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Perceived effectiveness of added-sugar warning label designs for U.S. restaurant menus: An online randomized controlled trial

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ABSTRACT

Added-sugar consumption in the U.S. exceeds recommended limits. Policymakers are considering requiring restaurants to use menu warning labels to indicate items high in added sugar. We sought to determine whether icon-only and icon-plus-text added-sugar menu labels were (1) perceived as more effective at potentially reducing consumption of items high in added sugar and (2) increased knowledge of menu items' added-sugar content relative to control labels, and if effects differed by label design. A national sample of U.S. adults (n = 1327) participated in an online randomized experiment. Participants viewed menu items with either a control label, 1 of 6 icon-only labels, or 1 of 18 icon-plus-text labels with 3 text variations. For their assigned label, participants provided ratings of perceived message effectiveness (a validated scale of a message's potential to change behavior). Participants were also asked to classify menu items by their added-sugar content. The icon-only and icon-plus-text labels were perceived as more effective than the control label (means: 3.7 and 3.7 vs. 3.1, respectively, on a 5-point scale; $p < 0.001$). The icon-only and icon-plus-text groups each correctly classified 71% of menu items by added-sugar content vs. 56% in the control group ($p < 0.001$). All icons and text variations were perceived as similarly effective. In conclusion, relative to a control label, icon-only and icon-plus-text added-sugar menu labels were perceived as effective and helped consumers identify items high in added sugar. Menu warning labels may be a promising strategy for reducing added-sugar consumption from restaurants, but research on behavioral effects in real-world settings is needed.

Clinical Trials Identifier: NCT04637412

1. Introduction

Added-sugar consumption increases risk of cardiometabolic diseases (Popkin and Nielsen, 2003; Malik and Hu, 2012; Yang et al., 2014). Yet, the majority of U.S. children and adults (57–80%) consume added sugar in excess of the 10% of total energy limit recommended by the *Dietary Guidelines* (US Department of Agriculture and US Department of Health and Human Services, 2020).

Restaurants are an important source of added sugar in the U.S. Although there are no recent estimates of the percent of total added

Abbreviations: ACS, American Community Survey; CAPTCHA, Completely Automated Public Turing test to tell Computers and Humans Apart; FOP, Front-of-package; PME, perceived message effectiveness; SSB, sugar-sweetened beverage..

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sugar that is consumed from restaurants, restaurants accounted for 16% of added-sugar intake in 2009–2010 (Drewnowski and Rehm, 2014), and consumption of added sugar from fast-food increased from 2003 to 2016 (Liu et al., 2020).

A first step in reducing added-sugar consumption from restaurants is to assist customers in identifying the added-sugar content of foods and beverages (Dallacker et al., 2018; Thomas Jr and Mills, 2006; König et al., 2019; Miller et al., 2020). Although the U.S. Food and Drug Administration requires quantitative added-sugar labelling on packaged foods, it has no such requirement for restaurants. Only calorie labeling is required on chain-restaurant menus. Even if quantitative added-sugar disclosures were required on menus, it is unclear if they would be effective. Studies of quantitative calorie and sodium menu labels have yielded mixed results for behavior (Crockett et al., 2018; Bleich et al., 2017; Alexander et al., 2021), potentially due to differential effectiveness by restaurant type, type of menu item, or customer characteristics like numeracy, education, and health consciousness (Bleich et al., 2017). To address these issues, warning labels have emerged as a strategy to provide factual and salient point-of-purchase information to inform consumers (Taillie et al., 2020a). Warning labels may also improve health behaviors by shifting attitudes, beliefs, intentions and social norms (Grummon and Hall, 2020; Hammond et al., 2006) and by encouraging product reformulation (Bleich et al., 2017; Roberto et al., 2021). Consequently, in 2016 and 2018, to address the similar issue of sodium in restaurants—New York City (NYC) and Philadelphia passed laws requiring chain restaurants to place warning labels next to items containing more sodium than the recommended daily limit (Philadelphia. Co. Bill No. 180001-A, 2021; New York City Department of Health and Mental Hygiene, 2022). Likewise, there have been recent legislative steps in NYC toward requiring added-sugar warning labels on restaurant menus (Int. No. 1326-B) (The New York City Council, 2022).

Although studies have tested sodium warning labels (Musicus et al., 2019) and enhanced calorie labeling (e.g., traffic lights) (Bleich et al., 2017; Prowse et al., 2020; Hobin et al., 2016; Hammond et al., 2013) on menus, there is a lack of research designing and evaluating the effects of added-sugar warning labels for menus. The effectiveness of front-of-package (FOP) warning labels (Grummon and Hall, 2020; Croker et al., 2020; Moran and Roberto, 2018) and point-of-decision signage (Leung et al., 2020) about sugar content and health consequences of sugar-sweetened beverages (SSBs) suggests that well-designed added-sugar warning labels for menus could also be effective for the restaurant setting. However, the amount of space on menus for warning labels is limited relative to packages, necessitating novel designs for added-sugar labels. Thus, this study was conducted to provide the foundation for rigorous evaluations of the impact of restaurant menu added-sugar warning labels on consumer behavior. Our objectives were to determine the relative performance of multiple added-sugar warning label designs while establishing whether restaurant menu added-sugar warning labels could change consumer perception and knowledge outcomes on the causal pathway between warning-label exposure and behavior change. Specifically, we sought to determine the relative effects of restaurant menu control labels, icon-only added-sugar warning labels, and icon-plus-text added-sugar warning labels on (1) perceived effectiveness for potentially reducing consumption of menu items high in added sugar (containing >50% of the recommended daily limit) and (2) knowledge of menu items' added-sugar content. Secondary objectives were to compare perceived knowledge gain between labels and to assess support for an added-sugar warning label policy.

