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RESEARCH ARTICLE

Sugar-Sweetened Beverage Health Warnings and Purchases: A Randomized Controlled Trial

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Introduction: Five U.S. states have proposed policies to require health warnings on sugar-sweetened beverages, but warnings' effects on actual purchase behavior remain uncertain. This study evaluated the impact of sugar-sweetened beverage health warnings on sugar-sweetened beverage purchases.

Study design: Participants completed one study visit to a life-sized replica of a convenience store in North Carolina. Participants chose six items (two beverages, two foods, and two household products). One item was randomly selected for them to purchase and take home. Participants also completed a questionnaire. Researchers collected data in 2018 and conducted analyses in 2019.

Setting/participants: Participants were a demographically diverse convenience sample of 400 adult sugar-sweetened beverage consumers (usual consumption ≥12 ounces/week).

Intervention: Research staff randomly assigned participants to a health warning arm (sugar-sweetened beverages in the store displayed a front-of-package health warning) or a control arm (sugar-sweetened beverages displayed a control label).

Main outcome measures: The primary trial outcome was sugar-sweetened beverage calories purchased. Secondary outcomes included reactions to trial labels (e.g., negative emotions) and sugar-sweetened beverage perceptions and attitudes (e.g., healthfulness).

Results: All 400 participants completed the trial and were included in analyses. Health warning arm participants were less likely to be Hispanic and to have overweight/obesity than control arm participants. In intent-to-treat analyses adjusting for Hispanic ethnicity and overweight/obesity, health warnings led to lower sugar-sweetened beverage purchases (adjusted difference, −31.4 calories; 95% CI= −57.9, −5.0). Unadjusted analyses yielded similar results (difference, −32.9 calories; 95% CI= −58.9, −7.0). Compared with the control label, sugar-sweetened beverage health warnings also led to higher intentions to limit sugar-sweetened beverage consumption and elicited more attention, negative emotions, thinking about the harms of sugar-sweetened beverage consumption, and anticipated social interactions. Trial arms did not differ on perceptions of sugar-sweetened beverages' added sugar content, healthfulness, appeal/coolness, or disease risk.

Conclusions: Brief exposure to health warnings reduced sugar-sweetened beverage purchases in this naturalistic RCT. Sugar-sweetened beverage health warning policies could discourage sugar-sweetened beverage consumption.

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INTRODUCTION

Excess consumption of sugar-sweetened beverages (SSBs) such as sodas, fruit drinks, and sports drinks is a pressing public health issue in the U.S. Average SSB consumption among U.S. adults remains well above recommended levels,[1–3] increasing risk for several of the most common preventable chronic diseases in the U.S., including obesity, diabetes, and cardiovascular disease.[4–7] Nutrition education and other behavioral interventions can yield small reductions in SSB consumption among those they reach.[8] However, the consensus among experts is that policy action is needed to achieve meaningful population-wide improvements in dietary behaviors and diet-related diseases.[9–12] Requiring health warnings on SSB containers is one promising policy for addressing overconsumption of SSBs.

Five U.S. states have proposed policies that would require health warnings on the front of SSB containers.[13–18] Experimental research on SSB warnings can inform future policies in the U.S. and globally. Several online studies have assessed SSB health warnings' impact on hypothetical intentions to purchase SSBs.[19–21] However, intentions are an imperfect predictor of behavior,[22] and few studies have assessed behavioral outcomes. One quasi-experiment conducted in a hospital cafeteria found that graphic SSB health warnings (but not text SSB health warnings) were associated with lower SSB purchases,[23] but this study did not use a randomized design. Another study used a randomized design and measured beverage purchases, but displayed beverages and health warnings on a computer screen, not in a retail environment.[24] To understand the impact of SSB health warnings on purchase behaviors, RCTs in naturalistic retail settings are needed. Such trials provide strong causal inference while also mimicking many real-world conditions consumers would experience if SSB health warning policies were implemented.

