 in 20 children are classified as overweight or obese.[4] Rates are increasing faster

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in India than the world average, and obesity prevalence is expected to more than triple by the year 2040, without intervention.[5, 6] At the same time India faces a major double burden of malnutrition as stunting and other forms of undernutrition remain high among the rural poor, in particular. [7-9]

These changes have occurred at a time when a remarkable diet transformation is occurring in India which affects rich and poor, young and old. In particular, growth of ultraprocessed food consumption in India is significant. As shown in neighboring Nepal, even preschools are increasingly being fed these foods as one study found 25% of preschoolers' caloric intake came from ultraprocessed food and this was linked with higher levels of stunting.[10] From 2006 to 2019, sales of ultra-processed snack food and sweetened beverages in India grew from 1 billion USD to 38 billion USD.[11]

Many ready-to-eat or ready-to-heat foods and drinks are high in added sugars, sodium, saturated fats, and refined carbohydrates. Excessive consumption of these nutrients increases risk of obesity and related NCDs.[12-24] A growing literature of both a large random controlled trial and over 45 longitudinal cohort studies have linked ultra-processed food with increased risk of overweight/obesity, diet-related NCDs and total and heart disease-linked mortality.[15, 25].

To reduce consumption of packaged foods high in added sugar, sodium, saturated fat, and trans fats, front-of-package labels (FOPLS) have been recommended by the World Health Organization (WHO), the World Bank and others**.** [26-34] The primary goals of front-of-package labels (FOPLs) are to inform consumers about the nutritional quality of food in a way that is quick and easy to understand and improve the nutritional quality of food purchases, with a secondary goal of stimulating reformulation in the food supply[35]**.** Interpretive FOPLs are particularly promising because they not only provide information about nutritional content, but also help consumers judge the healthfulness (or unhealthfulness) of products and provide guidance (encouragement or discouragement) about the decision to purchase. These are important to reduce intake of the major unhealthy processed foods consumed in India. By synthesizing complex nutrition facts into interpretable information, these labels may be especially valuable for populations with low literacy.

The evidence base on FOPLs is growing rapidly. Warning labels perhaps have the strongest evidence with regards to discouraging purchases of foods high in nutrients of concern, with recent systematic reviews of experimental and quasi-experimental data showing that warnings reduce selection of unhealthy products by 26% to 36%.[36, 37] Another recent review, focused on sugar, found that warnings were the most effective at increasing consumers' understanding of the high nutrient content in foods.[38] Real-world evidence from Chile, the first country to implement mandatory front-of-pack warnings, found that warning labels were linked to a 24% decrease in purchases of unhealthy foods[39] and helped both parents and children identify unhealthy food and drinks and discourage their consumption[40]. In contrast, there is limited real-world data about the effectiveness of other common interpretive FOPLs, such as traffic light labels or the Health Stars Rating (HSR) system.[35] Real-world data on traffic light labeling systems has been mixed: one UK-based study found a sizeable reduction in calories purchased linked to the traffic light policy[41], while another study found no association with purchases.[42] Data from Ecuador, which implemented a mandatory traffic light labeling system in 2014, have found low self-reported use of the labeling system[43] and no evidence that traffic light labels have influenced purchasing behaviors.[44, 45] Real-world evidence on the effectiveness of the HSR system has also been quite poor. Data from Australia and New Zealand,

 doi:10.20944/preprints202205.0058.v1

which implemented voluntary HSR schemes in YEAR and YEAR, respectively, show low uptake of the HSR(72)(49), with implementation skewed towards products considered to be healthier (i.e., with higher ratings). To our knowledge, there is no real-world evaluation evidence that HSR leads to healthier food purchases; meta-analyses and systematic reviews of experimental studies have similarly found low- or no- evidence that HSR impacts purchasing behaviors.[46-49]. Evidence in favor of the industry-promoted Guideline Daily Amounts (GDA) system is the weakest of all, with an array of both experimental and real-world evaluation studies from across the globe finding that relative to almost all other FOPL types, the GDAs are poorly understood, take the most time to evaluate, and are the least effective at influencing purchases. [38, 47, 50-59]

However, at the time this study was planned, there was virtually no evidence about what FOPL system will work best to inform Indian consumers about foods excess in these nutrients of concern and discourage purchases of these products. In this context, the objective of this study was to experimentally evaluate the impact of FOPLs on consumers' ability to correctly identify products as containing excess levels of nutrients of concern and intentions to purchase them, relative to a control label, in a sample of Indian adults across six states. Secondary outcomes included consumers' reactions to the FOPLs and perceptions of unhealthy products.

Given the diversity of the Indian population in terms of language, culture, dietary intake, and educational attainment, it is also essential to ensure that any FOPL regulation works well across the entire population as well as for different food categories. To address this, we explored whether the impact of FOPLs varied by product type, educational level, and state.

2. Materials and Methods

IRB

This study was reviewed and approved by the Institutional Review Board (IRB) at the International Institute for Population Sciences (IIPS) in Mumbai, India and by **BRANY (Biomedical Research Alliance of New York),** a national organization that provides IRB services.

This study was pre-registered at Open Science Framework in December 2022: https://osf.io/8kx3e. De-identified data is available at [add link at time of publication]. Participants provided written consent or, for those who could not provide a signature, verbal consent.

Setting

We carried out an in-person field experiment in rural and urban areas of 6 states (Assam, Delhi, Gujarat, Odisha, Karnataka, Uttar Pradesh) from January to March of 2022). These states were chosen purposively as sentinel sites to represent the geographic areas of India as well as key associated sociodemographic variations. From each of these states, one district was selected (Delhi, Mysuru, Bhubaneshwar, Lucknow, Ahmedabad, Guwahati).

First, four wards (two urban, one semi-urban, one peri-urban) were randomly chosen from each district. Next listing of potential survey locations was undertaken in each of these selected wards. Each location was classified into four clusters, namely, peak day

 doi:10.20944/preprints202205.0058.v1

peak-time, peak-day lean-time, lean-day lean-time, and lean-day peak-time. This generated sampling frame of time-location clusters (TLCs). Four TLCs per ward were randomly selected from list for survey. These locations were the places that sold packaged food items. These could be either shop/retail outlet (called Kirana shops locally), large grocery store (in a shopping mall or on a high street), group of small shops, or smaller petty shops (tea stalls, shops selling *paan* – betel leaves wrapped around tobacco, fruits etc.).

Participants

The participants were 2,869 adults between ages 18 and 60 years old. Recruitment of participant was done by intercepting the customers using the nth interval calculated for the location using the footfall during the TLC (Interval=Total Footfall recorded at the location during listing/28). The details of the intercepts were filled in the intercept forms. Once the nth person was intercepted, s/he was checked for eligibility and a request was made for interview. Interviews were conducted with those who consented. After the interview, the next nth person was intercepted, whereas after the refusal, immediate next person was intercepted. The person who agreed for the interview, was taken to a close by comfortable place for interview where disturbances from the street were minimal.

Within each state, quota were used to obtain approximately 50% of participants who were women and with an educational level of 12 years or less. Eligibility criteria included being between ages 18-60 years old and being involved in decision-making related to grocery purchases for their household at least half the time.

Stimuli

Four FOPLs were selected for testing based on conversations with Indian health advocacy organizations and governmental organizations indicating that these labels were of interest for informing an impending FOPL regulation. In addition, the GDA was selected because has already been voluntarily implemented on some products in India. Images of the FOPLs (as mocked up on sweet biscuits) are depicted in **Figure 1**.

Figure 1. Front-of-package labels (FOPLs)

 doi:10.20944/preprints202205.0058.v1

Warning label: The main design was modeled on the proposed warning label used in South Africa.[60] A design agency adapted the warning for India through design testing with 15 adults in five cities of India to ensure that the label was noticeable and understandable in a socioeconomically diverse population. The warning label was comprised of a white holding strap with the marker word ALERT! and at least one triangle-shaped warning and up to three warnings, depending on the nutrient content of the product (with text, HIGH IN SUGAR, HIGH IN SODIUM, or HIGH IN SATURATED fat). Based on prior evidence that icons increase perceived effectiveness and comprehension of the label across populations speaking different languages[61] and literacy levels[60], icons depicting sugar, salt, and saturated fat were also used.

HSR The HSR was modeled after the existing HSR system used in Australia and New Zealand. The circular label stated HEALTH STAR RATING and depicted a number of stars from 0.5 to 5 shaded in black to indicate the healthfulness of the product, with fewer stars indicating less health and more stars indicating healthy.

Traffic light labels The traffic light label was based on a simplified version of the system used in the UK and Ecuador. The label presented color-coded information on sugar, sodium, and saturated fat for each product, with red signaling high, amber signaling medium, and green signaling low content of that nutrient.

GDA The GDA was based on the existing GDA used voluntarily by the food industry in many countries. The GDA contained four blue shaded shapes containing nutritional information on calories, saturated fat, sugar, and salt (both the absolute content in calories or grams as well as the percent of an adult's guideline daily amount).

Control label Similar previous FOPL experimental studies[62, 63], a barcode label was used as a control label because it serves as a piece of visual information on the front of the food package while conveying neutral information about the product's nutritional content.

The labels were displayed on a series of products, including a savory biscuit, a loaf of bread, a fruit drink, a sweet biscuit, and a package of instant noodles (**Appendix A**). These product categories were chosen because they are commonly consumed, are often high in nutrients of concern, and because they represent categories where there may be high levels of consumer confusion about nutritional content of the products. A professional designer designed mock products to avoid the influence of brand preferences, though to increase realism, the mock products and their nutritional information were based on popular Indian brands.