2. Methods

2.1. Participants

We recruited a national sample of 1327 U.S. adults matching 2018 American Community Survey (ACS) 5-year estimates (2013–2018 American Community Survey, 2021) for age (18–34, 35–54, ≥55 years), gender, race and ethnicity (Hispanic [any race], non-Hispanic White, non-Hispanic Black, and non-Hispanic Asian), and education (≤high-school diploma/GED, some college, ≥bachelor's degree) from an online sample provided by Dynata. Dynata maintains large panels recruited via open enrollment and by-invitation-only methods (Dynata., 2018). After providing informed consent, a screener assessed eligibility: English-speaking U.S. residents aged 18–99 who reported purchasing from restaurants ≥1 time/month prior to the pandemic and passed a CAPTCHA. Upon completion of a 10–15 min Qualtrics questionnaire, participants were compensated through Dynata (equivalent to approximately $1.25–1.50). Data were collected November–December 2020 and analyzed January–June 2021. This study was approved by the UC Davis IRB and preregistered with AsPredicted.org (Appendix) and ClinicalTrials.gov (Identifier: NCT04637412). Analyses were pre-registered unless otherwise indicated.

2.2. Study design

Using an online between-subjects randomized controlled trial, participants were assigned to view restaurant menu excerpts with 1 of 25 labels (Appendix Fig. 1): a control label (QR code), 1 of 6 icon-only added-sugar warning labels (triangle, upside-down triangle, or octagon, each containing an exclamation mark or an exclamation mark over a spoon), or 1 of 18 icon-plus-text added-sugar warning labels (each of the 6 icons combined with each of 3 text variations: “High in Added Sugars”, “High Sugars”, and “Sugar Warning”). A simple allocation ratio (via Qualtrics Randomizer) was used for assignment. Label designs were based on requirements for sodium labels in NYC and Philadelphia chain restaurants (Philadelphia. Co. Bill No. 180001-A, 2021; New York City Department of Health and Mental Hygiene, 2022), Chile's FOP nutrient warning labels (Reyes et al., 2019), and SSB warning labels tested in young adults (Falbe et al., 2021).

First, participants were shown their assigned label and told “Next, we will ask you questions about the following label.” Then, participants viewed their label in the context of restaurant menu excerpts (Fig. 1) containing menu items from the highest grossing quick-service restaurant in the U.S(Technomic, 2021). For controls, all items on menu excerpts were labeled with the QR code, and the following disclosure statement appeared below the menu items: “[QR Code] Scan the QR code for more menu information.” The QR code provided a link to the restaurant's online menu. For the experimental conditions, only items high in added sugar (i.e., containing >50% the daily recommended limit or > 25 g added sugar) were labeled, with the following disclosure statement appearing below the menu items: “[Label] Item exceeds half the Daily Value for added sugars based on a 2,000 calorie diet. The U.S. Dietary Guidelines advises limiting added sugars.” The display of the labels was similar to requirements for sodium labels in NYC and Philadelphia (Philadelphia. Co. Bill No. 180001-A, 2021; New York City Department of Health and Mental Hygiene, 2022). All menu items were also labeled with calories as required by law (P.L. 111–148) in U.S. chains with >20 locations.

2.3. Survey procedures and measures

2.3.1. Perceived message effectiveness

To determine if the icon-only and icon-plus-text warning labels were perceived as more effective than a control label and if there were differences between designs, the primary outcome was perceived message effectiveness (PME) (Baig et al., 2019). PME was measured using an adapted version of the 3-item UNC PME Scale, which measures health concern, product attitude, and discouragement of product consumption (Baig et al., 2019). PME is used as an early indicator of a health message's potential to change behavior (Noar et al., 2018) (e.g., reduce consumption of menu items high in added sugar) and is a measure sensitive enough to detect small differences between label designs, yet has strong construct validity and is predictive of longer-term actual