To inform obesity prevention policy, this study conducted an RCT in an immersive, naturalistic convenience store laboratory to estimate the impact of SSB health warnings on SSB purchases. This study also assessed the impact of SSB health warnings on behavioral intentions, cognitive and affective message reactions, and SSB perceptions and attitudes.

METHODS

Study Population

Participants were adults aged ≥18 years; could read, write, and speak English; and were current SSB consumers, defined as consuming at least 1 serving (12 ounces) per week of SSBs as assessed using an adapted version of the BEVQ-15 beverage frequency questionnaire.[25] Research staff recruited and enrolled participants from May to September 2018 using Craigslist, Facebook, e-mail lists, university participant pools, in-person recruitment, and flyers. The University of North Carolina IRB approved all study procedures and all participants provided their written informed consent.

Intervention

The trial took place in a naturalistic convenience store laboratory located in the Fuqua Behavioral Lab at Duke University in Durham, North Carolina. The trial store is a life-sized replica of a typical convenience store, selling foods, beverages, and household products at real-world prices. Naturalistic laboratory stores like the one used in this study provide an immersive experience that simulates a real shopping trip.[26,27]

Beverages for sale included popular SSBs in 7 beverage categories: sodas, fruit drinks, sports drinks, energy drinks, sweetened ready-to-drink (RTD) teas, sweetened RTD coffees, and calorically flavored waters (Appendix Table 1, available online). Research staff examined household purchase data from North Carolina[28] to identify up to 5 popular products by volume purchased in each of the 7 beverage categories. For all categories except sodas and fruit drinks, the store sold 1 product; the store sold 5 types of soda and 2 types of fruit drinks because these beverage categories comprise most SSB calories consumed by U.S. adults.[1,29] SSB containers were 8.0–16.9 ounces, reflecting the typical amount consumed in a single sitting.[30]

For each SSB sold, the store also sold a non-SSB that closely matched the selected SSB in brand, flavor, and container size (Appendix Table 1, available online). Each soda, sports drink, energy drink, sweetened RTD tea, and flavored water was matched to the diet/low-calorie version of the product. Sweetened RTD coffee was matched to an unsweetened version of the same coffee, and fruit drinks were matched to similar 100% fruit juices. To more fully reflect the retail environment, the store also sold unflavored bottled water and non-calorically flavored sparkling water, despite these beverages having no corresponding SSBs.

The store also sold a variety of foods (e.g., chips, cookies, crackers, packaged fruit cups, nuts, cereal, canned soup, and pasta) in both single-serving and multipack/family sizes as well as household products (e.g., shampoo, soap, toothpaste, napkins, garbage bags, over-the-counter medications, and notebooks). These products were selected before the present study by the Behavioral Lab to interest participants and mimic a typical convenience store.

Beverages were priced to match standard retail prices in stores in lower- and middle-income areas surrounding the laboratory, similar to the approach used by others.[24] To ensure participants selected beverages based on their preferences, rather than simply selecting the least expensive items, prices were held constant across conditions, and each SSB and its corresponding non-SSB were priced identically (Appendix Table 1, available online). Prices for foods and household products remained at the levels that the Behavioral Lab had set previously to reflect real-world prices.

Research staff screened individuals for eligibility using an online questionnaire, inviting those eligible to schedule a time to visit the Behavioral Lab to complete the study. At the study visit, participants enrolled and provided written informed consent. Recruitment materials and consent documents indicated that the study intended to examine factors affecting consumer behavior but did not reveal the study's focus on SSBs or health warnings.

When participants arrived for their study visit, research staff assigned them to 1 of 2 trial arms, health warning or control. Study staff consulted a randomly ordered, prepopulated list of allocations and assigned participants to the next allocation on the list. The list was generated before study start by an independent biostatistician using simple randomization in a 1:1 allocation ratio. In the health warning arm, research staff applied a health warning label (Figure 1) directly to the front of all SSB containers in the trial store. The label displayed the message "WARNING: Beverages with added sugar contribute to tooth decay, diabetes, and obesity" in white text on a red octagon (1.5 inch-wide span) with a thin white border. This design was chosen for the SSB health warning because it performed well in an online randomized experiment.[31] For the control arm, staff applied a 1 inch X 2.625 inch bar code label (Figure 1) to the front of all SSB containers. A bar code image was chosen for the control label because beverage containers already display bar codes. Using a control label, rather than a no-label control arm, ensured that the study controlled for the effect of putting a label on SSB containers.

