The Effect of Graphic Warnings on Sugary-Drink Purchasing

Citation

Published Version

Permanent link

Terms of Use

Share Your Story

The Effect of Graphic Warnings on Sugary Drink Purchasing

Authors:

Grant E. Donnelly[1]*

Laura Y. Zatz[2]*

Dan Svirsky[3]

Leslie K. John[3]

[1]Marketing Unit, Harvard Business School

[2]Departments of Nutrition and Social & Behavioral Sciences, Harvard T.H. Chan School of

Public Health

[3]Negotiation, Organizations and Markets Unit, Harvard Business School

*Grant E. Donnelly and Laura Y. Zatz contributed equally to this article.

Correspondence should be addressed to Laura Y. Zatz, Harvard T.H. Chan School of Public

Health, Departments of Nutrition and Social & Behavioral Sciences, 665 Huntington Avenue,

Nutrition Department, 3rd Floor, Boston, MA 02115. (248) 703-9267 E-mail:

lzatz@mail.harvard.edu

Abstract

Governments have proposed text warning labels to decrease consumption of sugary drinks – a contributor to chronic diseases like diabetes. However, they may be less effective than more evocative, graphic warning labels. We field-tested the effectiveness of graphic warning labels (vs. text warning labels, calorie labels, and no labels), provided insight into psychological mechanisms driving effectiveness, and assessed consumer sentiment. Study 1 indicated that graphic warning labels reduced the share of sugary drinks purchased in a cafeteria, from 21.4% at baseline to 18.2%—an effect driven by substitution of water for sugary drinks. Study 2 showed that graphic warning labels work by heightening negative affect and prompting consideration of health consequences. Study 3 indicated that public support for graphic warning labels can be increased by conveying effectiveness information. These findings could spur more effective labeling policies that: facilitate healthier choices, do not decrease overall beverage purchases, and are publicly accepted.

Keywords: Decision Making, Food, Health, Policy Making, Preferences

The Effect of Graphic Warning Labels on Sugary Drink Purchasing

Consumption of sugary drinks, such as soda, is a leading contributor to major health problems including obesity (Ludwig, Peterson, & Gortmaker, 2001), diabetes (Schulze et al., 2004), and heart disease (Fung et al., 2009). To reduce purchasing and consumption of sugary drinks, several local and state governments have proposed warning labels highlighting health risks; for example, San Francisco passed a policy requiring text warning labels on sugary drink advertisements, but it has not been implemented due to legal challenges from industry (Wiener, Mar, Cohen, & Avalos, 2015). Despite these initiatives, there are no published field tests evaluating whether sugary drink warning labels achieve their intended purpose in the real world, though two recent scenario-based lab studies point to their promise (Roberto, Wong, Musicus, & Hammond, 2016; VanEpps & Roberto, 2016). Beyond the question of effectiveness, there have been no published nationally-representative polls evaluating whether the public would accept them.

Like calorie labels, warning labels aim to provide health-relevant information to induce healthy behavior change. However, past research underscores the limits of this approach; for example, the evidence on whether calorie labels reduce calorie purchasing is mixed (Bleich et al., 2017; Downs, Wisdom, Wansink, & Loewenstein, 2013). Unlike calorie labels, warning labels convey direct information about potential health harms, which might increase their potency. This information attempts to overcome factors that often lead to suboptimal health decisions, including visceral factors such as hunger and self-control limits (FDA, 2014; Loewenstein, Read, & Baumeister, 2003; Stroebe, van Koningsbruggen, Papies, & Aarts, 2013).

In addition to identifying the limitations of health information, research also suggests that it can be effective when provided in a salient and intuitively comprehensible way (Downs,

Loewenstein, & Wisdom, 2009; Fagerlin, Zikmund-Fisher, & Ubel, 2011; Korfage et al., 2013).

For example, people choose healthier beverages when calories are expressed in physical activity

equivalents (Bleich, Barry, Gary-Webb, & Herring, 2014; Bleich, Herring, Flagg, & Gary-Webb,

2012). Such translation is likely even more compelling when it triggers an affective response

(Loewenstein, 1996).