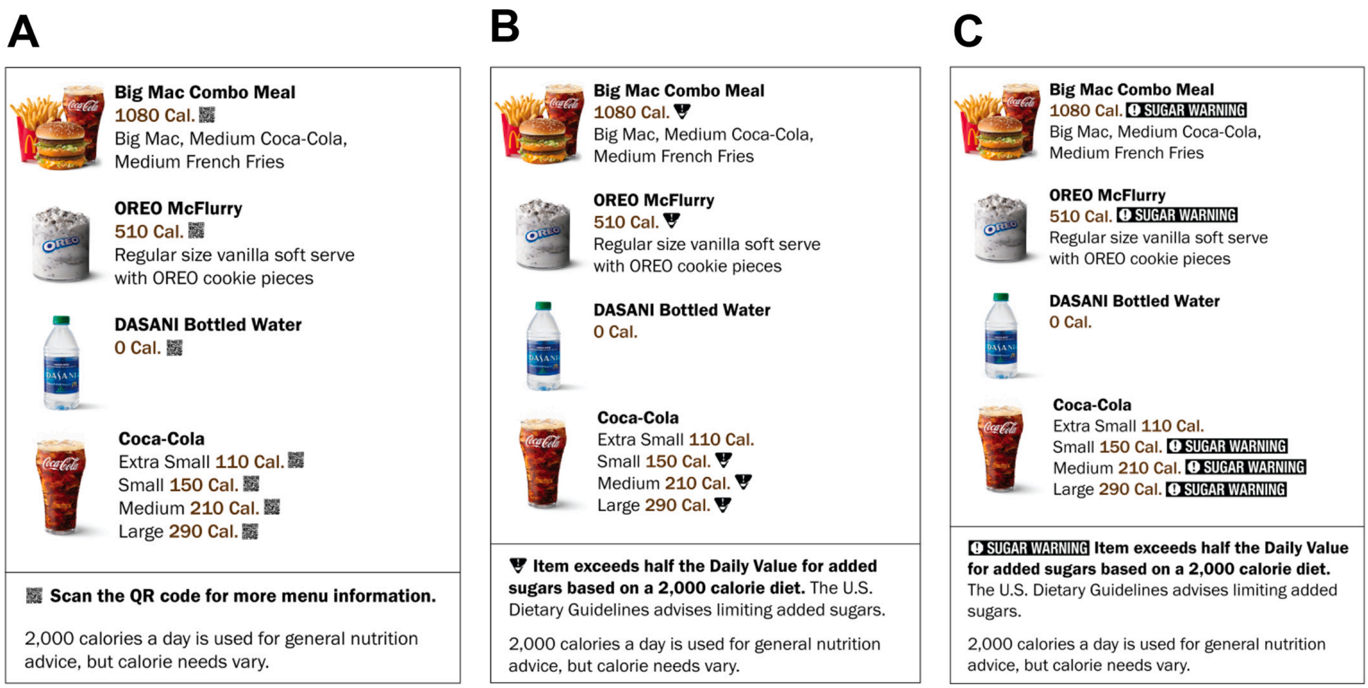

Fig. 1. Examples of menu excerpts used to assess perceived message effectiveness of (A) control, (B) icon-only added-sugar warning, and (C) icon-plus-text added-sugar warning labels.
Note: Participants were randomized to view menu excerpts with either a control label, 1 of 6 icon-only labels, or 1 of 18 icon-plus-text labels. The extra small cola slightly exceeds half the daily value for added sugars (25 g), but for the purposes of this study, we assumed that if added-sugar warning labels were required, chain restaurants would reformulate portion sizes downward so that items slightly exceeding the added-sugar threshold would fall just under it.

behavior (Baig et al., 2019; Noar et al., 2020). For instance, the UNC PME measure has been shown to mediate the impact of tobacco health warning labels on quit attempts in a longitudinal trial (Noar et al., 2020). The UNC PME measure has been used extensively in similar nutrition labeling experiments to identify the potential impact of warning labels (Hall et al., 2020a; Grummon et al., 2019; Taillie et al., 2021; Hall et al., 2021; Taillie et al., 2020b).

After participants were shown the restaurant menu excerpt (Fig. 1) labeled according to their assigned condition (i.e., control QR code, icon-only warning label, or icon-plus-text warning label), participants answered the following 3 PME questions using a 5-point scale (1 = "strongly disagree" to 5 = "strongly agree"): "This label makes me concerned about the health effects of consuming menu items high in added sugars", "This label makes consuming menu items high in added sugars seem unpleasant", and "This label discourages me from wanting to consume menu items high in added sugars." PME was calculated as the mean response to the 3 items (Cronbach's alpha in this study = 0.83). In addition to using PME to examine differences between the 3 main label groups, we used PME to examine differences between the 6 icon variations and between the 3 text variations (not pre-registered) because the achieved sample size provided 80% power to detect modest differences in PME (Cohen's $d = 0.27$ for icon and 0.22 for text) between label variations.

Additionally, to explore even smaller potential differences between label variations, in a within-subjects design, all participants viewed all 6 icon-only variations and all 3 warning text variations (accompanied by the triangle exclamation mark icon) one at a time in random order, in the context of a restaurant menu excerpt showing four soda sizes (e.g., small, large; Appendix Fig. 2). After viewing each label variation, participants reported how much the label discouraged them from consuming menu items high in added sugars (one of the 3 PME questions above) on a 5-point scale.

2.3.2. Knowledge of menu items' added-sugar content

To assess the second primary outcome, after providing responses to the 3-item PME scale, participants were shown another menu excerpt and asked to identify which of 8 items were high in added sugar (i.e., "have more than half the daily value for added sugars"). Four items were high in added sugar, labeled according to assigned condition (Appendix Fig. 3). The primary outcome measure was percent of the 8 items correctly classified as high in added sugar or not, which served as an objective indicator of knowledge.

2.3.3. Perceived knowledge gain

A secondary outcome was perceived knowledge gained: "Did you learn something new from this label? (yes/no)."