For each product, one commercial brand within each food category was selected. A mock nutrient profile was created based on this brand (±2% of the original nutrient profile model). Each label was then based off of the relevant nutrient profile model: for HSR, Australia's HSR calculator was used;[64] for warning labels and traffic light labels, the thresholds specified in the 2019 draft regulation for Food Safety Standards and Authority (FSSAI) were used; and for the GDA, national dietary guidelines were used.[65]

Cognitive testing and protocol development

The study protocol and measures used were developed and refined through an iterative process to ensure acceptability among diverse participants. First, study items were translated from English into five languages (Assamese, Gujarati, Hindi, Kannada, and Odia). Two rounds of cognitive interviews were completed to make sure the measures were properly adapted to the Indian context and well-understood in each language, while

 doi:10.20944/preprints202205.0058.v1

maintaining consistency with the underlying construct[66]. The interviews were completed in two phases, with each phase including four participants in each language (40 interviews total), with refinement of study measures occurring between phase one and two. After cognitive interviews were complete, items were refined, new additions were translated and back-translated to English before being reviewed by study co-authors. The field methodology (including recruitment and study implementation) was then pilot tested in a sample of 20 adults in an urban area of Delhi State in December of 2021 before further finalization of the study protocol.

Procedure

Participants were randomized to one of 5 arms: control label, HSR, warning, GDA, or traffic light label using an allocation ratio of 1:1:1:1:1. Participants then viewed a series of images of products, in random order, with an FOPL on the product according to assigned arm. In the control condition, all products had the barcode label. In the HSR condition, all products displayed stars. In the warning label condition, products displayed the relevant warning(s) for sugar, sodium, and/or saturated fat. In the GDA condition, all products had a GDA with the relevant nutritional information. In the traffic light condition, products displayed a multiple traffic light with the relevant color code (green, yellow, or red) for each nutrient.

Interviewers showed participants images of products using an A5 size booklet, in random order, and asked them to assess the product and their reactions to the label. At the end, the participant viewed images of all 5 FOPLs and answered questions about which label they preferred. All data were entered into a smartphone app during the interview.

At the end of the study, participants provided demographic information.

Measures

Socio-demographic and behavioral covariates were specified as follows: gender (man/woman), age (18-30, 31-40, 41 and older), education (≤12 years of education, >12 years), urbanicity (defined as peri-rural, semi-urban, and urban), and state (Assam, Delhi, Gujarat, Odisha, Karnataka, Uttar Pradesh). Languages included: Assamese (Assam), Gujarati (Gujarat), Hindi (Delhi, Uttar Pradesh), Kannada (Karnataka), and Odia (Odisha). Participants were also able to conduct the survey bilingually (in the language of the state and English), if they preferred. Financial situation was defined as a four-level variable: 1) can pay the bills and buy necessary and additional things; 2) can pay the bills and buy necessary things only; 3) can pay the bills but not buy necessary things; and 4) cannot pay bills. Household income was categorized as <RS. 10,0000; RS 10,001-25,000; 25,0001-50,000, and over RS. 50,000 Consumption of "high-in" food (sweet biscuits, salty biscuits, bread, and instant noodles) was categorized as never or less than one time per week, 1 time per week, or more than 2 times per week.

The codebook including product assessment items and label assessment items is available in **Appendix B**.

For all five products, participants rated their perceptions of the product. First, to assess their ability to correctly identify that the product had high contents of nutrients of concern, they answered the question "Do you think this product has high [nutrient of concern]?" (yes/no). For two products, the sweet biscuit and the instant noodles, the respondents were asked this question twice, one for each nutrient of concern.

 doi:10.20944/preprints202205.0058.v1

Next, they were asked, "Is this product unhealthy?" (yes/no). If they answered yes, they were asked, "how unhealthy is it?" with response options ranging from 1 to 3 (very much, somewhat, very little). They were then asked about visual attractiveness ("Do you think this product is visually attractive?") and intentions to purchase ("Will you purchase this product next week, if it were available?") with a yes/no response. Those who answered "yes" were asked the follow-up question ("How visually attractive," or "How likely," respectively) with two options again ranging from (1) very much to (3) very little.

Participants also completed a label assessment for three of five products (randomly selected). Participants answered whether the label grabbed their attention, made them feel concerned about the health problems of consuming the product, was understandable, taught them anything, was truthful, and was likable. For perceived message effectiveness, participants were asked if the label made them concerned about the health consequences of consuming the product, made the product seem unpleasant, and made them feel discouraged from wanting to consume the product. For all items, response options were yes/no. If the respondent answered yes, they were then asked "how much…" with responses ranging from (1) very much to (3) very little.

Finally, participants were asked to compare their label and select which label would a) most discourage them from consuming the product; b) most discourage them from feeding the product to a child age 1-12 years old; c) best informs them that the product has high [nutrient]; and d) is the easiest to understand.

Statistical Analysis

First, we recombined some measures. For all items measured on the Likert scale, we combined the agreement item (yes/no) with the strength of agreement item for each person to create a 4-point Likert scale, subsequently recoded from 1 (not at all) to 4 (very much) for a more intuitive interpretation. For perceived message effectiveness, Cronbach's alpha for the three items was > 0.7, so we created a scale that was the average of the three items for each product type. For the primary outcome, ability to correctly identify products high in nutrients of concern, we *a priori* specified this as correctly identifying *all* nutrients, since two products had multiple nutrients.

We descriptively reported sociodemographic characteristics and examined whether participant demographics differed by study arm using chi-square. Then, we descriptively reported unadjusted percentages and means (and standard deviations) for the two primary outcomes by product type.

For all main analyses, we examined differences between the control label and each of the other FOPL conditions. For all outcomes with multiple measurements for each person, we used mixed effects logistic regression for the correct identification of all 'high-in' nutrients and mixed effects linear regression for all other outcomes, with respondent-level random intercepts to account for repeated measures. Standard errors were clustered by interviewer. We included indicator variables for label type (between-subjects) and product type (within-subjects), as well as an interaction of label type and product type, if significant at the 5% level (as stated in the pre-registered analysis plan). The Holm procedure was used to adjust the p-values for multiple comparisons within each outcome (four tests for the four label types compared to the neutral label). This was done so the familywise error rate across the four tests within each outcome would not exceed 0.05, the nominal significance level.

 doi:10.20944/preprints202205.0058.v1

To evaluate the most discouraging label, the most informative label, and the label that was easiest to understand, we descriptively reported the percentage of participants that selected each label type as the most discouraging from consuming the product, most discouraging from feeding the product to a child, most informative, and the easiest to understand.

To assess whether the effect of FOPLs on the primary outcomes differed by socio-demographic and behavioral covariates, we conducted exploratory moderation analyses by adding, in turn, each moderator of interest and its interaction with label type to the main model. For potential moderators, we included education and state. We explored moderation by state instead of language (as stated in the pre-registration) since most states used their own language and state-level differences were of interest conceptually due to regional variation in the food supply and dietary behaviors. We also included urbanicity, gender, whether the survey was conducted bilingually, and weekly consumption of the five product types presented to the participants as additional exploratory moderators. As Cronbach's alpha was < 0.7 for the five consumption measures, separate models were estimated for each product, using the corresponding consumption measure as the exploratory moderator. Since separate models were fit for each product, there were no repeated measures and linear and logistic regressions were used. We tested for overall differences in the effect of each label (relative to the control, i.e. the difference in means between a given FOPL group and the control arm) across the levels of each moderator.

Finally, we conducted sensitivity analyses on the primary outcomes, in which we excluded participants who had been interviewed by one of the six interviewers with the highest or lowest three means among their respective respondents.

We used a two-sided significance level of 0.05 to conduct all statistical tests using Stata version 16.1.

3. Results

3.1 Descriptive results

Socio-demographic characteristics of the sample are reported in **Table 1**. No covariates were found to be unbalanced between study arms. The study was roughly distributed proportionately across all six states, with about half of the sample in urban areas and a quarter each in semi-urban and peri-rural areas. The sample was comprised of approximately half women and half with an education <12years, and the majority of the sample were able to pay the bills and buy what they need. Approximately 40% completed the interview in mixed language.

Table 1. Socio-demographic characteristics of the sample.