Indeed smoking cessation research has shown that graphic warning labels – which trigger

an affective response – can be more effective than text warnings across a variety of outcomes

(Noar et al., 2017; Noar et al., 2016a; Noar et al., 2016b; Purmehdi, Legoux, Carrillat, &

Senecal, 2017). Sometimes a "diminishing cascade of effects" (Purmehdi et al., 2017) is

observed whereby effects are strongest and most consistent for proximal measures of affective

arousal and attention, less so for behavioral intentions, and weakest for behaviors such as calls to

quit lines and cigarette consumption. Nonetheless even modest effects are noteworthy for such

an intractable behavior given that labeling is a relatively weak intervention compared to

approaches such as taxation and choice architecture.

Why might evocative, graphic warning labels be effective? Previous research and

theorizing suggests that affect serves as a cue that heightens and channels attention, increasing

consideration of the risks and consequences of a decision (Emery, Romer, Sheerin, Jamieson, &

Peters, 2014; Evans et al., 2015; Noar et al., 2016b). This hypothesized two-step process can

serve the adaptive function of helping people make wiser decisions (Loewenstein, Weber, Hsee,

& Welch, 2001; Peters, 2006; Peters, Lipkus, & Diefenbach, 2006; Slovic, Finucane, Peters, &

MacGregor, 2002).

Applied to sugary drink warnings, this reasoning suggests that warning labels might be

particularly effective when depicted pictorially (as opposed to merely textually). As a result, we

predicted that graphic warning labels would decrease sugary drink selection, and that this effect would be driven by a 2-stage process invoking negative affect, followed by increased consideration of health over taste.

Given the significant influence of public opinion on policy (Burstein, 2003) we also assessed consumer sentiment for placing graphic warning labels on sugary drinks. A recent study found that Americans generally prefer interventions that invoke primarily cognitive processes (e.g., facts about smoking risks) over those that invoke affect (e.g., pictures of cancer patients); however, support for the latter increased when people were informed of their effectiveness (Sunstein, 2016). We hypothesized that support for graphic warnings could be improved by conveying effectiveness information.

In sum, we: field-tested the effectiveness of graphic warning labels versus text, calorie, and no labels (Study 1), elucidated psychological mechanisms (Study 2), and assessed consumer sentiment (Study 3).

Study 1: Field Study

Methods

Study Setting and Procedures

The field study occurred in a hospital cafeteria in Massachusetts over 14 weeks (April-July 2016) beginning with a two-week baseline to collect beverage sales data. Next, each sugary drink labeling intervention ran for two weeks, each followed by a two-week washout period when no labels were displayed (cf. Bleich et al., 2014). We pre-specified that each intervention would run for two weeks, based on a power analysis with the following parameters: 95% power ($\beta = 0.05$), Type I error rate of 5% ($\alpha = 0.05$), a small effect (Cohen's $d = 0.20$), pre-baseline

sales of 378 sugary drinks and 1,721 non-sugary drinks sold per week (based on one month of

sales data of bottled drinks from February 2016, two months prior to our baseline period), and

assuming a Fisher's exact statistical testing procedure. This power analysis suggested that we

would only need to test each label for one week. However to be conservative, a priori, we

decided to use two-week intervals. Table 1 depicts the study timeline. The study was

preregistered at ClinicalTrials.gov (NCT02744859). Stimuli and data for this and both

subsequent studies are available here: https://osf.io/rh8pv/.

Table 1

Study 1 design

Baseline	Intervention					Post-intervention
2 weeks	2 weeks	2 weeks	2 weeks	2 weeks	2 weeks	2 weeks
No label	Calorie label	Washout: No label	Text warning	Washout: No label	Graphic warning	No label

The hospital defined sugary drinks as any beverage with more than 12 grams of sugar per

container (excluding milk and 100% juice). Drinks not meeting these criteria were not labeled.