2.3.4. Policy support

Another secondary outcome was support for added-sugar warning labels on menus. At the end of the questionnaire, all conditions were randomly shown 1 of the 24 added-sugar warning labels next to 4 soda sizes (Appendix Fig. 2). Participants were asked, "If the U.S. required that a warning label like this appeared on menu items high in added sugars (>25g), would you…?" Response options included: 1 = "strongly oppose…", 2 = "somewhat oppose…", 3 = "somewhat support…", and 4="strongly support this policy, " dichotomized into "oppose" or "support."

2.3.5. Other variables

Participants answered an attention check question asking the current month and sociodemographic (e.g., household income), anthropometric, and health behavior and status questions (e.g., "Are you trying to reduce your sugar intake? (yes/no)"; see appendix for questionnaire).

2.4. Analytic sample

The a-priori planned sample size of 1300 was estimated (using

G*Power 3.1)(Faul et al., 2007) to provide 86% power to detect a small difference in PME (i.e., Cohen's $d = 0.2$ [or scale difference = 0.2 given observed SDs]) between icon-only and icon-plus-text groups and > 99% power to detect a medium difference in PME (Cohen's $d = 0.5$ [or scale difference = 0.5 given observed SDs]) between control and icon-only labels. Prior research has found large effect sizes for differences in PME between FOP added-sugar and control labels (e.g., Cohen's $d = 1.5$) (Hall et al., 2021).

Of the 1459 eligible participants, 1404 completed the survey. Following our pre-registered analysis plan, we excluded participants who failed the attention check question ($n = 39$), provided the same nonsensical response to two open-ended questions ($n = 25$), or completed the survey in <30% of the median time ($n = 13$), leaving an analytic sample of $n = 1327$ (Fig. 2).

The 132 (9% of) eligible participants excluded were more likely than the analytic sample to be male (59% vs. 46%; Chi-square $p = 0.01$) and have a bachelor's degree or higher (44% vs. 28%; Chi-square $p < 0.01$).

2.5. Statistical analysis

To compare PME and knowledge outcomes between the 3 main label groups, we collapsed the 25 conditions into control, icon-only, and icon-plus-text groups. One-way ANOVA and Chi-square tests were used to compare differences in sociodemographic characteristics between the 3 main label groups.

2.5.1. Perceived message effectiveness

To determine if the icon-only and icon-plus-text labels were perceived as more effective than the control label, we used linear regression to regress PME (average of the 3 PME items) on an indicator for the icon-only main group and an indicator for the icon-plus-text main group. The same modeling approach (with a different reference group) was used to compare PME between the icon-only and icon-plus-text main groups.

Although this study was not powered to identify moderators, we explored potential differences in label effects on PME by gender, race, education, and reporting trying to reduce sugar intake (not pre-registered). To descriptively explore differential effects by population subgroup, we used the above linear regression model to stratify by each level of a potential moderator. To examine the statistical significance of potential moderators, we ran linear models unstratified with the addition of indicators for each level of a moderator and interaction terms between level of a moderator and warning label group. We report stratified effects on PME and p-values for interaction terms.

To determine if PME differed between the 6 icon variations, we grouped all warning label conditions together by icon (e.g., the triangle-exclamation-mark condition was grouped together with all triangle-exclamation-mark-plus-text conditions). Likewise, to determine if PME differed between the 3 text variations, we grouped all icon-plus-text conditions together by text (e.g., all conditions with "sugar warning" were grouped together regardless of icon). Grouping was performed because there was balance in the proportion of icons displayed with each text variation and vice versa among the icon-plus-text labels. We ran separate regression models for icon and text comparisons, regressing PME on indicators for label variations. We used the same grouping and modeling approach to explore differences in PME between icon shapes (triangle, octagon, upside-down triangle) and between images within icon shapes (exclamation mark and exclamation mark over a spoon).

For the within-subjects outcome of perceived discouragement (one of the PME items), we used separate linear mixed effects models with

