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RESEARCH ARTICLE

Effects of Sugary Beverage Text and Pictorial Warnings: A Randomized Trial

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Introduction: Multiple U.S. localities have introduced legislation requiring sugar-sweetened beverage warnings. This study effects of different warning designs on beverage selections and perceptions.

Study Design: The study was an RCT.

Setting/Participants: An online virtual convenience store and survey were used with a nationally representative sample of primary caregivers of 6–11-year-olds (n=961). Data were collected in January 2020 and analyzed in May–July 2020.

Intervention: Participants were randomized to view sugar-sweetened beverages with 1 of 4 front-of-package label designs: (1) no-warning control, (2) health-related text warning, (3) sugar pictorial warning (image of beverage sugar content in cubes/teaspoons/packets with health-related warning text), or (4) health pictorial warning (image of possible health consequences of overconsuming sugar-sweetened beverages with health-related warning text).

Main outcome measures: Outcomes included participants' beverage choice for their child and perceptions of beverages, their assigned labels, and warning policies.

Results: Proportionally fewer participants chose a sugar-sweetened beverage in the sugar pictorial warning condition (-13.4 percentage points; 95% CI= -21.6 to -0.1 percentage points; p=0.007) and in the health pictorial warning condition (-14.7 percentage points; 95% CI= -22.8 to -0.1 percentage points; p=0.004) compared to the control. Sugar pictorial warnings led to more accurate added-sugar content estimates than all conditions and greater label trust and support for sugar-sweetened beverage warning policies than health pictorial warnings.

Conclusions: Sugar-sweetened beverage warning policies may be most effective if they mandate images of beverages' added sugar content accompanied by warning text.

Trial Registration: This study is registered at www.clinicaltrials.gov NCT03648138.

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INTRODUCTION

Most U.S. children aged 2−11 years consume sugar-sweetened beverages (SSBs) daily,[1] and this consumption is associated with obesity, Type 2 diabetes, and cardiovascular disease.[2,3] Although soda consumption has declined modestly in recent years,[4] intake of other SSBs such as sports drinks has increased,[1] and overall SSB consumption remains at concerningly high levels.[1,5,6] There are also disparities in consumption, with higher SSB intake among Hispanic and non-Hispanic Black children than among non-Hispanic White children.[6]

To address the negative health impacts of SSB consumption, legislation has been introduced in U.S. states and cities, including California,[7] New York State,[8] Baltimore,[9] and San Francisco,[10] to require SSBs to display text-based health warning labels on product containers and/or advertisements, much like tobacco warning labels. The proposed warning text reads: "WARNING: Drinking beverages with added sugar(s) contributes to obesity, diabetes, and tooth decay." These warnings are meant to educate consumers about the potential health harms of overconsuming SSBs and to reduce consumption. Although SSB warnings have yet to be implemented in the U.S., various studies suggest that they can reduce SSB consumption[11−18] and that pictorial warnings (warnings with images) may be more effective than text-based warnings.[15,16,19−21] Other studies suggest that labels disclosing the number of teaspoons of added sugar in picture format (sugar pictorial warnings) may reduce SSB consumption,[21−24] but no studies have directly tested the effects of warnings with pictures depicting the health effects of added sugar consumption (health pictorial warnings) compared with those of sugar pictorial warnings.

This study's objective was to address this gap by comparing the effects of a text-based warning, health and sugar pictorial warnings, and a control on parents' beverage choices for their children in a virtual convenience store. A secondary objective was to test the labels' influence on parents' perceptions of beverages, labels, and warning label policy. Primary hypotheses were that (1) health or sugar pictorial warnings would be most effective at dissuading parents from selecting an SSB for their child and increasing perceived risks associated with overconsuming SSBs and (2) text warnings would be less effective than pictorial warnings but more effective than calorie labels alone. A third objective was to explore the potential differential effects by education and numeracy. On the basis of previous research showing that individuals with lower educational attainment and numeracy skills may benefit more from pictorial labels,[25−27] it was hypothesized that pictorial warnings would have a bigger impact among those with lower educational attainment and numeracy skills than text or control labels. It was also hypothesized that identifying as Republican would be associated with greater support for warning label policies after label exposure because Republicans have shown less support for warning label policies than Democrats[28] and therefore have more room to increase their support.

METHODS

Study Sample

Primary caregivers of at least 1 child aged 6−11 years were recruited to take part in an online RCT. Data were collected in January 2020 and analyzed in May−July 2020. Participants were recruited through Ipsos Public Affairs, a firm that uses address-based sampling methods to create a nationally representative web panel (KnowledgePanel). For this study, Ipsos invited adults from a nationally representative sample of U.S. households to take a KnowledgePanel survey. Selected panel members received an e-mail invitation to complete the survey on their computers (no smartphones) at their earliest convenience. To reduce selection bias, no specific survey details appeared in the invitation. Upon survey completion, qualified participants (n=1,016) were entered into the KnowledgePanel sweepstakes, an incentive program offering chances to win cash rewards and other prizes. As specified in the preregistration (Appendix, available online), participants were excluded if they completed the survey in <1/3 of the median completion time (14 minutes), used a duplicate IP address, or failed a data-integrity-check question asking participants to identify the current month. The final sample contained 961 participants (Table 1 and Figure 1). The University of Pennsylvania IRB approved this study.