		Control	**Warning**	**GDA**	**HSR**	**MTL**	**Total**
		n = 574	n = 598	n = 554	n = 601	n = 542	n = 2869
	P-value	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
State	0.114						
Odisha		79 (13.8)	94 (15.7)	92 (16.6)	88 (14.6)	83 (15.3)	436 (15.2)
Uttar Pradesh		83 (14.5)	89 (14.9)	102 (18.4)	90 (15.0)	91 (16.8)	455 (15.9)
Assam		99 (17.2)	110 (18.4)	92 (16.6)	90 (15.0)	75 (13.8)	466 (16.2)
Delhi		110 (19.2)	82 (13.7)	94 (17.0)	108 (18.0)	97 (17.9)	491 (17.1)
Karnataka		96 (16.7)	119 (19.9)	94 (17.0)	120 (20.0)	84 (15.5)	513 (17.9)

 doi:10.20944/preprints202205.0058.v1

Gujarat		107 (18.6)	104 (17.4)	80 (14.4)	105 (17.5)	112 (20.7)	508 (17.7)
Urbanicity	0.603						
Urban		307 (53.5)	289 (48.3)	286 (51.6)	309 (51.4)	285 (52.6)	1476 (51.4)
Semi-Urban		133 (23.2)	168 (28.1)	131 (23.6)	149 (24.8)	124 (22.9)	705 (24.6)
Peri-rural		134 (23.3)	141 (23.6)	137 (24.7)	143 (23.8)	133 (24.5)	688 (24.0)
Age category	0.880						
18-30y		195 (34.0)	209 (34.9)	176 (31.8)	205 (34.1)	190 (35.1)	975 (34.0)
31-40y		200 (34.8)	220 (36.8)	212 (38.3)	211 (35.1)	187 (34.5)	1030 (35.9)
41-60y		179 (31.2)	169 (28.3)	166 (30.0)	185 (30.8)	165 (30.4)	864 (30.1)
Gender	0.933						
Man		290 (50.5)	301 (50.3)	286 (51.6)	298 (49.6)	266 (49.1)	1441 (50.2)
Woman		284 (49.5)	297 (49.7)	268 (48.4)	303 (50.4)	276 (50.9)	1428 (49.8)
Education level	0.098						
< 12 years		256 (44.6)	237 (39.6)	254 (45.8)	255 (42.4)	254 (46.9)	1256 (43.8)
≥12 years		318 (55.4)	361 (60.4)	300 (54.2)	346 (57.6)	288 (53.1)	1613 (56.2)
Salty biscuit intake	0.279						
<1x/week		171 (29.8)	167 (27.9)	167 (30.1)	188 (31.3)	166 (30.6)	859 (29.9)
1x/ week		189 (32.9)	211 (35.3)	159 (28.7)	200 (33.3)	189 (34.9)	948 (33.0)
>1x/ week		214 (37.3)	220 (36.8)	228 (41.2)	213 (35.4)	187 (34.5)	1062 (37.0)
Sweet biscuit intake	0.068						
<1x/week		112 (19.5)	112 (18.7)	119 (21.5)	142 (23.6)	118 (21.8)	603 (21.0)
1x/ week		164 (28.6)	155 (25.9)	164 (29.6)	158 (26.3)	122 (22.5)	763 (26.6)
>1x/ week		298 (51.9)	331 (55.4)	271 (48.9)	301 (50.1)	302 (55.7)	1503 (52.4)
Bread intake	0.696						
<1x/week		137 (23.9)	169 (28.3)	146 (26.4)	156 (26.0)	130 (24.0)	738 (25.7)
1x/ week		148 (25.8)	151 (25.3)	145 (26.2)	168 (28.0)	148 (27.3)	760 (26.5)
>1x/ week		289 (50.3)	278 (46.5)	263 (47.5)	277 (46.1)	264 (48.7)	1371 (47.8)
Fruit drink intake	0.139						
<1x/week		245 (42.7)	231 (38.6)	248 (44.8)	251 (41.8)	228 (42.1)	1203 (41.9)
1x/ week		141 (24.6)	139 (23.2)	139 (25.1)	137 (22.8)	145 (26.8)	701 (24.4)
>1x/ week		188 (32.8)	228 (38.1)	167 (30.1)	213 (35.4)	169 (31.2)	965 (33.6)
Noodles intake	0.515						
<1x/week		201 (35.0)	202 (33.8)	206 (37.2)	238 (39.6)	190 (35.1)	1037 (36.1)
1x/ week		139 (24.2)	144 (24.1)	139 (25.1)	145 (24.1)	139 (25.6)	706 (24.6)
>1x/ week		234 (40.8)	252 (42.1)	209 (37.7)	218 (36.3)	213 (39.3)	1126 (39.2)
Financial situation	0.212						
Can pay bills, buy needed and additional things		216 (37.6)	247 (41.3)	208 (37.5)	240 (39.9)	200 (36.9)	1111 (38.7)
Can pay bills, buy what is needed		251 (43.7)	251 (42.0)	259 (46.8)	257 (42.8)	261 (48.2)	1279 (44.6)
Can only pay bills		86 (15.0)	80 (13.4)	57 (10.3)	78 (13.0)	60 (11.1)	361 (12.6)

Cannot pay bills		21 (3.7)	20 (3.3)	30 (5.4)	26 (4.3)	21 (3.9)	118 (4.1)
Mixed language	0.274						
Yes		231 (40.2)	242 (40.5)	204 (36.8)	251 (41.8)	234 (43.2)	1162 (40.5)

Note: Intake was measured as self-reported frequency of weekly consumption over previous 30 days. Mixed language reflects whether the language was conducted bilingually in the native state language and English. The P-value is from a chi-square test for differences by arm.

Overall descriptive results for all label and product assessment outcomes can be found in **Appendix C**. Descriptive results for label choice can be found in **Appendix D**.

Descriptive results for the primary outcomes by product type can be found in **Appendix E**. For the percent of participants who correctly identified all products high in nutrient(s) of concern, there were some observable differences by product type, with the highest percentage of participants in the control group correctly identifying the fruit drink (60.5%) and the lowest percentage identifying the sweet biscuit (24.7%). Thus, the difference between each FOPL and the control arm was smaller for all FOPL types for fruit drinks relative to most other product types. In contrast, the difference between each FOPL and the control arm tended to be higher for noodles and savory biscuits relative to the other products, though this varied somewhat by FOPL type. There were minimal differences by product type for intentions to purchase.

Descriptive results for the primary outcomes by state can be found in **Appendix F**. In the control group, Assam and Delhi were the states that had the lowest percentage of participants correctly identified products as containing high levels of nutrient(s) of concern (25.9% and 24.4%, respectively), while Uttar Pradesh and Karnataka were the highest (53.0% and 56.75%, respectively). For all FOPL types, the difference between each FOPL and the control arm was the smallest for the state of Odisha. For most FOPLs, the difference between each FOPL and the control arm was the greatest for the state of Uttar Pradesh, followed by Gujarat.

There were also observable differences in intentions to purchase products high in nutrients of concern by state. In the control group, intentions to purchase were highest in Assam (3.1 ± 0.8) to the lowest in Delhi (2.3 ± 1.1) and Gujarat (2.4 ± 1.0) and Odisha (2.4 ± 1.1)

3.2 Main results

Results on the primary outcomes can be found in **Figure 2** and **Figure 3.** Relative to the control group (39.1% of participants; 95% CI 32.0, 46.2), each FOPL led to an increase in the percentage of participants who correctly identified all products with high levels of nutrient(s) of concern, with the biggest differences observed for the warning label (60.8%, 95% CI 53.5, 68.0; p<0.001) followed by the traffic light label (54.8%, 95% CI 47.9, 61.8; p<0.001), GDA label (55.0%, 95% CI 47.1, 62.9; p<0.001), and HSR label (45.0%, 95% CI 37.2, 52.8; p<0.01). Relative to the control label (2.6, 95% CI 2.5, 2.7), only the warning label led to a reduction in intentions to consume (2.5, 95% CI 2.4, 2.5; p<0.01). Full numerical results for both outcomes are shown in **Appendix G.**

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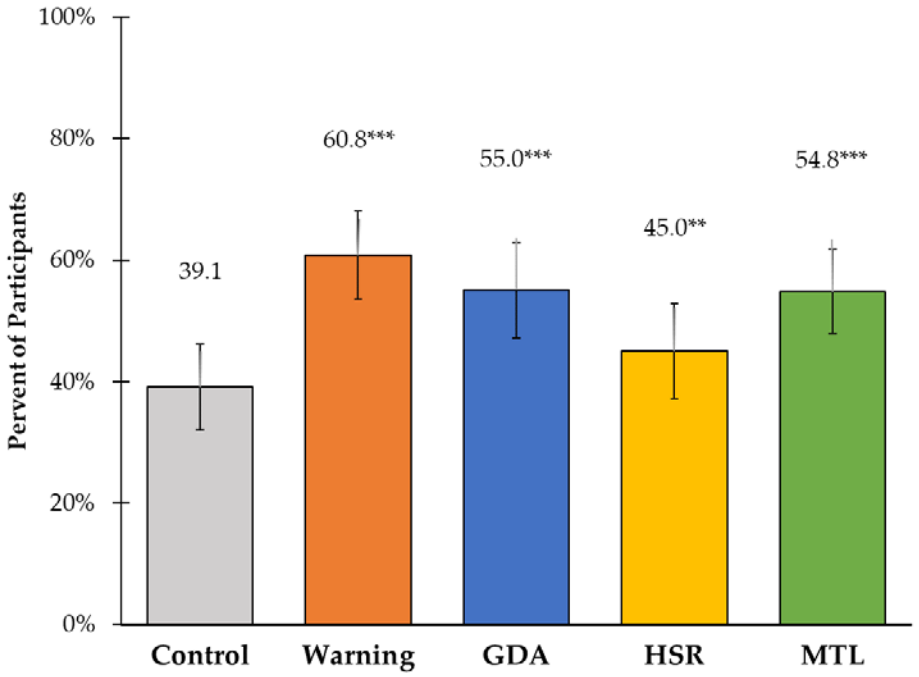
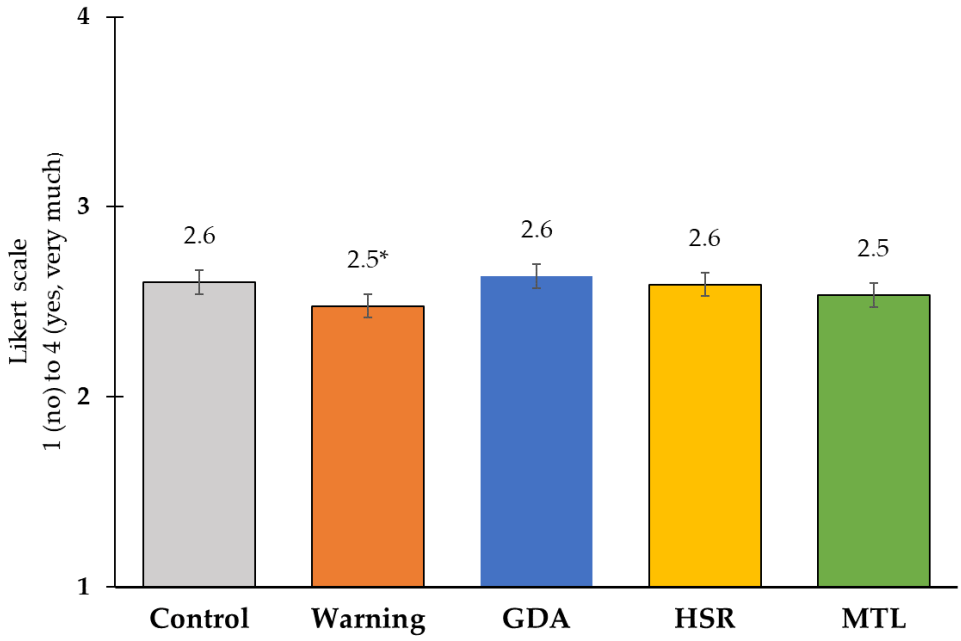