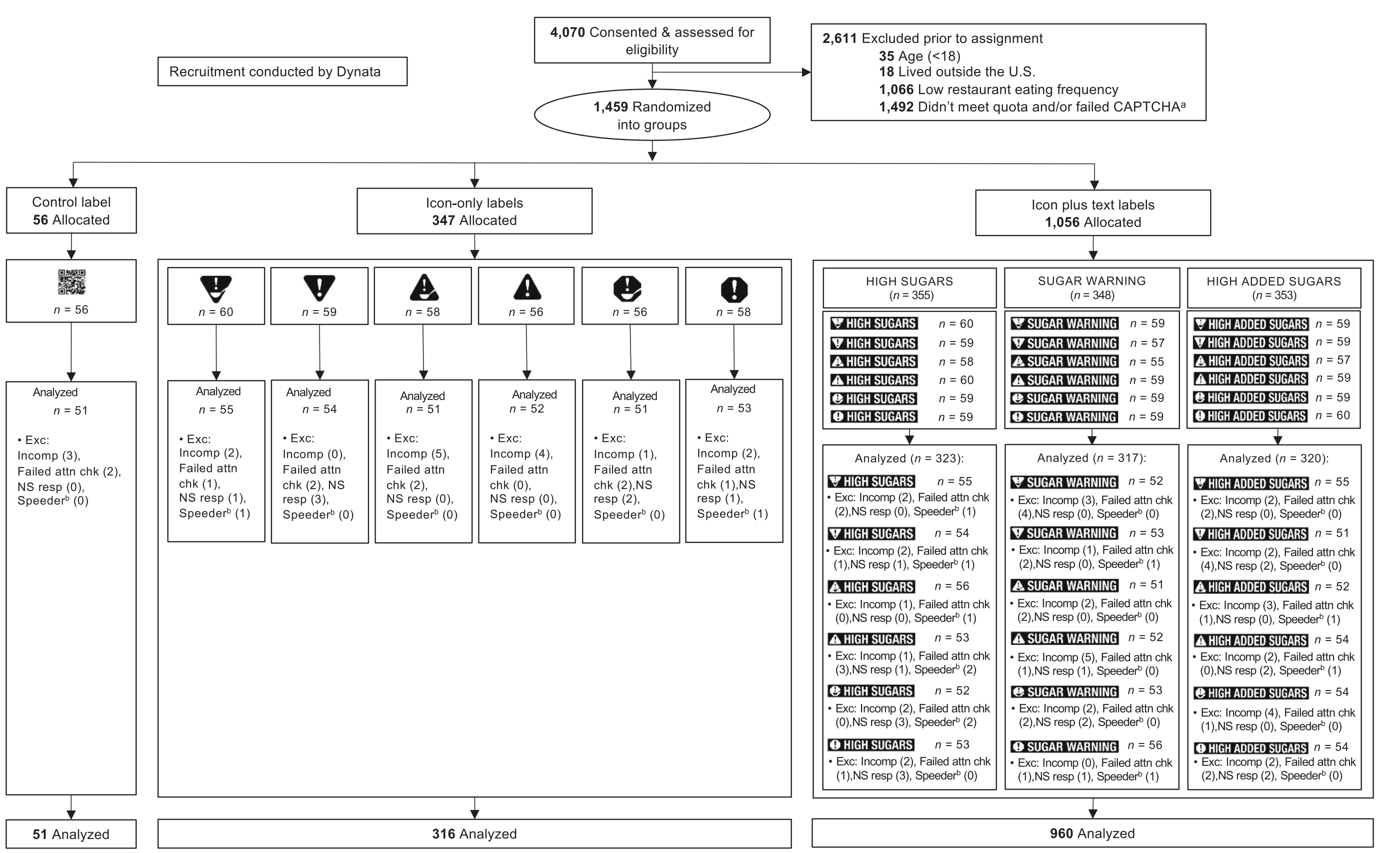

Fig. 2. CONSORT Diagram showing participant flow.
[a] CAPTCHA stands for Completely Automated Public Turing test to tell Computers and Humans Apart. It is a challenge-response test to determine a human user.
[b] Completion time less than 30% of the median completion time.
Exc—excluded; attn. chk—attention check; NS resp—nonsense response; Incomp—incomplete.

Table 1
Participant characteristics.

Characteristic, Mean ± SD or n(%[a])	Total ($N = 1327$)	Control ($n = 51$)	Icon-only ($n = 316$)	Icon-plus-text ($n = 960$)	P-value[b]
Age					
18–34 years	386 (29%)	16 (31%)	99 (31%)	271 (28%)	0.55
35–54 years	441 (33%)	17 (33%)	93 (29%)	331 (34%)	
55+ years	500 (38%)	18 (35%)	124 (39%)	358 (37%)	
Race andethnicity					
Hispanic any race	233 (18%)	9 (18%)	50 (16%)	174 (18%)	0.56
NH American Indian or Alaska Native alone	21 (2%)	2 (4%)	3 (1%)	16 (2%)	
NH Asian alone	69 (5%)	1 (2%)	17 (5%)	51 (5%)	
NH Black alone	161 (12%)	10 (20%)	40 (13%)	111 (12%)	
NH Native Hawaiian or Pacific Islander alone	3 (<1%)	0 (0%)	0 (0%)	3 (<1%)	
NH White alone	818 (62%)	28 (55%)	198 (63%)	592 (62%)	
NH More than 1 race	22 (2%)	1 (2%)	8 (3%)	13 (1%)	
Gender					
Woman	710 (54%)	30 (59%)	178 (56%)	502 (52%)	0.65
Man	611 (46%)	21 (41%)	137 (43%)	453 (47%)	
Non-binary / gender nonconforming	6 (<1%)	0 (0%)	1 (<1%)	5 (1%)	
Education level					
Up to a high school diploma / GED	541 (41%)	18 (35%)	130 (41%)	393 (41%)	0.35
Some college or associate's degree	409 (31%)	21 (41%)	95 (30%)	293 (31%)	
Bachelor's degree	210 (16%)	4 (8%)	57 (18%)	149 (16%)	
Graduate or professional degree	167 (13%)	8 (16%)	34 (11%)	125 (13%)	
Annual household income before taxes					
c ≤$35,000	478 (36%)	24 (47%)	104 (33%)	350 (37%)	0.18
$35,001-65,000	353 (27%)	9 (18%)	89 (28%)	255 (27%)	
$65,001-95,000	224 (17%)	7 (14%)	47 (15%)	170 (18%)	
>$95,000	266 (20%)	11 (22%)	75 (24%)	180 (19%)	
Region					
Midwest	274 (21%)	8 (16%)	71 (22%)	195 (20%)	0.69
Northeast	258 (19%)	13 (26%)	60 (19%)	185 (19%)	
South	550 (42%)	21 (41%)	121 (38%)	408 (43%)	
West	243 (18%)	8 (16%)	63 (20%)	172 (18%)	
U.S. Territory	2 (<1%)	1 (<2%)	1 (<1%)	0 (%)	
BMI (kg/m^2)	27.5 ± 7.4	27.3 ± 7.9	27.3 ± 7.6	27.6 ± 7.2	0.72
Diagnosed with pre-diabetes, diabetes, or obesity	339 (26%)	17 (34%)	88 (28%)	234 (25%)	0.19
Trying to reduce sugar intake	684 (52%)	24 (47%)	168 (54%)	492 (52%)	0.66
Reported dietary restrictions	223 (17%)	11 (22%)	56 (18%)	156 (16%)	0.54