Intervention

Participants were randomized using simple randomization to view beverages in a virtual store with 1 of 4 front-of-package label designs (Figure 2): (1) control (no warning); (2) text warning on SSBs based on language mandated in a proposed warning label bill in California[29]: "WARNING: Drinking beverages with added sugar(s) contributes to obesity, diabetes, and tooth decay"; (3) sugar pictorial warning (1 of 3 images that depicted the amount of sugar in a beverage in cubes, teaspoons, or packets with warning text); or (4) health pictorial warning (1 of 3 images that depicted possible health consequences of overconsuming SSBs, including dialysis, feet on a scale, or decayed teeth, along with warning text). The warning text's font size was standardized across conditions. The different sugar and health images were randomly assigned to SSBs in each condition. The dialysis and feet-on-a-scale images were additionally randomized to show either light-, medium-, or dark-colored skin tones. All beverage packages in the study displayed calorie labels in all conditions. In Conditions 2−4 (warning conditions), warnings appeared on all SSBs, which were defined as beverages with added sweeteners and ≥75 calories per 12 fluid

Table 1. Participant Characteristics, % (Unless Otherwise Indicated)

Characteristics	All	Control	Text	Sugar pictorial	Health pictorial
N	961	246	235	242	238
Female	52.7	54.9	50.6	52.9	52.1
Age, mean years, (SD)	39.4 (7.1)	39.5 (6.8)	39.3 (7.1)	39.2 (7.1)	39.4 (7.3)
BMI, mean (SD)[a]	28.4 (6.3)	28.7 (6.8)	29.0 (6.4)	27.9 (6.1)	28.2 (6.1)
Participant currently diagnosed with					
Overweight or obesity[b]	29.3	29.3	30.6	30.6	26.6
Type 2 diabetes[b]	3.5	2.9	2.6	5.9	2.5
Heart disease, heart attack, or other heart condition[c]	1.7	1.8	1.9	0.9	2.4
Participant relationship with weight[b]					
Trying to lose weight	59.8	60.6	60.0	57.5	60.9
Trying to gain weight	1.5	1.6	1.3	2.5	0.4
Not trying to lose or gain weight	38.8	37.8	38.7	40.0	38.7
Education					
High-school degree or less	23.6	25.6	23.8	24.4	20.6
Some college	23.9	24.0	24.3	22.3	25.2
Bachelor's degree or higher	52.5	50.4	51.9	53.3	54.2
Race/ethnicity					
White, non-Hispanic	70.3	69.1	71.9	69.8	70.6
Black, non-Hispanic	9.1	8.9	9.4	8.7	9.2
Hispanic	12.7	13.4	10.6	13.6	13.0
Other, non-Hispanic	5.0	5.3	4.7	5.0	5.0
2+ races, non-Hispanic	2.9	3.3	3.4	2.9	2.1
Marital status					
Married	80.0	81.7	78.7	83.1	76.5
Divorced	6.2	4.9	6.4	5.8	8.0
Never married	5.6	6.5	6.0	5.0	5.0
Living with partner	5.6	5.3	6.4	3.3	7.6
Separated	1.9	1.6	1.7	2.1	2.1
Widowed	0.6	0.0	0.9	0.8	0.8
Household income, $					
< 25,000	9.5	9.4	12.3	9.9	6.3
25,000–49,999	15.6	12.6	14.5	14.9	20.6
50,000–74,999	14.7	18.3	14.0	14.9	11.3
75,000–99,999	16.3	13.8	17.9	16.1	17.7
100,000–124,999	15.1	16.7	15.3	17.4	10.9
125,000–149,999	8.4	7.7	8.9	6.6	10.5
≥150,000	20.4	21.5	17.0	20.3	22.7
Employed	81.9	81.7	81.3	79.3	85.3
Party affiliation[c]					
Democrat	49.7	52.1	47.4	46.2	53.0
Republican	47.5	44.6	49.1	51.3	44.8
Other	2.9	3.3	3.5	2.5	2.2
Age of oldest child 6–11, mean years, (SD)	8.8 (1.7)	9.0 (1.7)	8.7 (1.7)	8.8 (1.7)	8.8 (1.7)
Child currently diagnosed with[b]					
Overweight or obesity	6.9	7.3	6.4	6.6	7.1
Type 2 diabetes	0.4	0.4	0.4	0.8	0.0
Frequency of child drinking beverages in knowledge/ perception tasks in the last month, mean (SD) (1=never to 9=2 or more times per day)					
Water	5.2 (3.1)	4.7 (3.1)	5.1 (3.2)	5.5 (3.1)[d]	5.4 (3.1)[d]
Orange juice	2.3 (1.6)	2.2 (1.5)	2.2 (1.7)	2.2 (1.5)	2.5 (1.9)[d]

(continued on next page)

Table 1. Participant Characteristics, % (Unless Otherwise Indicated) (*continued*)

Characteristics	All	Control	Text	Sugar pictorial	Health pictorial
Soda	1.8 (1.3)	1.8 (1.2)	1.8 (1.3)	1.8 (1.3)	1.9 (1.5)
Sports drink	1.8 (1.3)	1.8 (1.3)	1.8 (1.4)	1.7 (1.2)	1.8 (1.3)

Note: Continuous outcomes were tested for balance across conditions with ANOVA. Categorical outcomes were tested for balance across conditions with chi-square tests. All characteristics were evenly distributed across conditions except for the frequency of child drinking water and orange juice.
[a]8% missing, evenly distributed across conditions.
[b]<1% missing, evenly distributed across conditions.
[c]<2% missing, evenly distributed across conditions.
[d]Significantly different from control, $p<0.05$.

ounces on the basis of the criteria used in the proposed California warning label legislation.[29] This meant that 100% fruit juices such as orange juice did not qualify for a label.