When participants entered the store, they received a shopping basket and $10 in cash. Research staff asked participants to shop as they usually would and to choose 6 items: 2 household products, 2 foods, and 2 beverages. Researchers asked participants to place their choices in their basket and instructed them that 1 of these 6 items would be randomly selected for them to purchase and take home using the $10 cash incentive provided at the start of the shopping task. This procedure ensured that selections were real stakes (i.e., that all 6 items participants chose were items they actually wished to purchase).

Research staff left the store while participants completed the shopping task. When participants were ready to check out, research staff recorded all the products in their basket. Then, the researcher numbered the products and drew a number out of a basket to randomly select 1 item for the participant to purchase with the incentive cash at the product's listed price. The researcher gave the participant the change owed in cash. Participants then completed a questionnaire on a computer in a private room. Afterward, they received the item they had purchased in the shopping task and were debriefed about the purpose of the study.

Figure 1. Sugar-sweetened beverage health warning label (left) and control label (right) used in the trial (actual sizes).

Measures

The primary trial outcome was SSB calories purchased, calculated as the sum of calories per container from all SSBs in the participants' shopping basket when they completed the shopping task. Secondary purchase outcomes included purchase of any SSB, the number of SSBs purchased, and total calories purchased (from all products, including SSBs, non-SSBs, and foods).

Previous research on SSB[19–21] and cigarette health warnings[32–34] informed selection of secondary psychological outcomes. These outcomes were assessed in the post-shopping questionnaire with items and scales that have been validated or used in previous studies (Appendix Exhibit 1, available online). Psychological secondary outcomes included intentions to limit consumption of SSBs, including intentions to limit consumption of beverages with added sugar and intentions to limit consumption of the specific categories of SSBs sold in the trial store (e.g., sodas and fruit drinks). Questionnaires also assessed whether participants noticed the label applied to the SSBs (health warning or control) and 4 message reactions (i.e., responses to the trial labels): attention elicited by the label, cognitive elaboration (thinking about the label and thinking about the harms of SSB consumption), negative emotions elicited by the label (e.g., fear and regret), and anticipated social interactions about the label. Because the attention, elaboration, emotion, and social interactions items queried participants' responses to their trial label (e.g., *How much did the labels on the beverages make you feel anxious*?), only participants who indicated noticing the trial label received these items. Among participants who reported they did not notice the label, researchers coded responses to these items with the lowest value. Additionally, the questionnaire assessed 4 SSB perceptions and attitudes: perceived amount of added sugar in SSBs sold in the trial store, perceived healthfulness of consuming beverages with added sugar, positive attitudes (appeal and coolness) toward SSBs sold in the trial store, and negative outcome expectations (i.e., disease risk perceptions) regarding consuming beverages with added sugar.

Questionnaires also assessed participants' beliefs about the purpose of the study using an open-ended question presented before any other items. Researchers coded responses to this item to determine whether participants correctly guessed the purpose of the study (i.e., to assess the impact of SSB health warnings on purchase behavior).

Statistical Analysis

Power analyses used G*Power, version 3.1 to calculate sample size needs for detecting an effect of health warnings on SSB purchases using linear regression. Previous studies of SSB health warnings have examined purchase intentions (rather than actual purchases) as the primary outcome, finding medium[19,20] and large effect sizes.[21] To provide a conservative estimate of required sample size

accounting for the intention–behavior gap, power analyses assumed a small standardized effect (Cohen's f^2 =0.02). Analyses indicated that the target enrollment of 400 adults would provide 80% power to detect this effect or larger, assuming α=0.05.