GED—General Educational Development Test; SD—standard deviation; BMI—body mass index; NH—non-Hispanic.
[a] Missing values were not included in the denominator for calculating percentages
[b] One-way ANOVA for continuous variables and chi-square test for categorical variables were used to test for differences between groups at baseline.

restricted maximum likelihood to examine differences between the 6 icon variations and between the 3 text variations. These models regressed perceived discouragement on indicators for the icon in one model and text variations in the other model.

2.5.2. *Knowledge of menu items' added-sugar content*

The same linear regression modeling approach for between-subject differences in PME was used to examine main label group effects on knowledge (i.e., percent of the 8 menu items correctly classified as high in added sugar or not).

2.5.3. *Secondary outcomes*

For the secondary outcome of perceived knowledge gained, we used Poisson regression with a robust error variance (Zou, 2004) to estimate the prevalence ratio of reporting learning something new between the 3 main label groups. For the secondary outcome of policy support, we present the percentage of all participants who responded that they somewhat or strongly support an added-sugar menu-labeling policy.

Statistical tests were two-sided, used a critical alpha of 0.05, and were conducted using Stata/MPv15.1 (StataCorp, College Station, TX). For the primary outcomes of PME and knowledge of items' added-sugar content, we additionally calculated Cohen's *d* and examined statistical significance after using the Holm-Bonferroni procedure (Holm, 1979) (not pre-registered but added based on peer-reviewer feedback) to correct for multiple comparisons within each family of outcomes and comparisons (e.g., comparison of PME among the 3 main label groups, comparisons of PME among the 6 icon-only labels). We also used the Holm-Bonferroni procedure for the within-subjects outcome of perceived discouragement. We report when results were not significant after the procedure. All *p*-values presented are unadjusted.

3. Results

Table 1 shows participant characteristics. Reflecting 2018 ACS 5-year estimates, 18% of the study sample identified as Hispanic (any race), 5% non-Hispanic Asian, 12% non-Hispanic Black, and 62% non-Hispanic White. Approximately half (54%) reported being women. For annual household income before taxes, 36% reported ≤$35 K; 27% reported >$35-65 K; 17% reported >$65-95 K; and 20% reported >$95,000. There were no significant differences in characteristics by the 3 main between-subjects trial groups.

3.1. *Perceived message effectiveness*

The icon-only warning labels and the icon-plus-text warning labels were perceived as significantly more effective than the control label ($PME_{icon\text{-}only} = 3.7$ [95%CI: 3.6–3.9], $p < 0.001$ and $PME_{icon\text{-}plus\text{-}text} = 3.7$ [CI: 3.7–3.8], $p < 0.001$ vs. $PME_{control} = 3.1$ [CI: 2.8–3.4]; Fig. 3).

There was no significant difference in PME between the icon-only and icon-plus-text groups ($p = 0.75$). Appendix Table 1 shows model coefficients, 95% CIs, *P*-values, and Cohen's *d*.

In exploratory analyses of potential moderators (Appendix Table 2), the positive impact of icon-only labels and the icon-plus-text labels relative to the control label on perceived effectiveness was significantly

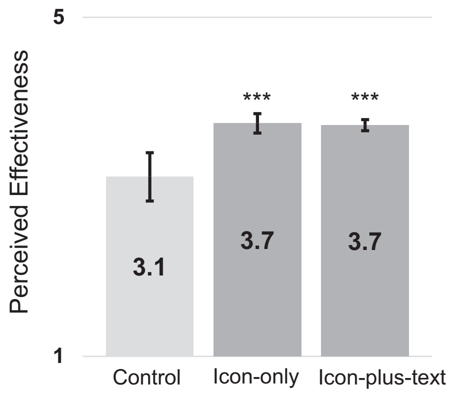

Fig. 3. Perceived message effectiveness by label group (control, icon-only added-sugar warning label, and icon-plus-text added-sugar warning label).
***$p < 0.001$ indicates statistically significant difference from the control group, including after using the Holm-Bonferroni procedure to correct for multiple testing.
Note: Error bars indicate 95% confidence intervals. There was no significant difference between the icon-only and icon-plus-text warning label groups.

stronger among those trying to reduce their sugar intake than those not trying ($p < 0.01$ and $p < 0.001$, respectively). Although no other interaction terms between potential moderators and warning labels were significant, coefficients from stratified models suggested potentially higher perceived effectiveness of icon-only and icon-plus-text warning labels relative to control labels among females, Hispanic participants, and those with a bachelor's degree.