Measures

After providing informed consent, all participants completed the same online survey (Appendix, available online). At the beginning of the survey, they were asked whether they had >1 child aged 6−11 years and, if so, to answer questions on the basis of their oldest child within that age range. Participants were informed that they would be entering a virtual store in which they would view beverages and choose 1 for their child. They were told that "some countries now require companies to display a label on beverages" (control condition) or "...a warning label on beverages with

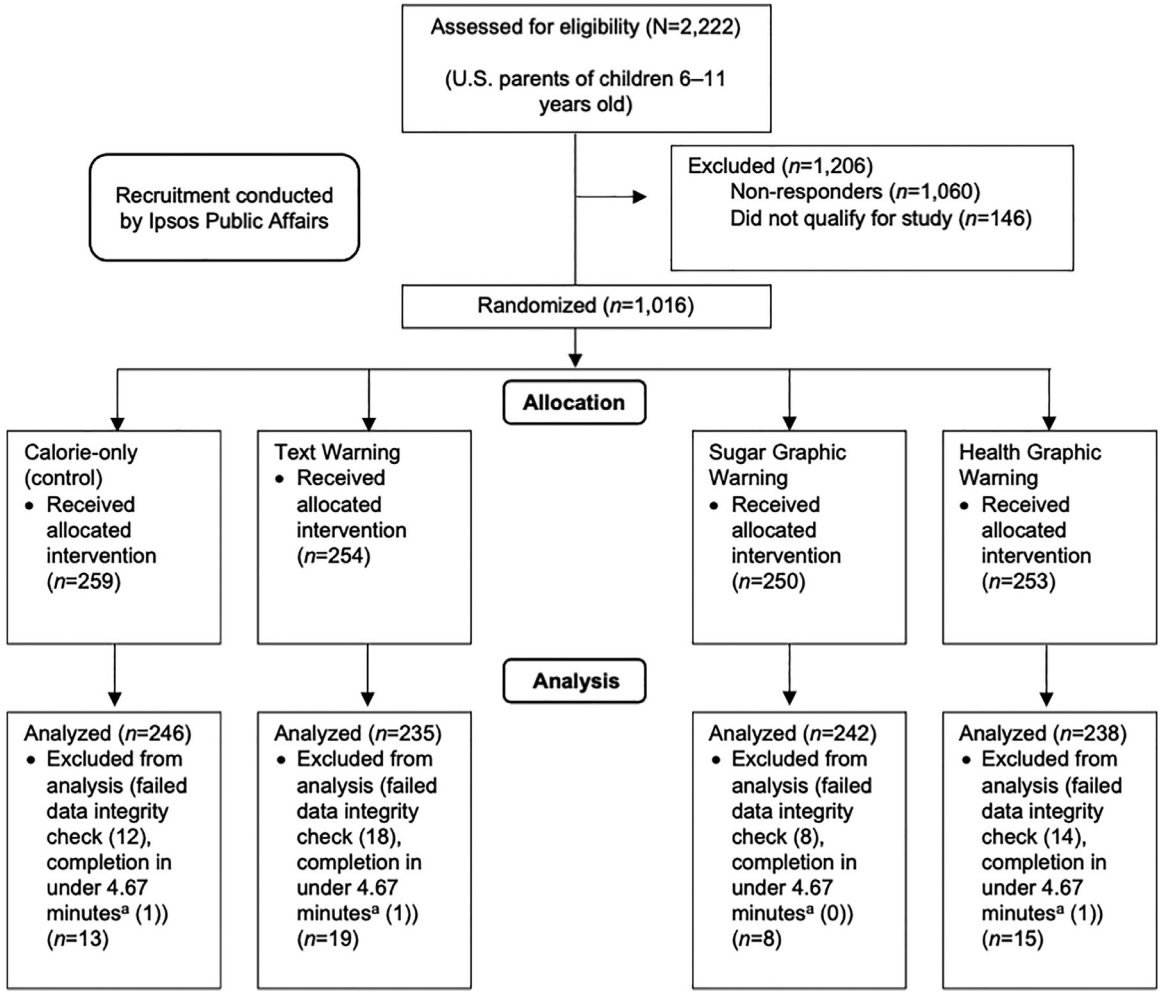

Figure 1. CONSORT diagram.

[a]One third of the median completion time, 14 minutes.