*** P-value <0.001 relative to the control label; ** P-value <0.01; * P-value <0.05; GDA= Guideline Daily Amounts, HSR= Health Star Rating, MTL= Multiple Traffic Light Label.

Figure 2. Percent of participants who correctly identified that products were high in nutrient(s) of concern, by study arm



** P-value <0.001 relative to the control label; ** P-value <0.01; * P-value <0.05; GDA= Guideline Daily Amounts, HSR= Health Star Rating, MTL= Multiple Traffic Light Label.

Figure 3. Mean purchase intentions, by study arm

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Results on other secondary outcomes can be found in **Table 2.** Relative to the control group (1.7, 95% CI 1.5, 1.8), each FOPL led to an increase in perceived message effectiveness, with the biggest difference observed for the warning label (2.1, 95% CI 1.9, 2.3; p<0.001), followed by the traffic light label (2.0, 95% CI 1.9, 2.2; p<0.001) and the GDA label (1.9, 95% CI 1.7, 2.0; p<0.001) and HSR label (1.9, 95% CI 1.8, 2.1; p<0.001).

Relative to the control group, all FOPL types led to increases in perceptions that products were unhealthy, while all but the HSR led to increases in perceptions that products were visually attractive (p<0.05 for all comparisons). With regards to label perceptions, relative to the control group, all FOPLs were rated higher as being attention-grabbing, making participants concerned about the health consequences of consuming the product, as being understandable, and as teaching them something new (p<0.05 for all comparisons). Relative to the control label, all FOPLs except for the HSR were rated higher on being true, while only the GDA and traffic light label were rated higher on being likable.

Table 2. Label reactions and product perceptions by arm, mean (95% CI)

	Control	Warning	p	GDA	p	HSR	P	MTL	p
Product perceptions									
Product is…									
Unhealthy	1.7 (1.6, 1.8)	2.1 (2.1, 2.2)	<0.001	1.9 (1.9, 2.0)	<.0.001	1.8 (1.8, 1.9)	0.002	2.0 (1.9, 2.1)	<0.001
Visually attractive	2.7 (2.6,2.8)	2.8 (2.7, 2.9)	0.048	2.9 (2.8, 3.0)	<0.001	2.8 (2.7, 2.8)	0.142	2.9 (2.7, 2.9)	0.004
Label reactions									
The label….									
Grabs attention	2.7 (2.6, 2.9)	2.9 (2.8, 3.1)	0.031	3.0 (2.8, 3.1)	0.004	2.8 (2.7,3.0)	0.040	3.0 (2.8, 3.1)	0.004
Makes me concerned about health consequences	1.9 (1.8, 1.9)	2.4 (2.3, 2.5)	<0.001	2.3 (2.2, 2.3)	<0.001	2.2 (2.1, 2.2)	<0.001	2.3 (2.2, 2.4)	<0.001
Is understandable	2.4 (2.2, 2.6)	2.8 (2.7, 3.0)	<0.001	2.8 (2.7, 3.0)	<0.001	2.7 (2.6, 2.9)	<0.001	2.7 (2.6, 2.9)	<0.001
Taught me something new	2.3 (2.1, 2.5)	2.8 (2.6, 3.0)	<0.001	2.8 (2.6, 3.0)	<0.001	2.7 (2.5, 2.8)	<0.001	2.7 (2.5, 2.9)	<0.001
Is true	2.6 (2.5, 2.7)	2.9 (2.7, 3.0)	<0.001	2.9 (2.7, 3.1)	<0.001	2.7 (2.5, 2.8)	0.066	2.8 (2.6, 3.0)	0.006
Liking the label	2.7 (2.5,2.9)	2.9 (2.7, 3.0)	0.072	2.9 (2.8,3.1)	0.035	2.8 (2.7,3.0)	0.054	2.9 (2.8,3.1)	0.006
PME	1.7 (1.5, 1.8)	2.1 (1.9,2.3)	<0.001	1.9 (1.7, 2.0)	<0.001	1.9 (1.8 2.1)	<0.001	2.0 (1.8, 2.2)	<0.001)

PME= perceived message effectiveness

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3.3 Moderation by sociodemographic and behavioral characteristics.

Results on moderation of the main outcomes by FOPL type can be found in **Tables 3** and **4**. For the ability to correctly identify all products high in nutrient(s) of concern, there was no moderation by any variable except for state (**Table 3**). For the impact of FOPLs on participants' ability to correctly identify products high in nutrients of concern, the pattern of results suggested that the impact of FOPLS was greatest among Uttar Pradesh. This state had the biggest differences between FOPL type (GDA, HSR, MTL) and control (or second biggest differences, for warning labels). In contrast, the impact of FOPLs was smallest in Odisha, with FOPLs either leading to no statistical difference compared to the control (warning labels, GDA, MTL) or a negative difference (HSR). Despite these differences there was some degree of consistency in the difference between FOPLs and the control across states, with the pattern of results generally showing the biggest differences for warnings, then for GDA or MTL, and relatively small differences for HSR.

Table 3. Effect of FOPL type on the percent of participants who correctly identified products high in nutrients of concern by moderation of socio-demographic characteristics

	Control	**Warning**		**GDA**		**HSR**		**MTL**	
	% (95% CI)	% (95% CI)	P[a]	% (95% CI)	P[a]	% (95% CI)	P[a]	% (95% CI)	P[a]
Education									
< 12 years	35.2 (27.3, 43.1)	51.5 (42.3, 60.6)	0.000	49.5 (40.3, 58.7)	0.000	45.2 (36.3, 54.2)	0.002	46.7 (37.9, 55.6)	0.000
≥12 years	42.3 (34.8, 49.8)	66.6 (59.5, 73.7)	0.000	59.6 (51.9, 67.3)	0.000	44.8 (36.3, 53.4)	0.437	61.8 (54.7, 68.9)	0.000
P[b]		**0.073**		**0.469**		**0.120**		**0.074**	
Language of interview									
State language	41.5 (34.1, 48.8)	63.3 (55.6, 71.1)	0.000	54.9 (45.4, 64.4)	0.001	44.6 (35.6, 53.6)	0.279	57.6 (50.8, 64.4)	0.000
Mixed (state language and English)	35.5 (23.8, 47.3)	57.0 (44.2, 69.7)	0.001	55.2 (42.9, 67.5)	0.000	45.7 (33.4, 57.9)	0.002	51.0 (38.0, 64.1)	0.001
P[b]		**0.955**		**0.354**		**0.103**		**0.910**	
Urbanicity									
Urban	40.0	59.9 (52.7, 67.1)	0.000	54.0 (44.4, 63.5)	0.001	47.3 (39.2, 55.3)	0.013	54.6 (47.0, 62.2)	0.000