There were no significant differences in PME between the 6 different icon-only label variations (Fig. 4A). When comparing text variations, "High Added Sugars" was perceived as only marginally more effective (PME = 3.8, $p = 0.03$) than "High Sugars" (PME = 3.7, Fig. 4B), but this difference was not significant after the Holm-Bonferroni procedure. In exploratory analyses, there were no significant differences in PME between icon shapes or between icon images within shapes (Appendix Fig. 4).

Within-subject perceived discouragement of product consumption (PME item) for each icon and text option are reported in Appendix Fig. 5; there were only negligible differences between icons and text variations (differences in PME were < 0.1; p-values<0.05).

3.2. Knowledge of menu items' added-sugar content

The icon-only group and the icon-plus-text group each correctly classified 71% of the 8 items as high in added sugar or not compared to the control group, which correctly classified 56% of the items (p-values<0.001; Appendix Fig. 6 and Appendix Table 3). There was no significant difference in knowledge between the icon-only and icon-plus-text groups.

3.3. Perceived knowledge gain

For the secondary outcome of perceived knowledge gained, a larger proportion of participants in the icon-only group (65%; prevalence ratio = 2.2, $p < 0.001$) and the icon-plus-text group (61%; prevalence ratio = 2.1, $p < 0.001$) reported learning something new from the labels than participants in the control group (29%). There was no significant difference between the icon-only and icon-plus-text groups.

3.4. Policy support

A total of 80% of all participants reported supporting a policy that requires labels on menu items high in added sugar.

4. Discussion

This is the first study to our knowledge to design and test added-sugar warning labels for restaurant menus. Compared to a control label, both the icon-only and the icon-plus-text added-sugar warning labels were perceived as more effective at potentially reducing consumption of menu items high in added sugar and increased knowledge of items' added-sugar content. Furthermore, a higher proportion of participants in the warning label groups perceived learning something new compared to the control group. For all of these outcomes, we found no significant differences between the icon-only and icon-plus-text groups. Also, there were no meaningful differences in perceived effectiveness between the six icon variations and between the three text variations. Reported policy support for requiring added-sugar warning labels on menus was high (80%).

Our findings that added-sugar warning labels for restaurant menus are perceived as effective and may educate consumers on menu items' added-sugar content are consistent with evidence from a small body of online experiments testing restaurant warning and traffic-light labels for other nutrients. This includes an online experiment in which icon-plus-text sodium warning labels reduced the amount of sodium

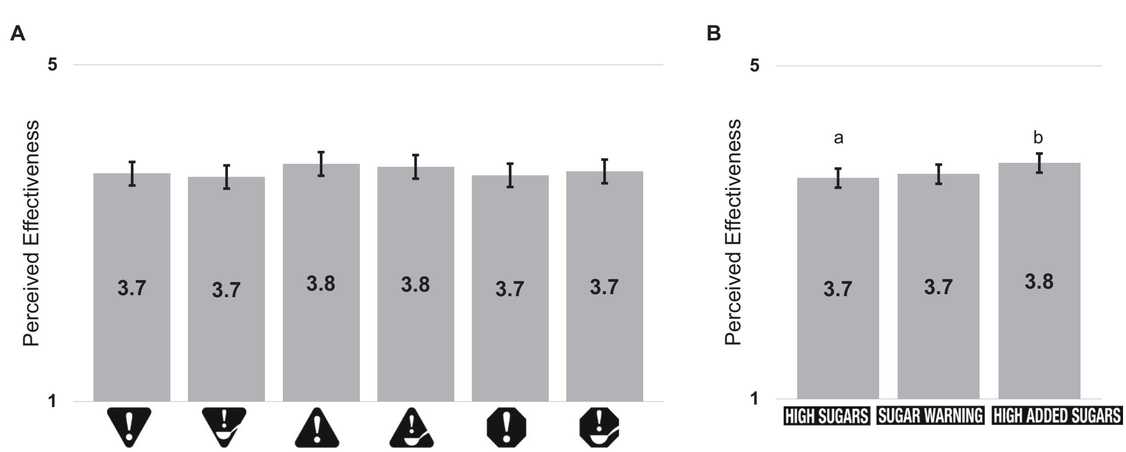

Fig. 4. Perceived message effectiveness by added-sugar warning label variation: (A) icon and (B) text.
[a] significantly different than b ($p = 0.03$) but not significantly different after using the Holm-Bonferroni procedure to correct for multiple testing.
Note: All labels with the same icon were grouped together, regardless of text. All labels with the same text were grouped together, regardless of icon. Error bars indicate 95% confidence intervals.

hypothetically ordered compared to a no-label control and increased knowledge of sodium content and perceived health risks of high-sodium meals (Musicus et al., 2019). Another online experiment tested several labeling schemes against a no-label control and found that quantitative calorie and sodium labels with a disclosure statement, and the same information with traffic-light labels, reduced the calorie and sodium content of meals parents hypothetically ordered for their children (Prowse et al., 2020). However, parents perceived the traffic-light labels as the most effective (Prowse et al., 2020). A third experiment tested multi-nutrient black octagon labels designed for food ordering websites and found that they reduced the probability of hypothetically ordering an item with excessive content (Gugliucci et al., 2021). Unlike this study, which focused on perceptions of message effectiveness, these prior studies examined hypothetical behavioral outcomes. A critical next step for added-sugar menu labels is testing them on hypothetical ordering, and ultimately on ordering and consumption in real-world settings.