The calorie label followed a U.S. Food and Drug Administration regulation and read: "120–290

calories per container. 2,000 calories a day is used for general nutrition advice, but calorie needs

vary" (FDA, 2016). The text warning label used the language proposed in San Francisco:

"WARNING: Drinking beverages with added sugar(s) contributes to obesity, diabetes, and tooth
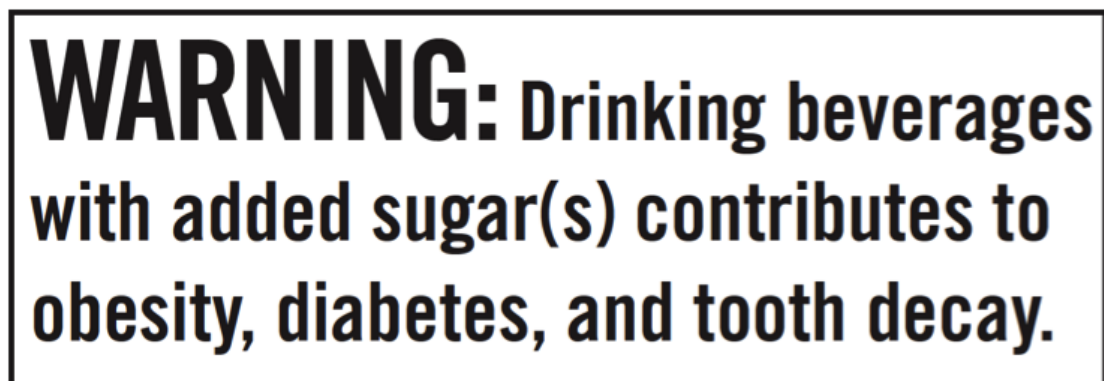
decay." The graphic warning label included the same text as the text warning label, but also

included images portraying obesity, diabetes, and tooth decay (Fig. 1). We chose images that

were similarly evocative to those found to be effective on tobacco products.

(a) Calorie label

(b) Text warning labelS

(c) Graphic warning label

Fig. 1. Labels used in Studies 1, 2, and 3: (a) calorie label; (b) text warning label; and (c) graphic warning label. Note: Study 2 only used (c).

All bottled sugary drinks were grouped. On the cooler shelves immediately below the sugary drinks, we placed 12 salient 8 x 3 inch labels with large font (Supplement Figs. S1 & S2). For fountain drinks, a 2½ x 1¼ inch label was displayed on each sugary drink dispenser (Supplement Fig. S3), for a total of four labels on the fountain machine. To minimize concerns that the labels could shift people toward buying sugary drinks elsewhere, as opposed to truly decreasing sugary drink purchasing, we also displayed labels in front of sugary drinks in the building's alternate retail outlet (five labels) and vending machines (five labels); however, we did not collect their sales data.

Our primary interest was whether the labels shifted consumers away from purchasing sugary drinks. Therefore, and consistent with recent soda labeling research (e.g., VanEpps & Roberto, 2016; Bleich et al., 2012), our primary outcome measure was the proportion of drinks

purchased that were sugary drinks.[1] This measure was superior to absolute units of sugary drinks purchased because it was less susceptible to sales fluctuations irrelevant to our treatment, such as differences in purchasing due to the day of the week (i.e., weekday vs. weekend) or seasonality; as a result we deemed the proportion measure to be both more valid and less noisy than the unit measure. For example, if the number of customers in the cafeteria doubled during one week, but the customers were drawn from the same population in terms of drink preferences, then the absolute units of sugary drinks purchased would double; however, one should not infer from this that the treatment that happened to be in place that week led individual customers to double their sugary drink purchasing. The change in absolute purchasing could therefore mask the variable of most interest: customers' drink choices.

This logic was supported by bottled drink sales data from February 2016 that we analyzed prior to the start of our study to inform its design. This analysis indicated that the number of drinks purchased varied across days (namely, decreasing on weekend days and holidays), whereas the proportion of sugary drinks purchased remained relatively constant, such that absolute units purchased mainly reflected changes in the number of customers rather than changes in drink choices. Nonetheless for completeness, we also provide the results using the units of sugary drinks purchased.

For secondary outcomes, we assessed beverage calories purchased, overall beverage purchases, share of drink types purchased, and the weight of fountain syrup dispensed.

---

[1] When we first attempted to pre-register the proportion measure on ClinicalTrials.gov, the administrator rejected the measure, providing feedback which we interpreted as mandating that the outcome be a raw measure (i.e., absolute unit sales) as opposed to a transformation (e.g., proportion sales). After changing the outcome to a raw measure (i.e., number of beverages) the pre-registration was accepted. For transparency and to allow readers to assess the robustness of our findings, we report results using both the proportion and the unit measures.