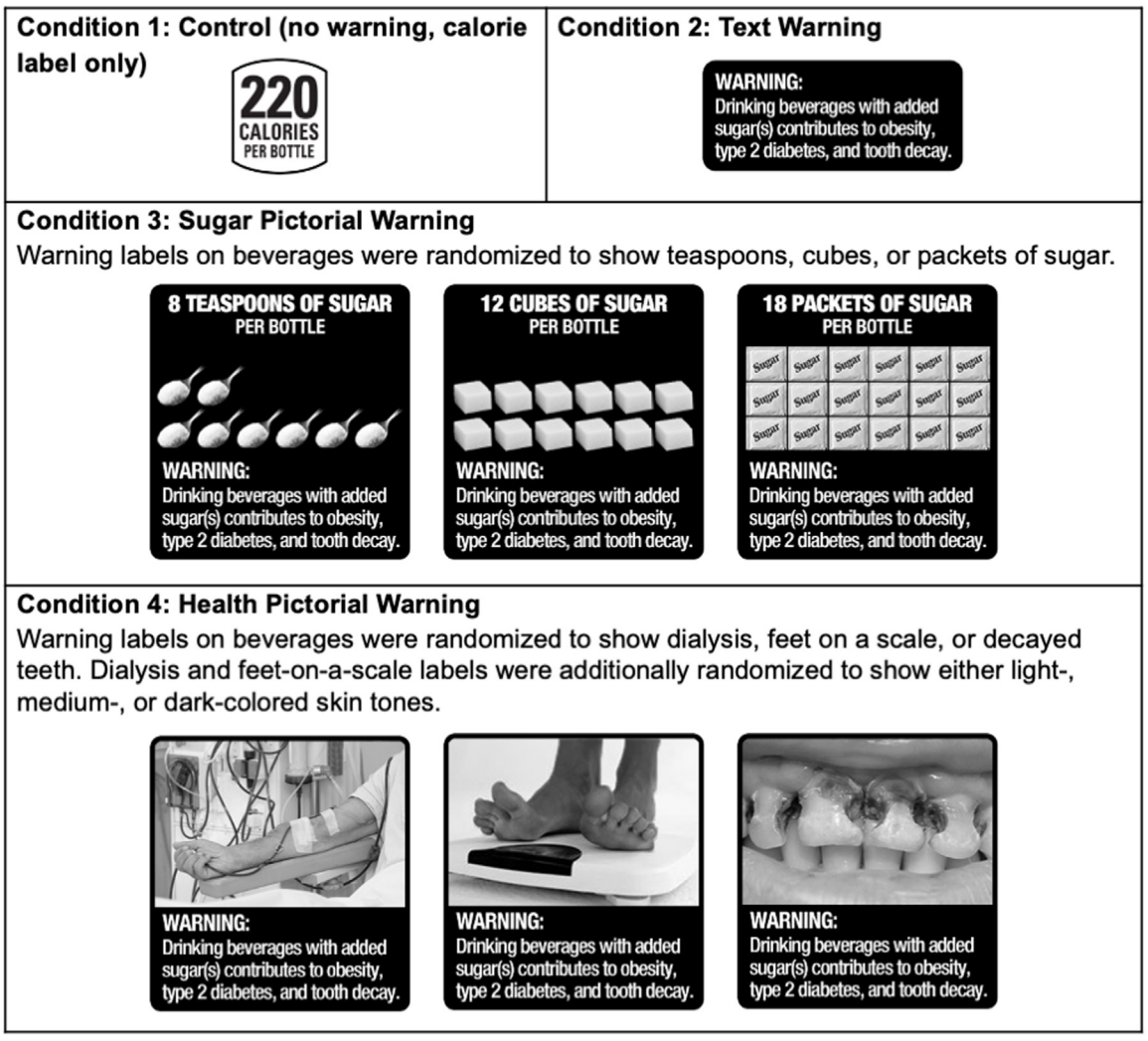

Figure 2. Warning label conditions.

Note: All beverages in the study displayed calorie labels regardless of the participant's condition. In Conditions 2−4, warning labels appeared on the front of the package of any beverage that contained added sweeteners and ≥75 calories per 12 fluid ounces.

added sugar" (warning conditions) and that they would see labels on beverages (control) or warning labels on beverages with added sugar (warning conditions) in the virtual store. An enlarged sample label appeared below this text according to the participants' randomized condition.

Participants then entered a virtual store in which they viewed 24 single-serve beverages and were instructed to select 1 to purchase for their child. Participants were told that they would be given a $2 coupon to purchase that beverage. After clicking on their beverage of choice, participants were shown an enlarged image of the beverage before it was added to their cart. Once a beverage was purchased, participants left the virtual store and completed an online survey. The 24 beverages in the store consisted of 12 unique beverages in pairs of 2, presented across 3 shelves (4 unique beverages/8 beverages per shelf). Of the 12 unique beverages, 7 beverages qualified as SSBs (e.g., soda, sweetened fruit-flavored drinks [fruit drinks]) and displayed warnings on the front of the package in Conditions 2−4 (Appendix, available online). All outcomes below were assessed after the beverage choice task.

The primary outcome was the percentage of participants who chose an SSB for their child in the virtual store. Other outcomes were the percentage of participants who chose each type of beverage for their child (e.g., soda, 100% juice) and the median beverage calories selected. Secondary outcomes assessed whether participants noticed any labels (other than calorie labels) on beverages in the virtual store (yes/no/I don't know) and whether they believed that the labels influenced their beverage choice (yes/no/I didn't see any labels besides calorie labels).

Another category of secondary outcomes was beverage knowledge. Participants were shown images of 4 beverages (sports drink, soda, water, and orange juice) one at a time in random order. The sports drink and soda displayed warnings in Conditions 2−4. While viewing those images, participants estimated each beverage's added sugar content on a continuous scale in teaspoons (open text response restricted to 0−9,999). Outcomes included

the percentage of participants in each condition who correctly estimated the number of teaspoons of added sugar in each beverage and the median estimated teaspoons for each beverage in each condition.

As a follow-up to the beverage knowledge questions, participants were asked about their beverage perceptions. While viewing each beverage image, they reported whether they thought their estimate was too little (1), just right (2), or too much (3) added sugar for their child. Participants rated how good they would feel about serving the beverage to their child, the child's enjoyment of the beverage, and purchase intentions for their child on 7-point Likert scales. They also rated health perceptions of the beverage on 7-point Likert scales, including how healthy the product was overall for their child and to what extent it would make their child feel energized; help them focus at school; help them live a healthy life; and increase their risk of weight gain, heart disease, and diabetes (these 3 risk items were reverse coded). These 7 questions were summed to create a health perceptions index from 7 to 49 (least to most healthy). Participants also reported the extent to which they would "favor or oppose a government policy requiring a warning label to be placed on beverages with added sugars" (−2 strongly disfavor to 2 strongly favor).

Participants were then shown their assigned label and answered a series of Likert-scale questions about their perceptions of it, including the likelihood of the label changing their thoughts of beverage healthfulness for their child, the extent to which the label encouraged them to give fewer beverages to their child, and their trust of information on the label. Participants also reported how worried, fearful, guilty, and disgusted/grossed out the label made them feel. These 4 items were averaged into a score measuring the overall negative reaction to the label on a scale of 1−5.

At the end of the survey, participants were asked to answer the single-item Berlin Numeracy Test, a validated instrument designed to quickly assess statistical numeracy.[30] This scale was used to examine whether certain labels were more or less effective for people with lower numeracy skills.