Similar to our findings, prior studies have found that, relative to control labels, FOP warning labels have higher PME and result in a higher percentage of participants correctly identifying items high in nutrients of concern (Taillie et al., 2020b). Also, compared to control labels, SSB warning labels reduced perceptions of healthfulness, purchasing, and consumption of SSBs (Grummon and Hall, 2020; Moran and Roberto, 2018; Hall et al., 2020b; An et al., 2021). FOP label effects appear to be similar across sociodemographic groups; however, we detected stronger menu warning label effects on PME in those trying to reduce sugar intake.

Unlike in our study, prior research has reported differences between warning label designs. A study examining multiple sodium warning labels found that an icon-only warning (triangle containing a saltshaker) reduced participants' ability to identify items high in sodium and was remembered less often compared to icon-plus-text labels (Musicus et al., 2019). Without accompanying text, the saltshaker may have been less understood and, due to smaller overall size, less noticeable. One possible reason we found no differences between icon-only and icon-plus-text labels is that assessing PME necessitates drawing participants' attention to the labels. When ordering from a menu, however, participants may be too distracted with other menu text and images to notice or properly interpret an icon-only label relative to an icon-plus-text label. Also, while our findings of no meaningful differences between icons is supported by a U.S. mixed-methods study that found triangle and octagon icons were perceived as similarly effective (Falbe et al., 2021), a study examining FOP nutrient warning labels in Colombia found that octagons were perceived as more effective than circles or triangles (Taillie et al., 2020b). Effectiveness of icon shapes may be culturally-dependent and based on how shapes are used elsewhere (e.g., traffic signs, other product warnings).

There are several future directions for testing menu warning labels. The current study tested only warning labels containing icons. Icons may improve potential effectiveness over text-only warning labels in populations with lower-English use, as was found in a prior study of FOP SSB warning labels (Hall et al., 2021), and thereby improve equity in outcomes. Potential ways to further increase equitable impacts include multi-language media campaigns introducing new labels and in-restaurant translations of warning label disclosure statements, ideally on the menu in the community's dominant non-English language(s), both of which should be studied. Additionally, added-sugar warning labels and sodium warning labels should be tested in combination vs. alone to determine if the combination dilutes or magnifies effects. Several (Prowse et al., 2020; Hobin et al., 2016; Scourboutakos et al., 2014), but not all(Hammond et al., 2013) studies testing calorie-plus-nutrient (e.g., sodium) menu labels have not found dilution of effects. Lastly, added-sugar and sodium menu warning labels should be tested against quantitative and traffic-light menu labels. Although a potential advantage of quantitative labels relative to warning labels is allowing finer comparisons of adjacent menu items (Hammond et al., 2013), disadvantages include occupying more menu space; requiring greater numeracy and cognitive effort to interpret, which may have equity implications (Bleich et al., 2017; Taillie et al., 2020a); and preemption at state and local levels by U.S. federal menu-labeling law (P.L. 111–148).

4.1. Strengths and limitations

To our knowledge, this is the first study to design and test a variety of added-sugar warning labels on restaurant menus. Other strengths are its randomized design, sample reflecting national distribution of key demographics, presentation of labels in the context of realistic menu excerpts, and use of a validated PME measure. Limitations include the lack of behavioral outcomes (e.g., ordering) and online study format, which may not be representative of real-world settings where repeated label exposure could enhance or reduce effectiveness (by increasing label understanding or through message fatigue). Moreover, the use of an online panel means that generalizability to other populations remains to be established, but online convenience samples tend to provide internally valid experimental results (Jeong et al., 2019; Weinberg et al., 2014; Berinsky et al., 2012). Although social desirability bias could have influenced PME and warning label support, this is unlikely given participant anonymity. Additionally, priming participants about the label (which was necessary to assess PME in the presence of other labels like calories) and using simplified instead of full-size menus (that may draw attention to the label) could have led to larger effect sizes than would be observed for ordering outcomes without priming. Future experiments are needed to determine if icon-only and icon-plus-text added-sugar menu labels result in meaningful behavioral changes in real-world settings. Another limitation is that this study was not powered to test for moderation of effects by participant characteristics. Lastly, warning labels may affect consumption by motivating restaurants to reformulate sugary items to avoid labeling; however, experiments such as this are unable to assess industry response to policy.

5. Conclusion

Both icon-only and icon-plus-text warning labels for restaurant menu items high in added sugar were perceived as more effective than control labels for potentially reducing consumption of menu items high in added sugar and increased knowledge of items' added-sugar content. There were no significant differences when comparing icon-only to icon-plus-text labels. Most participants (80%) supported using added-sugar warning labels on restaurant menus. These promising results support the need to further develop and test restaurant menu added-sugar warning labels by conducting experiments with menu ordering outcomes to determine behavioral effects.

Credit author statement

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All authors have contributed to the review and editing of this manuscript and have read and agreed to the published version of the manuscript. S.S. and D.N. played no role in the data collection, experimental design, or data analysis.

Declaration of Competing Interest

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Sarah Sorscher and DeAnna Nara are employees of CSPI, a non-profit organization, which has advocated for menu warning label policies. There are no other financial or personal disclosures.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ypmed.2022.107090.

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