Analyses of trial outcomes included all randomized participants (intent-to-treat analyses). Analyses examined differences between trial arms in participant characteristics using chi-square tests and *t*-tests for categorical and continuous variables, respectively. Analyses used a critical α=0.05 and 2-tailed statistical tests. Analyses used Stata SE, version 15.1 in 2019.

Analyses examined the impact of the trial arm on SSB calories purchased controlling for any participant characteristics found to differ between trial arms. Although the pre-analysis plan specified using ordinary least squares (OLS) regression to examine SSB calories purchased, this outcome was zero-inflated, and a 2-part model better fit the data (Akaike information criterion, 2-part model: 3,332; OLS: 5,068). Thus, analyses of the primary outcome used a 2-part model with logistic regression to examine the probability of purchasing any SSB calories and OLS regression to examine the amount of SSB calories purchased conditional on having purchased any SSB calories. Sensitivity analyses excluding participants who correctly identified the purpose of the study (*n*=18, 4.5% of the sample) revealed similar results, so subsequent analyses included all participants. To examine whether the effect of the health warnings on SSB purchases differed by participant characteristics, analyses added participant characteristics and their interaction with trial arm to separate models for each characteristic.

To examine secondary outcomes, analyses used 2-part models for non-SSB calories (which were zero-inflated), OLS regression for all other continuous outcomes, and logistic regression for dichotomous outcomes, again controlling for participant characteristics that differed between trial arms. Though the pre-analysis plan specified using Poisson regression for count outcomes (i.e., number of SSBs purchased), the data were overdispersed, so these analyses instead used negative binomial regression.[35] To account for potential heteroskedasticity, all models for continuous variables used robust SEs. Results report unadjusted point estimates (means and proportions) and adjusted differences (ADs) controlling for participant characteristics that differed between arms. Unadjusted differences were very similar (Appendix Table 2, available online). No interim analyses were conducted. Except where noted, all outcomes and analyses described were prespecified in the trial's Protocol and Statistical Analysis Plan (available from http://clinicaltrials.gov/ct2/show/NCT03511937).

RESULTS

A total of 400 adult SSB consumers enrolled in the study. All received their allocated intervention and were included in analyses (Figure 2). The average age in the sample was 29.0 (SD=10.3) years. Participants were diverse: more than half were nonwhite; 10% identified as gay, lesbian, or bisexual; and more than half had an annual household income <$50,000 (Table 1). Of the 11 conducted balance tests, 2 were statistically significant. Participants in the control arm were more likely than participants in the health warning arm to be Hispanic (p=0.004) and to have a BMI in the overweight/obese range (BMI ≥25 kg/m^2, p=0.03).