Two data sources were used to measure outcomes due to differences in how the cafeteria's point-of-sale system recorded beverage purchases. For bottled drinks, each specific type (i.e., unique size and flavor) of bottled drink had its own product code; however, for fountain drinks, the system only recorded beverage size (not type or flavor). Thus, for bottled drinks, the data source was the cafeteria's point-of-sales system, which provided a daily summary of the number of each beverage type that had been purchased. For fountain drinks, a researcher weighed the boxes of syrup that were mixed with carbonated water to produce fountain drinks; the weights were recorded once per week. Each type (e.g., Diet Coke) used a unique ratio of carbonated water to syrup when dispensing a drink, so the weight of syrup was converted to a proxy for the number of fountain drinks sold by type.

Results

During the study period, an average of 2,548 (*SD* = 290.0) bottled drinks were purchased weekly (*NS* between weeks), approximately 20.5% (*SD* = 1.6%) of which were sugary drinks. Below, we report the results of analyses for our primary outcome of the proportion of sugary drinks purchased, followed by the same analyses using the units of sugary drinks purchased as the outcome. We then report the results for the number of calories purchased. Next, we ran a substitution analysis in which we assessed whether the label caused people to buy other types of drinks, or to forego purchasing a drink altogether. Lastly, we examined whether the effect of the label was constant throughout the two week period in which it was present.

Proportion of sugary drinks purchased

Our primary analysis was a Fisher's exact test of the proportion of bottled sugary drinks purchased by treatment. This was the simplest and most powerful statistical test of our

interventions on sugary drink purchasing, and the test on which our power analysis was based. During baseline, 21.4% of bottled drinks purchased were sugary drinks. This percent was statistically indistinguishable from the share of sugary drinks purchased during the calorie label (21.5%, Fisher's exact $p = .84$) and text warning label interventions (21.0%, Fisher's exact $p = .66$). However, during the graphic warning label intervention, the average daily share of sugary drinks purchased decreased to 18.2% (Fisher's exact $p < .001$), for an overall drop of 3.2 percentage points (which is a 14.8% reduction compared to baseline consumption). Graphic warning labels also reduced purchasing relative to both calorie (Fisher's exact $p < .001$) and text warning labels (Fisher's exact $p = .001$).

Next, because we tested our labels consecutively as opposed to concurrently, we considered possible effects of seasonality in two ways. This was important because seasonal changes in drinking habits over the course of our study could potentially confound the relationship between the labels and beverage sales. We first calculated descriptive statistics for the proportion of bottled sugary drinks purchased during each of our intervention periods as well as each two-week calendar period from 2014 and 2015 that matched our intervention periods (Table 2).

During 2016, when the graphic warning labels were displayed, there was a drop in the proportion of sugary drinks purchased – a drop that did not occur during the same calendar period in either of the prior two years. Thus the descriptive statistics provided preliminary evidence that the decreased purchasing during the graphic warning label treatment was not a byproduct of cyclical sales.

Table 2

Bottled drink purchases during Study 1 intervention periods (2016) and matched historical control periods (2014, 2015).

2016			2015			2014		
Calendar Dates	Total Bottles Bought	Sugary Drinks Bought (%)	Calendar Dates	Total Bottles Bought	Sugary Drinks Bought (%)	Calendar Dates	Total Bottles Bought	Sugary Drinks Bought (%)
4/25 – 5/8 (Baseline)	5,085	1087 (21.4)	4/27 – 5/10	5,359	1018 (19.0)	4/28 – 5/11	4,420	977 (22.1)
5/9 – 5/22 (Calorie Labels)	5,414	1166 (21.5)	5/11 – 5/24	6,816	1377 (20.2)	5/12 – 5/25	4,721	958 (20.3)
6/6 – 6/19 (Text Warning)	4,863	1021 (21.0)	6/8 – 6/21	5,865	1126 (19.2)	6/9 – 6/22	4,954	991 (20.0)
7/4 – 7/17 (Graphic Warning)	5,021	914 (18.2)	7/6 – 7/19	5,362	1206 (22.5)	7/7 – 7/14	4,491	1010 (22.5)

Second, we conducted a series of regression analyses to test whether the results held when controlling for seasonality. We started with an unadjusted multivariable regression to predict the proportion of bottled drinks purchased that were sugary drinks on each day of our

study, with dichotomous independent variables for each of the three labeling interventions (Table S1A). We used a robust variance estimator to account for heteroskedasticity. The reference category was the baseline period, so coefficients on each of the dichotomous independent variables indicated differences relative to baseline. We then sequentially added seasonality covariates. To test whether two labeling interventions differed from each other, we ran the unadjusted regression, but changed the reference category to the intervention period of interest (i.e., the calorie label period would be the reference period when comparing the graphic warning label period to the calorie label period).