Baseline participant demographic information was mostly provided by Ipsos from their demographic profile assessment administered to all panelists. These items included gender, age, height, weight, education, race, ethnicity, marital status, household income, employment status, and political party affiliation. In this survey, participants were also asked to report their oldest child's age, height, and weight as well as health information, including their relationship with their weight (trying to lose, gain, or neither) and whether they or their child had ever been diagnosed with overweight, obesity, or Type 2 diabetes. Participants also reported how often their child drank each of the 4 beverages from the knowledge/perception items in the last month (9 options from never to 2 or more times/day).

Statistical Analysis

Analyses were preregistered with clinicaltrials.gov (identification NCT03648138) and AsPredicted.org (Appendix, available online). To assess balance in baseline characteristics across conditions, ANOVAs for continuous variables and chi-square tests for categorical variables were performed. Per CONSORT guidelines for randomized trials, unadjusted linear and logistic regressions were used to compare continuous and categorical outcomes, respectively, across conditions. Wilcoxon rank sum tests were used to compare the secondary outcomes of participants' median calories selected in the virtual store and median estimated teaspoons of added sugar in each beverage because the data were highly skewed with non-normal residual distribution owing to many participants choosing 0-calorie beverages for their children in the virtual store and providing a wide range of added sugar estimates.

Sensitivity analyses were conducted in which knowledge and perception outcomes for water and orange juice controlled for the frequency of participants' children consuming those beverages because their consumption frequency was imbalanced across conditions. Results did not differ significantly from those of unadjusted analyses, so unadjusted results are presented. Results from analyses with and without population survey weights also did not differ, so unweighted results are presented.

Exploratory analyses were conducted to examine whether label effects on beverage choice differed by parents' educational attainment (college education or higher versus less than college education) or numeracy (numeracy question correct versus incorrect). Another exploratory analysis examined whether the effect of label condition on support for an SSB warning label policy differed by political party affiliation (Democrat, Republican, or other). These moderation analyses used logistic/linear regression models with an interaction term for the condition and the variable of interest. A third exploratory analysis examined perceived label influence among the full sample of participants instead of just among those who reported seeing a label. All analyses used the Holm−Bonferroni procedure to correct for multiple comparisons (6 comparisons per regression model across 4 conditions),[31] and all reported p-values reflect these corrections.

RESULTS

Participants' (n=961) sociodemographics (distributed evenly across conditions) and frequency of serving each beverage to their child are shown in Table 1. Roughly half of the participants were female and had not completed college. Seventy percent of the sample identified as non-Hispanic White, 9% identified as non-Hispanic Black, and 13% identified as Hispanic. Political affiliation was fairly evenly split between Democrats (50%) and Republicans (47%), with 3% identifying as other.

For the primary outcome of beverage choice, differences compared with the control were observed for pictorial warnings but not for text warnings. The percentage of participants who chose an SSB for their child was 13.4 percentage points (pp) lower in the sugar pictorial warning condition (95% CI= −21.6 pp and −0.1 pp; p=0.007) and 14.7 pp lower in the health pictorial warning condition (95% CI= −22.8 pp and −0.1 pp; p=0.004) than in the control (Table 2). Sugar and health pictorial warning participants also chose significantly fewer beverage calories (both medians=0 kcal) than control participants (median=130 kcal, p-value versus sugar pictorial=0.004, p-value versus health pictorial=0.024) (Table 2 and Appendix Table 1, available online). There were no significant differences between warning and control

conditions in the SSB or non-SSB subtypes (e.g., sports drink, water) chosen. There was no significant moderation by education or numeracy in exploratory analyses.

Among the warning conditions, both pictorial warnings led to fewer participants selecting SSBs than text warnings. The percentage of participants who chose an SSB for their child was 13.5 pp lower in the sugar pictorial warning condition (95% CI= −21.8 pp and −0.1 pp; p=0.007) and 14.8 pp lower in the health pictorial warning condition (95% CI= −23.1 pp and −0.1 pp; p=0.004) than in the text warning group (Table 2). The sugar pictorial warning resulted in 8.2 pp fewer participants selecting fruit drinks than text warnings (95% CI= −13.1 pp and −3.3 pp, p=0.011). There were no significant differences in beverage choice between the 2 pictorial warnings.

For the warning label awareness outcome, the percentage of participants who reported seeing labels other than calorie labels was 15.9 pp higher in the sugar pictorial warning condition (95% CI=7.2 pp and 24.6 pp, p=0.002) and 15.5 pp higher in the health pictorial warning condition (95% CI=6.8 pp and 24.3 pp, p=0.003) than in the control (Table 2). Of those who reported seeing a noncalorie label, about half reported that the label influenced their purchasing decision, and there were no differences by condition. In an exploratory analysis among the full sample, more participants reported that the label influenced their purchasing decision in the sugar pictorial warning condition than in the text warning condition (+11.0 pp, 95% CI=3.2 pp and 18.7 pp, p=0.036).

Regarding beverage knowledge, a significantly larger proportion of sugar pictorial warning participants correctly estimated the exact number of teaspoons of added sugar in the SSBs (sports drink: 66.5%, SE=3.0%; soda: 52.9%, SE=3.2%) than the participants in all other conditions (all ps<0.001) (Table 2). Sugar pictorial warning participants also provided more accurate estimates of the number of teaspoons of added sugar in the sports drink (median: 8 teaspoons) and soda (median: 15 teaspoons) overall, whereas the median estimates in the other conditions were significantly less accurate and lower (sports drink: 5−6 teaspoons; soda: 10 teaspoons). A higher percentage of sugar pictorial warning participants correctly estimated the number of teaspoons of added sugar in orange juice (0 teaspoons) than health pictorial warning participants (+11.7 pp, 95% CI=4.2 pp and 19.2 pp, p=0.017).