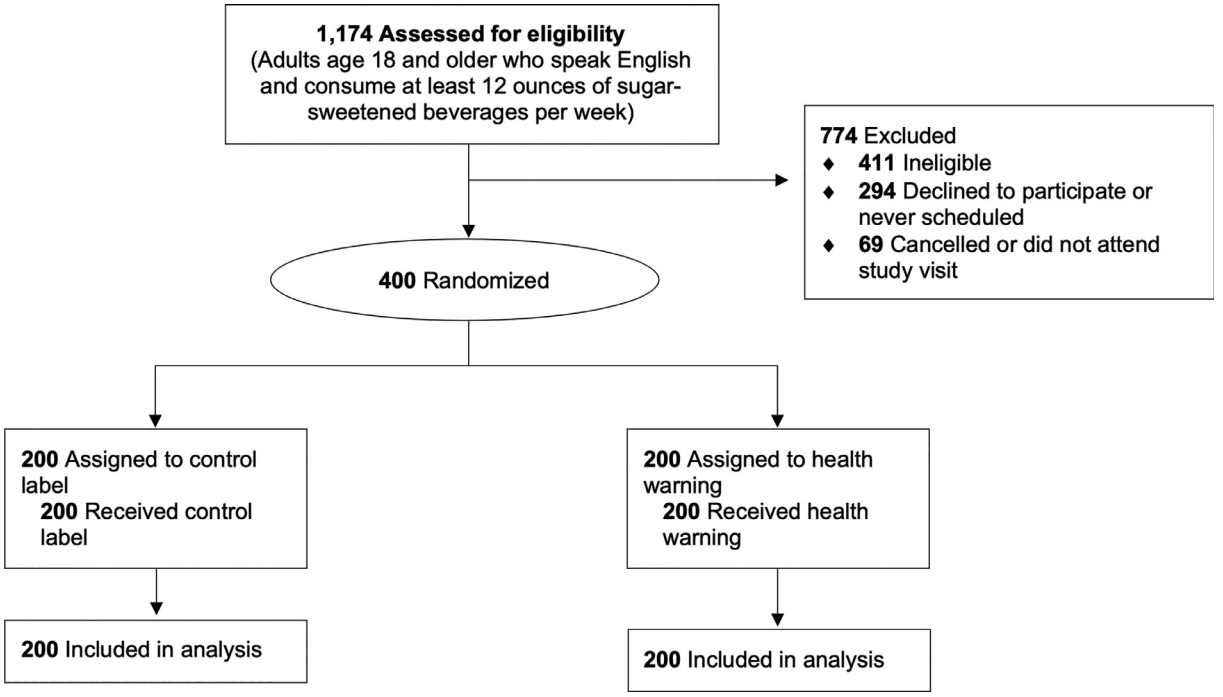

Figure 2. CONSORT flow diagram.

Table 1. Participant Characteristics by Trial Arm

Characteristics	Control arm, *n* (%) (*n*=200)	Health warning arm, *n* (%) (*n*=200)
Age, years		
18–29	125 (63)	132 (66)
30–39	47 (24)	41 (21)
40–54	22 (11)	19 (10)
≥55	6 (3)	8 (4)
Mean (SD)	29.0 (10.3)	29.0 (10.5)
Gender		
Male	83 (42)	76 (38)
Female	115 (58)	121 (61)
Transgender or other	2 (1)	3 (2)
Gay, lesbian, or bisexual	21 (11)	20 (10)
Hispanic	25 (13)	9 (5)
Race		
White	87 (44)	93 (47)
Black or African American	46 (23)	43 (22)
Asian	47 (24)	51 (26)
Other/multiracial[a]	17 (9)	12 (6)
Low education (some college or less)[b]	47 (24)	47 (24)
Limited health literacy[c]	40 (20)	34 (17)
Household income, annual		
$0 – $24,999	47 (24)	49 (25)
$25,000–$49,999	61 (31)	54 (27)
$50,000–$74,999	22 (11)	34 (17)
≥$75,000	69 (35)	63 (32)
Sugar-sweetened beverage consumption		
Low (≤60 oz/week[d])	103 (52)	100 (50)
High (>60 oz/week[d])	97 (49)	100 (50)
Overweight (BMI ≥25 kg/m^2)	93 (47)	72 (36)

Note: Missing demographic data ranged from 0% to 1%. In the 11 balance tests conducted, 2 statistically significant differences between the health warning and control arm were observed: proportion Hispanic (p=0.004) and proportion overweight (p=0.03).
[a]Includes participants who marked "other race," American Indian/Native American, Native Hawaiian or Pacific Islander, or who marked multiple races.
[b]Educational attainment for participants ≤25 years (who may still be completing degrees) was assessed using mother's or father's educational attainment, whichever was higher.
[c]"Possibility" or "high likelihood" of limited health literacy based on score on the Newest Vital Sign questionnaire.[36]
[d]Sample median.