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	(32.2, 47.7)							
Semi-Urban	44.1 (36.0, 52.2)	68.0 (59.9, 76.0)	0.000	58.7 (48.8, 68.7)	0.004	44.8 (34.1, 55.4)	0.858	55.7 (46.2, 65.1)	0.015
Peri-rural	32.2 (24.1, 40.3)	53.8 (44.0, 63.5)	0.000	53.6 (45.7, 61.5)	0.000	40.4 (30.4, 50.5)	0.054	54.6 (46.7, 62.4)	0.000
P[b]		**0.678**		**0.273**		**0.244**		**0.135**	
Gender									
Men	40.6 (32.3, 48.9)	61.2 (54.4, 68.0)	0.000	54.2 (45.5, 62.9)	0.000	46.6 (37.9, 55.2)	0.094	54.3 (46.0, 62.7)	0.000
Women	37.6 (30.1, 45.2)	60.4 (51.4, 69.3)	0.000	55.9 (46.4, 65.4)	0.000	43.5 (34.8, 52.2)	0.054	55.3 (47.5, 63.0)	0.000
P[b]		**0.607**		**0.316**		**0.981**		**0.301**	
State									
Odisha	47.1 (32.2, 62.1)	46.4 (30.9, 62.0)	0.923	50.4 (36.7, 64.0)	0.521	39.1 (24.0, 54.2)	0.024	42.7 (25.5, 59.8)	0.322
Uttar Pradesh	54.1 (32.7, 75.5)	86.0 (76.7, 95.2)	0.002	86.0 (77.7, 94.3)	0.001	68.5 (47.1, 90.0)	0.011	78.9 (68.0, 89.8)	0.012
Assam	25.8 (11.3, 40.3)	47.2 (34.7, 59.8)	0.002	33.2 (19.5, 47.0)	0.138	21.9 (6.0, 37.9)	0.121	45.8 (31.2, 60.3)	0.002
Delhi	23.2 (9.1, 37.3)	59.5 (42.5, 76.5)	0.000	42.6 (27.6, 57.5)	0.037	30.4 (23.1, 37.8)	0.229	42.0 (27.2, 56.8)	0.014
Karnataka	57.4 (43.8, 71.0)	72.2 (58.4, 86.0)	0.000	60.7 (47.0, 74.4)	0.178	63.4 (51.8, 75.0)	0.026	64.8 (55.4, 74.3)	0.046
Gujarat	33.4 (18.2, 48.6)	53.8 (34.6, 73.1)	0.023	52.4 (34.5, 70.3)	0.063	44.5 (24.2, 64.8)	0.109	53.0 (36.8, 69.2)	0.006
P[b]		**0.025**		**0.027**		**0.000**		**0.002**	

Table continued, next page

 doi:10.20944/preprints202205.0058.v1

	Control % (95% CI)	Warning % (95% CI)	P[a]	GDA % (95% CI)	P[a]	HSR % (95% CI)	P[a]	MTL % (95% CI)	P[a]
Sweet biscuit intake									
<1x/week	25.0 (13.1, 36.9)	51.8 (36.4, 67.2)	0.000	36.1 (22.7, 49.5)	0.071	27.5 (16.4, 38.6)	0.645	36.4 (27.0, 45.9)	0.050
1x/ week	22.0 (14.0, 29.9)	39.4 (27.1, 51.6)	0.002	35.4 (22.1, 48.6)	0.013	27.8 (16.2, 39.5)	0.231	29.5 (20.1, 38.9)	0.095
>1x/ week	26.2 (15.9, 36.5)	49.2 (38.7, 59.8)	0.000	42.4 (29.7, 55.1)	0.001	30.9 (19.6, 42.2)	0.218	36.8 (26.4, 47.2)	0.006
P[b]		**0.347**		**0.732**		**0.894**		**0.788**	
Bread intake									
<1x/week	42.3 (31.0, 53.7)	66.3 (54.8, 77.7)	0.000	50.0 (39.4, 60.6)	0.205	50.0 (37.8, 62.2)	0.320	61.5 (52.7, 70.4)	0.002
1x/ week	50.0 (37.0, 63.0)	62.9 (48.6, 77.2)	0.091	54.5 (41.9, 67.1)	0.555	50.0 (38.0, 62.0)	1.000	60.8 (48.1, 73.5)	0.110
>1x/ week	45.0 (35.2, 54.8)	73.0 (64.8, 81.2)	0.000	61.6 (50.0, 73.2)	0.001	48.0 (36.7, 59.3)	0.455	62.5 (51.4, 73.6)	0.004
P[b]		**0.148**		**0.292**		**0.718**		**0.582**	
Fruit drink intake									
<1x/week	58.4 (47.2, 69.6)	75.8 (66.0, 85.5)	0.000	73.8 (63.0, 84.5)	0.005	69.7 (57.6, 81.8)	0.041	75.0 (62.7, 87.3)	0.000
1x/ week	59.6 (46.6, 72.6)	79.1 (68.7, 89.6)	0.004	77.0 (66.4, 87.6)	0.012	61.3 (44.5, 78.1)	0.798	75.2 (64.4, 86.0)	0.017
>1x/ week	63.8 (52.2, 75.5)	76.3 (66.1, 86.5)	0.020	70.7 (58.6, 82.7)	0.264	59.2 (47.0, 71.3)	0.365	70.4 (60.2, 80.6)	0.266

P^b		**0.522**		**0.363**		**0.138**		**0.336**	
Noodle intake									
<1x/week	31.3 (20.9, 41.8)	62.9 (52.5, 73.2)	0.000	48.5 (36.9, 60.2)	0.004	44.1 (30.6, 57.6)	0.028	54.7 (46.5, 63.0)	0.000
1x/ week	29.5 (18.2, 40.8)	54.2 (41.6, 66.8)	0.000	47.5 (36.7, 58.3)	0.004	44.1 (34.0, 54.3)	0.007	41.7 (30.1, 53.4)	0.070
>1x/ week	27.4 (18.4, 36.3)	46.8 (35.0, 58.6)	0.000	45.9 (33.6, 58.3)	0.002	34.4 (22.9, 45.9)	0.097	53.5 (41.4, 65.6)	0.000
P^b		**0.207**		**0.983**		**0.559**		**0.218**	
Savory biscuit intake									
<1x/week	32.7 (20.8, 44.7)	52.7 (38.9, 66.5)	0.001	52.1 (40.7, 63.4)	0.000	46.3 (33.9, 58.6)	0.013	53.6 (43.4, 63.9)	0.001
1x/ week	40.2 (29.2, 51.2)	59.2 (48.8, 69.7)	0.002	57.2 (45.2, 69.3)	0.010	40.5 (29.6, 51.4)	0.951	51.9 (41.5, 62.2)	0.037
>1x/ week	34.6 (22.9, 46.3)	60.0 (47.4, 72.6)	0.000	61.0 (47.3, 74.7)	0.000	44.6 (30.3, 58.9)	0.017	57.8 (42.2, 73.3)	0.001
P^b		**0.673**		**0.344**		**0.096**		**0.267**	

Note: P^a is the value for the difference between each FOPL type and the control. P^b is the value for equal differences with the control mean across moderation levels, within FOPL arm.

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For intentions to purchase, there was no moderation by most variables (**Table 4)**. For the HSR label, there was moderation by urbanicity such that the effect of HSR was greater for semi-urban and peri-rural areas than for urban areas (p=0.004).

Table 4. Effect of FOPL type on intentions to consume products high in nutrients of concern by moderation of socio-demographic characteristics

	Control	Warning		GDA		HSR		MTL	
	Mean (95% CI)	Mean (95% CI)	P[a]	Mean (95% CI)	P[a]	Mean (95% CI)	P[a]	Mean (95% CI)	P[a]
Education									
< 12 years	2.6 (2.4, 2.8)	2.5 (2.3, 2.7)	0.408	2.6 (2.5, 2.8)	0.507	2.6 (2.5, 2.8)	0.743	2.5 (2.4, 2.7)	0.405
≥12 years	2.6 (2.5, 2.8)	2.4 (2.3, 2.6)	0.014	2.6 (2.5, 2.8)	0.875	2.6 (2.4, 2.7)	0.433	2.5 (2.4, 2.7)	0.256
P[b]		0.298		0.647		0.503		0.941	
Language of interview									
State language	2.7 (2.5, 2.9)	2.6 (2.4, 2.8)	0.086	2.7 (2.5, 2.9)	0.801	2.7 (2.5, 2.8)	0.446	2.6 (2.4, 2.8)	0.159
Mixed (state language and English)	2.4 (2.2, 2.7)	2.3 (2.1, 2.5)	0.115	2.5 (2.3, 2.7)	0.284	2.5 (2.3, 2.6)	0.606	2.4 (2.2, 2.6)	0.906
P[b]		0.720		0.329		0.377		0.312	
Urbanicity									
Urban	2.6 (2.4, 2.8)	2.4 (2.3, 2.6)	0.005	2.6 (2.5, 2.8)	0.793	2.5 (2.3, 2.6)	0.033	2.5 (2.4, 2.7)	0.256
Semi-Urban	2.6 (2.4, 2.7)	2.6 (2.4, 2.8)	0.643	2.7 (2.6, 2.9)	0.053	2.7 (2.5, 2.8)	0.139	2.5 (2.3, 2.6)	0.299
Peri-rural	2.6 (2.4, 2.9)	2.4 (2.2, 2.6)	0.033	2.6 (2.4, 2.8)	0.508	2.7 (2.6, 2.9)	0.312	2.6 (2.4, 2.9)	0.944
P[b]		0.055		0.208		0.004		0.780	
Gender									
Men	2.6 (2.4, 2.8)	2.5 (2.3, 2.7)	0.113	2.7 (2.5, 2.9)	0.705	2.6 (2.4, 2.8)	0.741	2.6 (2.4, 2.8)	0.501
Women	2.6 (2.4, 2.8)	2.4 (2.3, 2.6)	0.070	2.6 (2.5, 2.8)	0.728	2.6 (2.4, 2.7)	0.992	2.5 (2.3, 2.7)	0.235
P[b]		0.765		0.916		0.806		0.788	
State									
Odisha	2.4 (2.1, 2.7)	2.2 (2.0, 2.5)	0.123	2.2 (1.9, 2.4)	0.061	2.2 (2.0, 2.5)	0.033	2.1 (1.8, 2.4)	0.002
Uttar Pradesh	2.7 (2.2, 3.1)	2.6 (2.3, 3.0)	0.945	2.8 (2.4, 3.1)	0.610	2.7 (2.4, 3.0)	0.976	2.8 (2.4, 3.1)	0.552
Assam	3.1 (2.9, 3.3)	2.8 (2.7, 3.0)	0.043	3.1 (2.9, 3.3)	0.951	3.1 (2.8, 3.3)	0.714	3.0 (2.9, 3.1)	0.217
Delhi	2.3 (2.1, 2.6)	2.0 (1.6, 2.3)	0.004	2.5 (2.2, 2.8)	0.250	2.4 (2.1, 2.6)	0.663	2.3 (2.1, 2.5)	0.910
Karnataka	2.7 (2.5, 2.9)	2.8 (2.5, 3.1)	0.362	2.8 (2.6, 3.0)	0.322	2.7 (2.5, 2.9)	0.707	2.7 (2.4, 3.1)	0.847
Gujarat	2.4 (2.0, 2.9)	2.2 (1.8, 2.6)	0.015	2.4 (2.1, 2.7)	0.900	2.5 (2.1, 2.8)	0.808	2.4 (2.1, 2.7)	0.608
P[b]		0.056		0.304		0.492		0.177	
Sweet biscuit intake									
<1x/week	2.6 (2.3, 2.8)	2.5 (2.2, 2.7)	0.555	2.5 (2.3, 2.8)	0.845	2.5 (2.3, 2.7)	0.654	2.3 (2.1, 2.5)	0.048
1x/ week	2.6 (2.4, 2.8)	2.5 (2.3, 2.7)	0.341	2.7 (2.5, 2.9)	0.470	2.7 (2.5, 2.8)	0.337	2.7 (2.5, 2.9)	0.407
>1x/ week	2.7 (2.5, 2.9)	2.5 (2.3, 2.7)	0.056	2.7 (2.5, 3.0)	0.675	2.7 (2.5, 2.9)	0.884	2.6 (2.4, 2.9)	0.500
P[b]		0.820		0.718		0.627		0.070	