Regarding beverage perceptions, sugar pictorial warnings led to stronger perceptions that the sports drink had too much added sugar than the control (p=0.024) (Table 2). Both pictorial warnings led to stronger perceptions that the sports drink had too much added sugar than the text warnings (text versus sugar pictorial p=0.005; text versus health pictorial p=0.034).

For warning label policy perception outcomes, although most participants overall (66.9%) somewhat or strongly favored an SSB warning policy, participants who saw sugar pictorial warnings favored an SSB warning policy significantly more than participants who saw health pictorial warnings (p=0.014) (Table 2). In exploratory analyses, effects did not differ by political affiliation.

Regarding warning label perceptions, all warnings resulted in participants reporting that the label would make them less likely to give beverages with warnings to their child (Table 2) and elicited significantly stronger negative reactions (e.g., fear, disgust) than the control, with both pictorial warnings having larger effects than text warnings. Health pictorial warnings in particular elicited significantly stronger negative reactions than the sugar pictorial warning (p=0.044) and text warning (p<0.001). However, participants reported significantly less trust in the information on health pictorial warnings than sugar pictorial (p=0.011) and text (p=0.022) warnings. Compared with the control, sugar pictorial warnings changed participants' perceptions of beverage healthiness for their children (p=0.002).

DISCUSSION

In this randomized controlled experiment using a nationally representative sample, pictorial warnings depicting the negative health impacts of SSB consumption and pictorial warnings depicting SSBs' added sugar content significantly reduced parents' selections of SSBs for their children in a virtual convenience store compared with text-only warnings and calorie labels alone. These findings are supported by a growing body of research suggesting that pictorial warnings are significantly more effective than text-only warnings on SSBs[15,16,19–21] and tobacco products.[32] A real-world evaluation of SSB warnings also found a lack of behavioral effects from text warnings compared with a control,[15] as was found in this study, but online trials have found text warnings to reduce selections of SSBs compared with a control.[11,13] This study's results are also similar to those of a study that found that pictorial health labels and pictorial sugar disclosures on SSBs (without warning language) decreased parents' SSB selections for their children compared with a no-warning control.[23]

Although the 2 types of pictorial warnings in this study performed similarly on most measures,

Table 2. Beverage Choice, Beverage Knowledge and Perceptions, and Policy and Label Perceptions

Outcomes	Control (*n*=246)	Text (*n*=235)	Sugar pictorial (*n*=242)	Health pictorial (*n*=238)
Beverage choice (primary outcome)				
Parent chose SSB for child, % (SE) (primary outcome)	39.0 (3.1)c,d	39.1 (3.2)[c,d]	**25.6 (2.8)**[a,b]	**24.4 (2.8)**[a,b]
Calories chosen, median	130[c,d]	130	**0**[a]	**0**[a]
Parent chose SSB subtype for child, % (SE)				
Sports drink	13.4 (2.2)	13.6 (2.2)	12.0 (2.1)	10.5 (2.0)
Soda	11.0 (2.0)	7.2 (1.7)	5.0 (1.4)	4.6 (1.4)
Fruit drink	8.9 (1.8)	12.3 (2.2)[c]	4.1 (1.3)[b]	5.5 (1.5)
Sweetened tea	5.7 (1.5)	6.0 (1.5)	4.5 (1.3)	3.8 (1.2)
Parent chose non-SSB subtype for child, % (SE)				
Water	34.1 (3.0)	36.2 (3.1)	44.2 (3.2)	41.6 (3.2)
Juice	18.3 (2.5)	14.5 (2.3)	18.2 (2.5)	21.8 (2.7)
Seltzer	3.7 (1.2)	4.7 (1.4)	4.1 (1.3)	5.9 (1.5)
Unsweetened tea	3.7 (1.2)	3.4 (1.2)	4.1 (1.3)	2.9 (1.1)
Diet soda	1.2 (0.7)	2.1 (0.9)	3.7 (1.2)	3.4 (1.2)
Secondary outcomes:				
Warning label awareness				
Noticed noncalorie label, % (SE)	37.0 (3.1)[c,d]	42.1 (3.2)	**52.9 (3.2)**[a]	**52.5 (3.2)**[a]
Noncalorie label influenced purchase among those who noticed noncalorie label, % (SE)	56.0 (5.2)	48.0 (5.1)	58.6 (4.4)	51.2 (4.5)
Noncalorie label influenced purchase among full sample, % (SE)	20.7 (2.6)	20.0 (2.6)[c]	31.0 (3.0)[b]	26.9 (2.9)
Sports drink, knowledge & perceptions				
Correctly estimated 8 teaspoons of added sugar, % (SE)	4.9 (1.4)[c]	4.3 (1.3)[c]	**66.5 (3.0)**[a,b,d]	7.1 (1.7)[c]
Estimated teaspoons of added sugar, median (25th percentile, 75th percentile)	5 (3,10)[c,d]	5 (3,10)[c,d]	**8 (8,8)**[a,b,d]	**6 (4,10)**[a,b,c]
Estimated amount of added sugar is appropriate for the child, mean (SE) (too little=1, just right=2, too much=3)	2.7 (0.0)[c]	2.7 (0.0)[c,d]	**2.8 (0.0)**[a,b]	2.8 (0.0)[b]
Parent feels good serving beverage to child, mean (SE) (1–7)	3.2 (0.1)	3.2 (0.1)	2.9 (0.1)	2.9 (0.1)
Child enjoyment of beverage, mean (SE) (1–7)	4.7 (0.1)	4.6 (0.1)	4.7 (0.1)	4.7 (0.1)
Purchase intentions for the child, mean (SE) (1–7)	2.6 (0.1)	2.6 (0.1)	2.4 (0.1)	2.4 (0.1)
Health perception index, mean (SE) (7–49)	25.0 (0.5)	24.7 (0.5)	23.3 (0.5)	23.3 (0.4)
Soda, knowledge and perceptions				
Correctly estimated 15 teaspoons of added sugar, % (SE)	6.5 (1.6)[c]	4.7 (1.4)[c]	**52.9 (3.2)**[a,b,d]	8.0 (1.8)[c]
Estimated teaspoons of added sugar, median (25th percentile, 75th percentile)	10 (5,20)[c]	10 (5,18)[c]	**15 (12,15)**[a,b,d]	10 (6,20)[c]
Estimated amount of added sugar is appropriate for the child, mean (SE) (too little=1, just right=2, too much=3)	3.0 (0.0)	3.0 (0.0)	3.0 (0.0)	3.0 (0.0)
Parent feels good serving beverage to child, mean (SE) (1–7)	1.6 (0.1)	1.8 (0.1)	1.7 (0.1)	1.7 (0.1)
Child enjoyment of beverage, mean (SE) (1–7)	4.4 (0.1)	4.4 (0.1)	4.5 (0.1)	4.5 (0.1)
Purchase intentions for the child, mean (SE) (1–7)	1.9 (0.1)	1.8 (0.1)	1.9 (0.1)	1.9 (0.1)
Health perception index, mean (SE) (7–49)	15.4 (0.4)	15.7 (0.4)	15.5 (0.4)	15.7 (0.4)
Water, knowledge and perceptions				
Correctly estimated 0 teaspoons of added sugar, % (SE)	97.6 (1.0)	98.3 (0.8)	96.7 (1.2)	95.4 (1.4)
Estimated teaspoons of added sugar, median (25th percentile, 75th percentile)	0 (0,0)	0 (0,0)	0 (0,0)	0 (0,0)
Estimated amount of added sugar is appropriate for the child, mean (SE) (too little=1, just right=2, too much=3)	2.0 (0.0)	2.0 (0.0)	2.0 (0.0)	2.0 (0.0)