Participants in the control arm purchased an average of 143.2 (SE=9.7) calories from SSBs, the primary trial outcome (Table 2). Participants in the health warning arm purchased 109.9 (SE=9.5) calories from SSBs. In adjusted analyses, health warnings led to a reduction of −31.4 calories of SSBs purchased (95% CI= −57.9, −5.0). Unadjusted analyses yielded similar results (difference, −32.9 calories; 95% CI= −58.9, −7.0). The effect of SSB health warnings on SSB purchases did not differ by any of the 10 examined participant characteristics (i.e., age, gender, sexual orientation, Hispanic ethnicity, race, educational attainment, income, health literacy, usual SSB intake, and overweight/obese status; p>0.20 for all interactions) (Appendix Table 3, available online). Health warnings also led to lower likelihood of purchasing an SSB (64% vs 50%, AD= −13 percentage points, 95% CI= −23%, −4%) and lower number of SSBs purchased (0.9 beverages vs 0.7 beverages, AD= −0.2 SSBs, 95% CI= −0.4, −0.1). Results were similar in unadjusted analyses (Appendix Table 2, available online).

The SSB health warnings led to higher intentions to limit consumption of the SSBs sold in the trial store (e.g., intentions to limit consumption of sodas or fruit drinks) (p=0.005), but intentions to limit consumption of beverages with added sugar did not differ between trial arms (p=0.403) (Table 2). Participants in the health warning arm were more likely to notice the trial label (p<0.001) and reported greater attention to the label (p<0.001). The health warning also led to more thinking about the trial label and harms of SSB consumption, higher levels of negative emotions, and higher anticipation of talking with others about the label (all p<0.001). Perceived amount of added sugar in SSBs, perceived healthfulness, positive product attitudes, and negative outcome expectations did not differ by trial arm.

To understand purchase behaviors more broadly, analyses also examined the impact of health warnings on calories purchased from foods, from non-SSBs, and from all sources (i.e., total calories from SSBs, non-SSBs, and foods) (Table 2). Only the latter, total calories from all sources, was preregistered as a secondary outcome. Participants in the health warning arm purchased somewhat more calories from non-SSBs than participants in the control arm (driven almost entirely by higher juice purchases), although the difference was not significant (AD=12.5 calories, 95% CI= −1.6, 26.6). Trial arms did not differ on calories purchased from foods (AD= −49.5 calories, 95% CI= −271.3, 172.3) or in total calories purchased from all sources (AD= −69.4, 95% CI= −295.5, 156.6).

DISCUSSION

This naturalistic RCT with 400 U.S. adults found that health warnings reduced SSB purchases. Consistent with previous studies,[19,20,31] the effectiveness of SSB health warnings did not differ across diverse population groups, including racial/ethnic minorities as well as adults with limited health literacy, lower education, lower income, and an overweight/obese BMI. The observed reduction of 31 SSB calories per transaction represents a 22%

Table 2. Impact of Sugar-Sweetened Beverage Health Warnings on Purchase Behaviors and Psychological Outcomes, *n*=400 Adults

Outcome	Control, unadjusted mean (SE) (*n*=200)	Health warning, unadjusted mean (SE) (*n*=200)	Adjusted impact of SSB health warning[a] (95% CI)	*p*-value
Purchase behaviors				
Calories purchased by source				
SSBs (primary outcome)	143.2 (9.7)	109.9 (9.5)	**–31.4 (–57.9, –5.0)**	**0.020***
Non-SSBs[b]	32.9 (4.5)	47.1 (5.5)	12.5 (–1.6, 26.6)	0.082
Foods[b]	2,259.5 (75.6)	2,208.7 (81.3)	–49.5 (–271.3, 172.3)	0.661
Total calories purchased	2,435.6 (77.5)	2,365.6 (82.9)	–69.4 (–295.5, 156.6)	0.546
Purchase of an SSB, % (*n*)	64 (128)	50 (100)	**–13 (–23%, –4%)**	**0.006****
Number of SSBs purchased	0.9 (0.06)	0.7 (0.06)	**–0.2 (–0.4, –0.1)**	**0.010***
Behavioral intentions				
Intentions to limit consumption of beverages with added sugar[c]	4.7 (0.13)	4.8 (0.13)	0.2 (–0.2, 0.5)	0.403
Intentions to limit consumption of SSBs in trial store[c]	5.0 (0.12)	5.5 (0.10)	**0.4 (0.1, 0.8)**	**0.005****
Responses to trial labels				
Noticed trial label, % (*n*)	33 (65)	75 (150)	**37 (32, 43)**	**<0.001*****
Attention to label[d,e]	1.5 (0.06)	3.1 (0.11)	**1.7 (1.4, 1.9)**	**<0.001*****
Thinking about warning message/harms[d,e]	1.2 (0.04)	2.3 (0.09)	**1.1 (0.9, 1.3)**	**<0.001*****
Negative emotions elicited by label[d,e]	1.1 (0.02)	1.5 (0.05)	**0.4 (0.3, 0.5)**	**<0.001*****
Anticipated social interactions about label[d,e]	1.3 (0.05)	2.2 (0.09)	**0.9 (0.7, 1.1)**	**<0.001*****
SSB perceptions and attitudes				
Perceived amount of added sugar in SSBs in trial store[f]	3.6 (0.02)	3.6 (0.02)	0.07 (–0.001, 0.13)	0.055
Perceived healthfulness of consuming SSBs in trial store[c]	2.4 (0.06)	2.3 (0.06)	–0.10 (–0.27, 0.07)	0.258
Positive product attitudes toward SSBs in trial store[c]	4.1 (0.08)	4.1 (0.07)	–0.09 (–0.30, 0.13)	0.416
Negative outcome expectations about beverages with added sugar[c]	6.1 (0.07)	6.2 (0.06)	0.05 (–0.14, 0.24)	0.609