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Bread intake									
<1x/week	2.5 (2.3, 2.8)	2.4 (2.1, 2.7)	0.470	2.5 (2.3, 2.7)	0.768	2.5 (2.2, 2.7)	0.515	2.2 (2.0, 2.4)	0.029
1x/ week	2.6 (2.3, 2.9)	2.4 (2.1, 2.7)	0.079	2.5 (2.3, 2.6)	0.207	2.6 (2.4, 2.7)	0.716	2.6 (2.3, 2.8)	0.779
>1x/ week	2.7 (2.5, 2.9)	2.6 (2.4, 2.8)	0.527	2.8 (2.6, 3.0)	0.212	2.8 (2.7, 3.0)	0.112	2.7 (2.4, 2.9)	0.663
P^b		0.724		0.142		0.325		0.140	
Fruit drink intake									
<1x/week	2.5 (2.3, 2.8)	2.4 (2.1, 2.7)	0.271	2.6 (2.4, 2.8)	0.437	2.5 (2.3, 2.7)	0.996	2.3 (2.1, 2.6)	0.100
1x/ week	2.5 (2.3, 2.8)	2.4 (2.2, 2.6)	0.485	2.5 (2.3, 2.7)	0.876	2.6 (2.4, 2.8)	0.470	2.6 (2.4, 2.8)	0.491
>1x/ week	2.7 (2.5, 2.8)	2.5 (2.3, 2.7)	0.094	2.7 (2.5, 3.0)	0.453	2.7 (2.5, 2.8)	0.974	2.6 (2.4, 2.9)	0.940
P^b		0.765		0.886		0.790		0.220	

Table continued, next page

	Mean (95% CI)	Mean (95% CI)	P^a	Mean (95% CI)	P^a	Mean (95% CI)	P^a	Mean (95% CI)	P^a
Noodle intake									
<1x/week	2.5 (2.3, 2.7)	2.4 (2.1, 2.7)	0.556	2.4 (2.2, 2.7)	0.826	2.4 (2.2, 2.6)	0.337	2.3 (2.1, 2.5)	0.033
1x/ week	2.6 (2.3, 2.8)	2.4 (2.2, 2.6)	0.096	2.7 (2.5, 2.9)	0.159	2.5 (2.3, 2.7)	0.559	2.6 (2.4, 2.8)	0.950
>1x/ week	2.6 (2.3, 2.9)	2.5 (2.3, 2.6)	0.203	2.6 (2.5, 2.8)	0.746	2.6 (2.3, 2.8)	0.882	2.6 (2.4, 2.8)	0.818
P^b		0.782		0.500		0.840		0.208	
Savory biscuit intake									
<1x/week	2.5 (2.3, 2.7)	2.5 (2.3, 2.7)	0.886	2.5 (2.3, 2.8)	0.606	2.4 (2.2, 2.7)	0.639	2.5 (2.3, 2.7)	0.710
1x/ week	2.7 (2.4, 2.9)	2.5 (2.4, 2.7)	0.263	2.6 (2.4, 2.8)	0.592	2.6 (2.4, 2.8)	0.449	2.7 (2.5, 2.9)	0.959
>1x/ week	2.8 (2.5, 3.0)	2.5 (2.3, 2.8)	0.012	2.7 (2.5, 3.0)	0.957	2.8 (2.6, 3.0)	0.834	2.6 (2.3, 3.0)	0.325
P^b		0.329		0.739		0.783		0.636	

Note: P^a is the value for the difference between each FOPL type and the control. P^b is the value for equal differences with the control mean across moderation levels, within FOPL arm.

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Label selection

The results for when participants were asked which label they prefer are shown in **Figure 4**. Warning labels were most often selected as most likely to discourage consumption of the high-in products by adults, and warnings, GDA, and HSR most often selected as the most likely to discourage feeding the products to children. Participants selected MTL as the easiest to understand label and GDA as the most informative label.

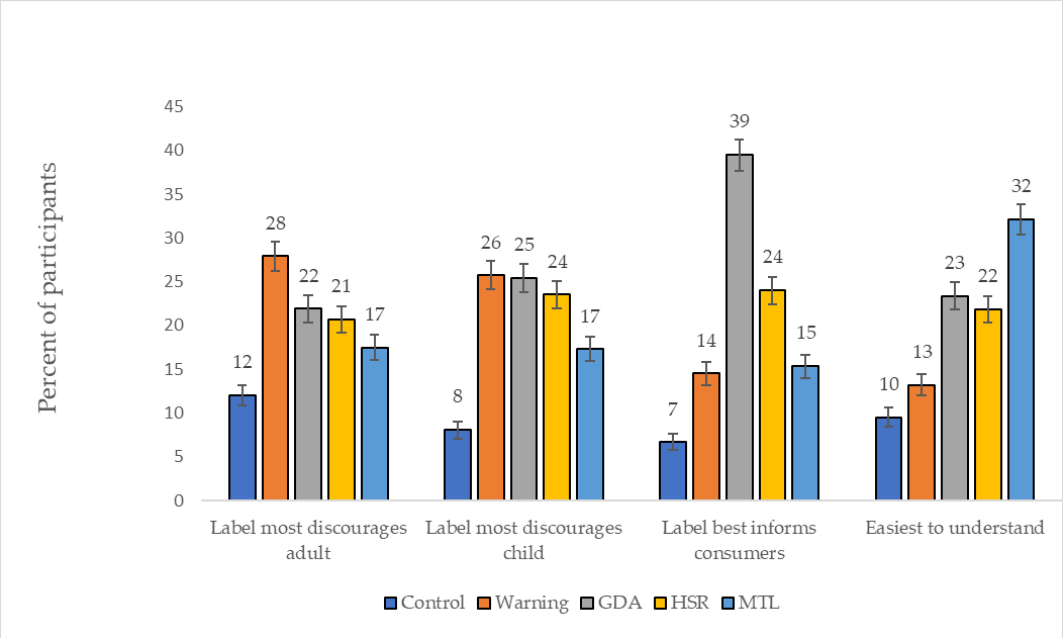

Figure 4. Percent of participants selecting a particular FOPL

Sensitivity analyses

Results from the sensitivity analyses of main outcomes excluding respondents who were interviewed by interviewers with the highest or lowest means are found in **Appendix H**. There was no difference in the pattern of results for either outcome.

4. Discussion

This experimental in-person study of adults in six states of India found that, relative to a control label, FOPLs improved participant's ability to correctly identify products high in nutrients of concern, including sugar, saturated fat, and sodium. The warning label showed the biggest impact on this outcome and was also the only FOPL to reduce participants' intentions to purchase these unhealthy products. Warning labels also showed the biggest impact on a number of secondary outcomes, including perceived message effectiveness, an outcome that has been previously shown to predict behavioral change.[67]

The finding that warning labels were the most effective FOPL on the pre-specified primary outcomes-- helping consumers identify products high in nutrients of concern and reducing intentions to purchase these products-- is consistent with prior conceptual frameworks, empirical evidence, and public health goals.