(*continued on next page*)

Table 2. Beverage Choice, Beverage Knowledge and Perceptions, and Policy and Label Perceptions (*continued*)

Outcomes	Control (*n*=246)	Text (*n*=235)	Sugar pictorial (*n*=242)	Health pictorial (*n*=238)
Parent feels good serving beverage to child, mean (SE) (1–7)	6.0 (0.1)	6.2 (0.1)	6.2 (0.1)	6.1 (0.1)
Child enjoyment of beverage, mean (SE) (1–7)	5.2 (0.1)	5.2 (0.1)	5.2 (0.1)	5.0 (0.1)
Purchase intentions for the child, mean (SE) (1–7)	5.2 (0.1)	5.4 (0.1)	5.6 (0.1)	5.4 (0.1)
Health perception index, mean (SE) (7–49)	41.8 (0.4)	41.7 (0.4)	42.1 (0.4)	41.7 (0.4)
Orange juice, knowledge and perceptions				
Correctly estimated 0 teaspoons of added sugar, % (SE)	20.3 (2.6)	21.7 (2.7)	29.3 (2.9)[d]	17.7 (2.5)[c]
Estimated teaspoons of added sugar, median (25th percentile, 75th percentile)	3 (1,7)	3 (1,6)	3 (0,8)	3 (2,8)
Estimated amount of added sugar is appropriate for the child, mean (SE) (too little=1, just right=2, too much=3)	2.5 (0.0)	2.5 (0.0)	2.5 (0.0)	2.5 (0.0)
Parent feels good serving beverage to child, mean (SE) (1–7)	4.3 (0.1)	4.4 (0.1)	4.5 (0.1)	4.5 (0.1)
Child enjoyment of beverage, mean (SE) (1–7)	4.7 (0.1)	4.8 (0.1)	4.8 (0.1)	4.8 (0.1)
Purchase intentions for the child, mean (SE) (1–7)	3.4 (0.1)	3.3 (0.1)	3.5 (0.1)	3.5 (0.1)
Health perception index, mean (SE) (7–49)	29.6 (0.5)	29.4 (0.4)	29.6 (0.5)	29.3 (0.5)
Warning label policy perceptions				
Favor SSB warning label policy, mean (SE) (−2 strongly disfavor; 2 strongly favor)	0.9 (0.1)	0.9 (0.1)	1.1 (0.1)[d]	0.8 (0.1)[c]
Warning label perceptions				
Likelihood of label changing thoughts of beverage healthiness for the child, mean (SE) (1–5)	3.2 (0.1)[c]	3.2 (0.1)[c]	**3.7 (0.1)[a,b]**	3.5 (0.1)
Label encourages giving fewer beverages to child, mean (SE) (1–5)	3.6 (0.1)[b,c,d]	**3.9 (0.1)[a]**	**4.0 (0.1)[a]**	**3.9 (0.1)[a]**
Trust of information on label, mean (SE) (1–7)	5.2 (0.1)	5.4 (0.1)[d]	5.4 (0.1)[d]	5.0 (0.1)[b,c]
Negative reaction to the label, mean (SE) (1–5)	2.2 (0.1)[b,c,d]	**2.5 (0.1)[a,c,d]**	**2.8 (0.1)[a,b,d]**	**3.0 (0.1)[a,b,c]**