Note: Boldface indicates statistical significance (*$p<0.05$; **$p<0.01$; ***$p<0.001$).
[a]Adjusted differences in predicted means (continuous or count outcomes) or predicted probabilities (dichotomous outcomes) between health warning and control arms.
[b]Calories purchased from nonsugar-sweetened beverages and from foods were not registered as secondary outcomes.
[c]Response scale for intentions, perceived healthfulness of SSB consumption, positive SSB product attitudes, and negative outcome expectations ranged from 1 to 7, with 7 indicating higher quantity or stronger endorsement.
[d]Participants who indicated that they did not notice the trial label were not shown items about attention, cognitive elaboration, negative emotions, or anticipated social interactions; their responses to these items were coded with the lowest value.
[e]Response scale for attention, thinking about warning message/harms, negative emotions, and social interactions ranged from 1 to 5, with 5 indicating higher quantity or stronger endorsement.
[f]Response scale for perceived amount of added sugar ranged from 1 to 4, with 4 indicating higher quantity.
SSB, sugar-sweetened beverage.

decrease over the control arm and could have meaningful population-level health implications if sustained over time. For example, recent microsimulation studies[37–39] have found that reducing average SSB intake by about 25 to 30 calories per day could lower obesity prevalence by 1.5–2.4% and Type 2 diabetes incidence by up to 2.6%.

These findings fill an important gap in research on SSB health warnings. Few studies of SSB health warnings have measured actual behavior, instead assessing hypothetical purchase intentions.[19–21] Those that have measured behavioral outcomes either lacked a randomized design[23] or displayed beverages and health warnings on a computer screen, not in a retail environment.[24] RCTs in naturalistic, immersive settings like the laboratory store used in the present study have the benefit of providing a controlled environment while also simulating many of the conditions consumers would experience in the real world if SSB health warning policies were implemented.

Experience with tobacco litigation suggests that this type of study—an RCT examining a behavioral outcome—could be important in determining the legal fate of SSB warnings. The implementation of a 2009 law requiring pictorial cigarette warnings in the U.S. has been stalled since the U.S. Court of Appeals for the District of Columbia Circuit struck down the Food and Drug Administration's proposed warnings in *R.J. Reynolds vs. FDA*.[40] The decision centered in part on the lack of causal evidence of behavioral impact of the proposed warnings; despite substantial evidence of pictorial warnings' benefits from observational studies with behavioral endpoints and randomized experiments with nonbehavioral endpoints,[34,41] the court asserted that the Food and Drug Administration had "not provided a shred of evidence" that pictorial warnings would reduce actual smoking rates.[40] By examining a behavioral outcome using a randomized design, studies like the present one can help build an evidence base to inform SSB warning policymaking and potential litigation.