First, the conceptual framework for nutrient warnings posits that they are particularly well suited to reduce consumption of 'high-in' products because of their binary nature,

which facilitates quick decisions, and their ability to signal a warning, which communicates action (to discourage consumption). [35, 68] Second, our study results are consistent with other empirical evidence in India and elsewhere. For example, our finding that warnings were the only FOPL to impact behavioral intentions is consistent with a separate recent study conducted on FOPLs among Indian consumers, which also found that, compared to GDA and HSR labels, the warnings led to the biggest impact on intentions to purchase unhealthy products. [69] In addition, our findings are consistent with a recently published systematic review of randomized controlled trials and quasi-experiments, which found that warning labels were more effective than color coded labels (e.g., traffic lights) in discouraging unhealthy food purchasing behavior.[36]

It is worth noting that there is some controversy in the field about which public health goals should be prioritized when it comes to the desired outcome of an FOPL system. The current study was designed to test FOPLs' impact on antecedents to reducing purchases of foods and drinks high in nutrients of concern because global dietary recommendations consistently agree on the importance on preventing or reducing consumption of excess amounts of sugar, sodium, saturated fat, and added sugar.[70-72] These results suggest that warning labels hold the most promise for helping Indian consumers identify 'high-in' products and discourage their consumption, though these findings should be replicated in a behavioral trial in which actual purchases or intake behaviors are measured.

In contrast, this study found that the HSR system was the lowest-performing FOPL (relative to the control) with regards to helping consumers identify "high-in" products, and had no impact on behavioral intentions. These findings are consistent with a recent study which found that even when only a single star is displayed, warning labels outperform the HSR system in reducing intention to purchase 'high-in' products[73]. In addition, a recent experiment among Colombian adults found that the HSR consistently performed worse than the warning label on multiple outcomes, including identifying "high in" products and reducing intentions to purchase these products[74].

One likely reason for the HSR's low performance is that it was designed with different public goals in mind. While warnings are designed with the goal to discourage the most unhealthy purchases, while others, like the HSR are designed to nudge towards "healthier" purchases. Previous studies have showed that the HSR help consumers rank products based on healthfulness [75] and help nudge them towards healthier choices[76]. Yet, it is unclear from a health perspective whether shifting consumers from a lower-scoring product to a higher-scoring product will result in meaningful gains for health. This of particular concern because in a mandatory HSR system, ultraprocessed products could be eligible to carry up to 5 stars, implying that these products are healthier and should be encouraged- despite a rapdily growing body of evidence from controlled feeding studies and from many prospective cohort studies showing that ultraprocessed foods are linked to weight gain, overweight/obesity, and an array of adverse cardiometabolic effects[17, 25, 77-98] In addition, others have criticized the HSR system for misrepresenting nutrition science,[99] in part due to the use of an algorithm that does not reflect how human metabolism works (e.g., the presence of beneficial ingredients such as fiber or protein does not offset the harms of sugar, sodium, or saturated fat). To design an effective FOPL system for Indian consumers, policymakers should consider not only the design of the FOPL itself, but the underlying nutirtional profile and health goal (e.g., reducing consumption of the most unhealthy items vs. encouraging healthier (yet likely to be ultraprocessed) options).

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With regards to secondary outcomes on product perceptions and label reactions, outcomes were mixed, though the pattern suggested a strong performance of warning labels and poor performance for HSR. Warning labels performed best on perceived message effectiveness, a scale that reflects both message perceptions (judgments about how well the message will lead to persuasion) and effects perceptions (how well the message will change behavioral antecedents or the actual behavior).[100, 101] Perceived message effectiveness has been used in the development of many health messages across a range of products[102-104], and is predictive of behavioral change[67], offering further support for warnings as a strong FOPL to discourage consumption of "high-in" products among Indian consumers. Warning labels also performed best on other outcomes (identifying products as unhealthy, making participants concerned about health consequences) and similarly to the GDA and/or the MTL on other outcomes (understandable, taught me something new, is true, liking), though the magnitude of difference between FOPLs was small across all outcomes. The GDA and MTL performed best on grabbing attention and led to the smallest increase in visual attractiveness (a positive outcome, given that the goal is to decrease participants' desire to consume a product). The HSR performed worse than all other FOPL types tested (except the control) on every secondary outcome.

When shown all the FOPLS and asked to select which one they most preferred on a range of outcomes, results were mixed. Warning labels were most frequently chosen as the label that would most discourage consumption by adults or feeding the products to children. In contrast, GDA label and MTL label were selected as most informative and easiest to understand. However, there is no evidence that these preference measures are predictive of actual behavior change. In addition, conceptually, preference for or 'liking' of the label may inversely associated with the intended behavioral change (discouraging purchases) as they may attract consumers towards selecting the product.

With regards to effect modification by socio-demographic and dietary factors, our study found mixed results. Importantly, we found that the impact of FOPLS did not vary for high vs. low educated populations, which suggests that FOPLs hold promise as a population intervention across populations. On the other hand, this study did not assess literacy, and so were not able to understand whether the FOPLs performed well among illiterate populations, which is especially important considering that approximately a quarter of the population is illiterate (and this figure is higher amongst women and in rural areas). [105] Few studies have looked at FOPLS among illiterate populations. However, principles of visual communication suggest and empirical data shows that imagery can better convey health risk information than can text or numerical information, [106-109] particularly to low literacy groups. This suggests that the warning label (which in this study, carried icons depicting sugar, salt, and saturated fat) and the HSR (which uses stars) would hold an advantage over labels such as the traffic light or GDA label. Limited empirical data also illustrates the promise of using icons with warnings, in particular: one focus group study in South Africa suggested that warnings with icons would work well among illiterate population.[60] Other work from the US found that warnings with icons were perceived as more effective among populations with lower English language literacy.[109] Future research in India should test the effectiveness of FOPLs in populations with low literacy.

We did observe some differences in the impact of FOPL by state. While the pattern of results consistently found that warning labels performed best, the impact of FOPLs was the smallest in the state of Odisha, where FOPLs either had no impact (warnings, GDA, or MTL) or a negative impact (HSR), relative to the control. An effective FOPL policy for India should consider using a state-based educational campaign to ensure that the FOPL is well-understood and used across different populations.

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Limitations of this study included that it measured only participants' self-reported perceptions and reactions. Future experimental trials with more realistic products in more realistic settings that more closely mirror real-world food environments will be necessary. In addition, further testing in populations with low literacy will be important to ensuring that an FOPL system works well for all Indian consumers. Strengths of this study included the large sample, inclusion of six states (and five languages).

5. Conclusions

The results of this in-person randomized experiment found that warning labels performed best on helping Indian consumers identify products that are high in sugar, sodium, and saturated fat and were the only FOPL type to reduce intentions to purchase these products. This pattern of results suggests that the warning label is the optimal FOPL to achieve the goal of reducing purchases intakes of unhealthy products high in nutrients of concern. Replication of this study with behavioral outcomes would provide stronger evidence to support FOPL policies in the Indian population.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: De-identified data can be found at Open Science Framework at: [link to be posted when paper is published].

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Appendix A.

Figure A1. Images of products used, without FOPLs

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Appendix B. Codebook
Product Assessment

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Excs_sf	B10. Do you think this product has high [sugar/sodium/saturated fat]?	1 = Yes 0= No
Unhealthy_sf	B11a. Is this product unhealthy?	1 = Yes (Go to C11b) 0= No (Go to C12a)
	B11b. How unhealthy it is?	1 = Very much 2 = Somewhat 3 = Very little
Ppa_sf	B12a. Do you think this product is visually attractive?	1 = Yes (Go to C12b) 0= No (Go to C13a)
	B12b. How visually attractive is this product?	1 = Very much 2 = Somewhat 3 = Very little
Buy_lkly_sf	B13a. Will you purchase this product next week, if it were available?	1 = Yes (Go to C13b) 0= No
	B13b. How likely is it for you to want to purchase this product next week, if it were available?	1 = Very much 2 = Somewhat 3 = Very little

Label Assessment

Attention_sf	B1a. Does this label grab your attention?	1 = Yes (Go to C1b) 0= No (Go to C2a)
	B1b. How much does this label grab your attention?	1 = Very much 2 = Somewhat 3 = Very little
PME_conc_sf	B2a. Does the label make you feel concerned about the health consequences of consuming this product?	1 = Yes (Go to C2b) 0= No (Go to C3a)
	B2b. How concerned would you be about the health consequences of consuming this product?	1 = Very much 2 = Somewhat 3 = Very little
PME_unpl_sf	B3a. Does the label make this product seem unpleasant to you?	1 = Yes (Go to C3b) 0= No (Go to C4a)
	B3b. How unpleasant does this product seem to you?	1 = Very much 2 = Somewhat 3 = Very little
Pme_disc_sf	B4a. Does the label make you feel discouraged from wanting to consume this product?	1 = Yes (Got to C4b) 0= No (Go to C5a)
	B4b. How discouraged do you feel from wanting to consume this product?	1 = Very much 2 = Somewhat 3 = Very little

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Cog_elab_sf	B5a. Does the label make you think about the health problems caused by consuming this product?	1 = Yes (Go to C5b) 0= No (Go to C6a)
	B5b. How much does the label make you think about the health problems caused by consuming this product?	1 = Very much 2 = Somewhat 3 = Very little
Understand_sf	B6a. Do you understand what the label means?	1 = Yes (Go to C6b) 0= No (Go to C7a)
	B6b. How much do you understand what the label means?	1 = Very much 2 = Somewhat 3 = Very little
Learn_new_sf	B7a. Has the label taught you anything?	1 = Yes (Go to C7b) 0= No (Go to C8a)
	B7b. How much has the label taught you?	1 = Very much 2 = Somewhat 3 = Very little
Trust_sf	B8a. Do you think what label says is true?	1 = Yes (Go to C8b) 0= No (Go to C9a)
	B8b. How much do you think what the label says is true?	1 = Very much 2 = Somewhat 3 = Very little
Liking_sf	B9a. Do you like to have this label on the products?	1 = Yes (Go to C9b) 0= No (Go T0 10a)
	B9b. How much would you like for products to have the label?	1 = Very much 2 = Somewhat 3 = Very little

Appendix C.