Note: Boldface indicates statistical significance compared with the control (Bonferroni–Holm–corrected $p<0.05$).
In the beverage choice task, 12 unique beverages were shown, including 7 SSBs—1 sports drink, 2 sodas, 2 fruit drinks, and 2 sweetened teas—and 5 non-SSBs—1 water, 1 100% juice, 1 seltzer, 1 unsweetened tea, and 1 diet soda.
[a]Significantly different from control; Bonferroni–Holm corrected $p<0.05$.
[b]Significantly different from text warning; Bonferroni–Holm corrected $p<0.05$.
[c]Significantly different from sugar pictorial warning; Bonferroni–Holm corrected $p<0.05$.
[d]Significantly different from health pictorial warning; Bonferroni–Holm corrected $p<0.05$.
SSB, sugar-sweetened beverage.

participants who saw sugar pictorial warnings more accurately estimated the amount of added sugar in SSBs, reported significantly more trust in the label's information, and more strongly supported SSB warning policies than those who saw health pictorial warnings. Sugar pictorial warnings may have been favored because participants may have viewed them as more objective/factual than images depicting long-term health outcomes, which will not affect every individual who regularly consumes SSBs. The only outcome showing a stronger effect of health pictorial warnings than sugar pictorial warnings was negative emotional reactions. Overall, this study's results suggest that including an image on a warning label is likely to increase its effectiveness. Although sugar and health pictorial warnings had similar influences on behavior, the additional benefits of sugar pictorial warnings on knowledge, label trust, and policy support suggest that they may be preferred to health pictorial warnings. In addition, health pictorial warnings may be more likely to increase obesity stigma and blame individuals for experiencing negative health consequences; this is an important area for future research.[33]

This study's findings suggest multiple mechanisms through which pictorial warnings may outperform text-only warnings. Sugar pictorial warnings appear to have worked in part by increasing knowledge, a mechanism supported by previous research.[34] Sugar pictorial warnings improved parents' ability to correctly estimate the added-sugar content of 2 labeled beverages—a soda and a sports drink. Previous SSB warning research found that warnings can correct parent

misperceptions that certain SSBs such as sports drinks are healthier than soda.[35] Sugar and health pictorial warnings reduced healthy perceptions of the sports drink but not of soda in this study, although the *p*-value was no longer significant after correcting for multiple comparisons. However, soda was rated as the least healthy beverage in all conditions, so warnings may be less effective on drinks caregivers already perceive to be unhealthy.

Pictorial warnings may also have been more effective than text warnings owing to increased salience. Participants were more likely to recall seeing them, potentially owing to the larger amount of package space they occupied and the surprising/shocking nature of the images.[36] This increased ability of pictorial warnings to capture and hold visual attention has also increased recall and knowledge in tobacco studies.[37,38] Both types of pictorial warnings also elicited greater negative reactions, with health pictorial warnings particularly eliciting more negative reactions than all other conditions. Tobacco research suggests that warnings change behavior by increasing negative effects and cognitive elaboration,[39,40] and negative emotional reactions have been shown to be associated with increases in thinking about risks, intentions to quit, and quitting behaviors.[36,41]

Although SSB warnings may decrease consumption, the large proportion of participants who did not remember seeing the pictorial warnings suggest that warning policies should be accompanied by education campaigns to ensure that consumers are aware of the labels and understand how to use them. Despite showing participants an enlarged example warning label in the survey's introduction and showing them an enlarged image of their chosen beverage with the warning on it, only 53% of participants in both pictorial warning conditions and 42% in the text warning condition reported seeing any warnings in the virtual store. Among participants who recalled seeing sugar pictorial warnings, one third to one half incorrectly estimated how many teaspoons of added sugar were in the soda and sports drink, despite being shown exactly how many teaspoons of added sugar were in each beverage on the warning. However, their median estimates of teaspoons of added sugar in both beverages were correct; median estimates in all other conditions were significantly lower. It is possible that repeated exposure to these warnings in a real-world context would prompt more attention.[42]

Strengths of this study include its randomized controlled design to perform a direct comparison of multiple warnings in a realistic virtual convenience store using a large, nationally representative sample. This study is the first, to the authors' knowledge, to directly compare the effects of health pictorial warnings, sugar pictorial warnings, and text warnings with those of a nonwarning control.

Limitations

This study had several limitations. First, the survey introduction primed participants to be aware of warning labels, which may have made them more salient than in a real-world context; however, repeated exposure to warnings in the real world likely increases their saliency over a single online exposure. Participants may have also experienced social desirability bias to select healthier options. However, this seems unlikely given participant anonymity and the fact that many people selected SSBs. Actual purchases were not measured, but participants were told that they would receive a coupon to purchase a beverage of their choice, which provided an incentive for them to choose a beverage they actually wanted. Orange juice did not carry a warning label in this study despite its high sugar content (34 g of naturally occurring, not added, sugar per bottle), which may have reduced label trust in some participants, given that pediatricians recommend limiting children's fruit juice intake.[43] The study also only examined a 1-time exposure to the warnings, but their effect may change over time after repeated exposures in a real-world context. In addition, we studied labels that were fairly large. Label effects might be significantly reduced if smaller labels were adopted. Furthermore, to keep the font size standardized, text warnings occupied less package space than pictorial warnings. Future studies should compare text and pictorial warnings occupying the same amount of package space. It would also be useful to compare sugar pictorial warnings with warnings that use icons or symbols plus text, which may be easier to implement than visual displays of individual beverages' sugar content. Participants may also not have been familiar with the pictorial warning's depiction of dialysis, but it was shown with text and in the context of other pictorial warnings that are likely more familiar (e.g., tooth decay). Finally, the exploratory analyses may have been underpowered to detect differences in effects by education, numeracy, or political affiliation.

CONCLUSIONS

Results suggest that SSB warning policies may be most effective if they include images of beverages' added sugar content accompanied by warning text. More behavioral data testing SSB warnings are needed in real-world settings.

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SUPPLEMENTAL MATERIAL

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