The weight loss benefits of reducing SSB consumption depend on the extent to which individuals compensate for decreased SSB consumption by increasing caloric intake from other sources.[42,43] This trial provides some insights on compensatory behaviors. SSB health warnings induced a not-statistically significant 12.5 calorie increase in purchases of non-SSBs (mostly juice), partially offsetting the reduction in SSB calories purchased. Trial arms did not differ on calories purchased from foods or in total calories purchased from all sources. This could be because of the large variance in these outcomes overwhelming the differences between trial arms. For example, the SD in total calories purchased (1,134 calories) was more than an order of magnitude larger than the impact of health warnings on this outcome (−69 calories). There remains debate about whether policies should narrowly target SSBs, or expand to include additional products.[11,44,45] Future studies with larger sample sizes are needed to more fully elucidate the effect of health warnings on calories purchased from different sources, particularly from caloric beverages not legally defined as SSBs, such as fruit juice.

Two previous studies have evaluated the impact of text SSB health warnings on real-stakes beverage purchases. In contrast to this study, neither found that the text warnings reduced consumers' SSB purchases.[23,24] One possible explanation for the differing results is that the warnings tested in the studies used different designs. Previous work has found that front-of-package labels that describe health effects,[31,46] are octagonal,[31,47] and use red to signal unhealthfulness[31,47–49] may be more effective than labels without these characteristics. The warnings used in this study used all 3 characteristics, whereas those tested previously each lacked 1 or more of these characteristics, and it may be that these design features are important for maximizing warnings' behavioral impacts.

Few studies have examined how SSB health warnings exert their effects on behavior. The Tobacco Warnings Model[32,34] proposes that warnings operate by increasing attention, which in turn elicits stronger negative emotions, more social interactions with others about the warning, more thinking about harms, and ultimately greater motivation for behavior change. This study found support for this model. In this trial, SSB health warnings elicited more attention, stronger negative emotions, higher likelihood of social interactions, and more thinking about the harms of SSB consumption than control labels. Health warnings also increased participants' intentions to limit consumption of the SSBs sold in the trial store. By contrast, there were no differences between trial arms in perceptions of added sugar content in SSBs, positive attitudes toward SSBs, or expectations that SSB consumption increases disease risk. These results stand in contrast to online studies reporting that SSB health warnings influence perceptions, attitudes, and beliefs about SSBs,[19–21] but are consistent with studies of pictorial cigarette warnings that find little effect of warnings on attitudes or perceptions of disease risk.[32,33]

Limitations

Two key strengths of this study are the use of an RCT and the objective measurement of a behavioral outcome. Other strengths include the diverse sample of SSB consumers and the laboratory store setting that mimicked a true convenience store environment and displayed SSB

health warnings on actual SSB containers. One limitation of this study is that participants had only a brief exposure to SSB health warnings. If SSB warning policies were implemented, consumers would see warnings every time they shopped for beverages. Donnelly and colleagues[23] found that the impact of graphic SSB health warnings on purchases was consistent over a 2-week intervention period in their quasi-experiment, but effects beyond this timeframe remain unknown. Another limitation is that the naturalistic trial store had some differences from real stores, including that the store sold beverages off the shelf instead of from a refrigerated display case. The SSB health warning labels also obscured the branding on some products; to control for this, researchers placed both the health warning and control labels in similar locations on SSB containers. Additionally, participants were aware that their purchases would be recorded, and this knowledge may have influenced their behavior. However, purchases were recorded in both trial arms, and few participants correctly guessed the trial's purpose, making it unlikely that knowledge of being assessed influenced the trial findings.

CONCLUSIONS

Five U.S. states have proposed but not yet implemented SSB health warning policies. Findings from this naturalistic RCT suggest that SSB health warning policies could reduce SSB purchases, providing timely information for policymakers as they seek to identify strategies to reduce overconsumption of SSBs.

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SUPPLEMENTAL MATERIAL

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