Table. Descriptive statistics for the product and label assessment outcomes by arm

	n	Control	Warning	GDA	HSR	MTL
Product perceptions		**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Identified all "high-in" nutrients	14345	1125 (39.2)	1819 (60.8)	1517 (54.8)	1363 (45.4)	1495 (55.2)
		Mean (SD)	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
How likely would you be to buy this product next week?	14345	2.6 (1.1)	2.5 (1.0)	2.6 (1.0)	2.6 (1.0)	2.5 (1.1)
How unhealthy is this product?	14345	1.7 (1.0)	2.1 (1.2)	1.9 (1.2)	1.8 (1.1)	2.0 (1.2)
How visually attractive is this product?	14345	2.7 (1.1)	2.8 (1.0)	2.9 (1.0)	2.8 (1.0)	2.9 (1.0)
Label reactions						
Does the label grab your attention?	8607	2.7 (1.0)	2.9 (1.0)	3.0 (1.0)	2.8 (1.0)	3.0 (1.0)
Perceived message effectiveness	8607	1.7 (0.8)	2.1 (0.9)	1.9 (0.8)	1.9 (0.9)	2.0 (0.9)
Does the label make you think about health problems caused by this product?	8607	1.9 (1.1)	2.4 (1.2)	2.3 (1.2)	2.2 (1.2)	2.3 (1.2)

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Do you understand the label?	8607	2.4 (1.1)	2.8 (1.1)	2.8 (1.1)	2.7 (1.1)	2.8 (1.1)
Does the label teach you anything?	8607	2.3 (1.2)	2.8 (1.1)	2.8 (1.1)	2.7 (1.1)	2.7 (1.2)
Do you think what the label says is true?	8607	2.6 (1.1)	2.9 (1.1)	2.9 (1.0)	2.7 (1.1)	2.8 (1.1)
Do you like to have the label on this product?	8607	2.7 (1.1)	2.9 (1.0)	2.9 (1.0)	2.8 (1.0)	2.9 (1.0)

Note: Product perceptions were assessed on all 5 products, label reactions were assessed on 3 products.

Appendix D.

Table. Descriptive statistics for the label choice outcomes by arm

		Control	**Warning**	**GDA**	**HSR**	**MTL**
	n	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Which label discourages you most from consuming this product?	2869					
Control		66 (11.5)	73 (12.2)	61 (11.0)	80 (13.3)	65 (12.0)
Warning		174 (30.3)	171 (28.6)	137 (24.7)	161 (26.8)	158 (29.2)
GDA		113 (19.7)	124 (20.7)	125 (22.6)	149 (24.8)	117 (21.6)
HSR		124 (21.6)	131 (21.9)	110 (19.9)	126 (21.0)	102 (18.8)
MTL		97 (16.9)	99 (16.6)	121 (21.8)	85 (14.1)	100 (18.5)
Which label discourages you most from feeding this product to a child?	2869					
Control		52 (9.1)	54 (9.0)	43 (7.8)	41 (6.8)	41 (7.6)
Warning		140 (24.4)	146 (24.4)	138 (24.9)	174 (29.0)	140 (25.8)
GDA		148 (25.8)	164 (27.4)	153 (27.6)	139 (23.1)	125 (23.1)
HSR		136 (23.7)	139 (23.2)	126 (22.7)	148 (24.6)	126 (23.2)
MTL		98 (17.1)	95 (15.9)	94 (17.0)	99 (16.5)	110 (20.3)

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Which label best informs you that this product has high [nutrient]?	2869					
Control		44 (7.7)	37 (6.2)	37 (6.7)	43 (7.2)	30 (5.5)
Warning		70 (12.2)	99 (16.6)	91 (16.4)	78 (13.0)	78 (14.4)
GDA		234 (40.8)	237 (39.6)	221 (39.9)	234 (38.9)	207 (38.2)
HSR		133 (23.2)	149 (24.9)	125 (22.6)	147 (24.5)	135 (24.9)
MTL		93 (16.2)	76 (12.7)	80 (14.4)	99 (16.5)	92 (17.0)
Which label is easiest to understand?	2869					
Control		77 (13.4)	45 (7.5)	50 (9.0)	56 (9.3)	45 (8.3)
Warning		66 (11.5)	97 (16.2)	75 (13.5)	67 (11.1)	74 (13.7)
GDA		131 (22.8)	152 (25.4)	148 (26.7)	134 (22.3)	105 (19.4)
HSR		120 (20.9)	130 (21.7)	122 (22.0)	142 (23.6)	112 (20.7)
MTL		180 (31.4)	174 (29.1)	159 (28.7)	202 (33.6)	206 (38.0)

Appendix E.

Table. Descriptive results on primary outcomes by study arm, by product type

	Control		**Warning**		**GDA**		**HSR**		**MTL**	
Correctly identified all high-in "nutrients	n	%	n	%	n	%	n	%	n	%
Sweet biscuits	142	24.7	282	47.2	216	39.0	176	29.3	190	35.1
Bread	262	45.6	410	68.6	314	56.7	295	49.1	335	61.8
Fruit drink	347	60.5	459	76.8	408	73.6	385	64.1	399	73.6
Noodles	168	29.3	323	54.0	262	47.3	244	40.6	276	50.9
Savory biscuits	206	35.9	345	57.7	317	57.2	263	43.8	295	54.4
Purchase intentions	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Sweet biscuits	2.6	1.1	2.5	1.0	2.7	1.0	2.6	1.0	2.6	1.1
Bread	2.6	1.1	2.5	1.1	2.6	1.0	2.7	1.0	2.5	1.1
Fruit drink	2.6	1.1	2.4	1.0	2.6	1.0	2.6	1.0	2.5	1.1
Noodles	2.5	1.1	2.4	1.0	2.6	1.0	2.5	1.1	2.5	1.0
Savory biscuits	2.6	1.0	2.5	1.0	2.6	1.0	2.6	1.0	2.6	1.1

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Appendix F.

Table. Descriptive results on primary outcomes by study arm, by state

	Control		**Warning**		**GDA**		**HSR**		**MTL**	
Correctly identified all high-in "nutrients	n	%	n	%	n	%	n	%	n	%
Odisha	189	47.8	221	47.0	233	50.7	173	39.3	180	43.4
Uttar Pradesh	224	54.0	382	85.8	438	85.9	305	67.8	363	79.8
Assam	128	25.9	260	47.3	154	33.5	101	22.4	172	45.9
Delhi	134	24.4	241	58.8	201	42.8	168	31.1	208	42.9
Karnataka	272	56.7	429	72.1	283	60.2	380	63.3	272	64.8
Gujarat	178	33.3	286	55.0	208	52.0	236	45.0	300	53.6
Purchase intentions	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Odisha	2.4	1.1	2.2	1.1	2.2	1.1	2.2	1.1	2.1	1.1
Uttar Pradesh	2.7	1.1	2.6	1.0	2.8	1.0	2.7	1.0	2.8	1.0
Assam	3.1	0.8	2.8	1.0	3.1	0.8	3.1	0.9	3	0.9
Delhi	2.3	1.1	2	1.1	2.5	1.1	2.4	1.1	2.3	1.1
Karnataka	2.7	0.9	2.8	0.9	2.8	0.9	2.7	0.9	2.7	0.9

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Gujarat	2.4	1.0	2.2	0.9	2.4	0.9	2.5	0.9	2.4	1.0

Appendix G.

Table. Results for primary outcome by label arm (n=14,345 observations).

	Control	**Warning**		**GDA**		**HSR**		**MTL**	
	%	**%**	**p**	**%**	**p**	**%**	**p**	**%**	**p**
	(95% CI)	**(95% CI)**		**(95% CI)**		**(95% CI)**		**(95% CI)**	
Identified all	39.1	60.8	<0.001	55.0	<0.001	45.0	0.008	54.8	<0.001
"high-in" nutrients	(32.0, 46.2)	(53.5, 68.0)		(47.1, 62.9)		(37.1, 52.8)		(47.9, 61.8)	
	Mean	**Mean**		**Mean**		**Mean**		**Mean (95%**	
	(95% CI)	**(95% CI)**		**(95% CI)**		**(95% CI)**		**CI)**	
How likely would	2.6	2.5	0.018	2.6	1.000	2.6	0.7263	2.6	0.393
you be to buy this	(2.5, 2.7)	(2.4, 2.5)		(2.6, 2.7)		(2.5, 2.7)		(2.5, 2.6)	
product next week?									

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Appendix H.

Table. Sensitivity results of primary outcomes excluding interviewers with the highest or lowest three means among their respective respondents (n=354 and 303 respondents [1770 and 1515 obs.] for identifying all excess nutrients and purchase intentions, respectively)

	n	Control	Warning	GDA	HSR	MTL
		% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
Identified all "high-in" nutrients	12575	38.6 (32.0, 45.2)	62.7 (57.1, 68.3)	54.8 (47.1, 62.5)	43.9 (36.3, 51.5)	58.6 (51.3, 62.3)
		Mean (95% CI)	**Mean (95% CI)**	**Mean (95% CI)**	**Mean (95% CI)**	**Mean (95% CI)**
How likely would you be to buy this product next week?	12830	2.6 (2.5, 2.7)	2.5 (2.4, 2.6)	2.6 (2.5, 2.7)	2.6 (2.5, 2.6)	2.6 (2.5, 2.6)

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