In the unadjusted model (Table S1A, model 1), the daily proportion of sugary drinks purchased was 3.4 percentage points lower during the graphic warning label period compared to baseline, $\beta = -0.034$, $SE = 0.01$, $p = .001$, but it was constant during the calorie and text warning labels.

When controlling for historical sales by adding fixed calendar week effects (i.e., the average proportion of sugary drinks sold in the same calendar week in 2014 and 2015), the proportion of sugary drinks purchased was constant during the calorie and text warning labels, but declined by 5.9 percentage points during the graphic warning label treatment, $\beta = -0.059$, $SE = 0.023$, $p = .01$ (Table S1A, model 2). In other words, the effect of the graphic warning labels became stronger when controlling for historical sales. The effect was also robust to the addition of a control for heat index (calculated using the mean daily temperature and mean daily humidity). In this model, the daily proportion of sugary drinks purchased declined by 6.3 percentage points, $\beta = -0.063$, $SE = 0.022$, $p < .001$; the coefficient for heat index was not statistically significant (Table S1A, model 3).

Although our analyses are focused on bottled drinks, results of a parallel analysis for fountain drinks also revealed a statistically significant effect of graphic warning labels on sugary drink purchasing (Supplement). We focused on bottled drinks for several reasons. First, the vast majority (about 90%) of drink purchases were bottled drinks. Second, focusing on bottled drinks enabled us to control for seasonality, which was not possible for fountain drinks because: a) we did not have historical data on changes in fountain syrup weight so we were unable to control for fixed calendar week effects; and b) fountain drink data were measured at the weekly level which would limit the number of observations per treatment in the regressions to two and prevent us from controlling for daily heat index. Therefore, the fountain drink analysis was restricted to the Fisher's exact test. Third, sales data for the two drink formats (fountain versus bottled) were obtained from different data sources: change in syrup weight vs. number of units sold.

Units of sugary drinks purchased

The results of analyses using the units of bottled sugary drinks purchased as the outcome were generally consistent, though weaker, than the results reported above which used the proportion of sugary drinks purchased.

The results of the primary analysis using Fisher's exact test were equivalent when using the units of bottled sugary drinks purchased as the outcome measure. During the graphic warning label period, consumers purchased fewer bottled sugary drinks compared to baseline (Fisher's exact $p = .005$; Table 2). There was no significant difference between the baseline period and the calorie label period (Fisher's exact $p = .25$) or between the baseline period and the text warning label period (Fisher's exact $p = .31$).

The analyses to examine potential effects of seasonality on the units of bottled sugary drinks, are presented in Table 2 and Table S1B. Consistent with the proportion measure, the units

of sugary drinks purchased declined when the graphic warning labels were displayed in 2016, but not during the same calendar period in 2014 or 2015 (Table 2). In all regression models, the number of bottled sugary drinks purchased dropped during the graphic warning treatment by 10 to 20 bottles per day; however, this effect was not always statistically significant. We suspect this is because the unit sales outcome was much noisier than the proportion measure: the standard deviation for the absolute units of sugary drinks purchased during our study (38.7 bottles) was roughly half of the mean, whereas the standard deviation for the proportion measure (0.037) was 16% of the mean. Empirically, this noise occurred in large part because fewer customers frequented the cafeteria on weekend days and holidays: the number of sugary drinks purchased declined from nearly 100 bottles per day during weekdays to 25 bottles per day on weekends. Hence, the estimated drop in units of sugary drinks purchased had a much wider confidence interval when holidays and weekend days were not controlled for in the regression. This phenomenon was not an issue for our primary results using the proportion measure because the proportion of sugary drinks sold was similar on holidays/weekend days and weekdays.

In the unadjusted regression model, there was not a statistically significant decline in the units of sugary drinks sold during the graphic warning label intervention, $\beta = -12.36$, $SE = 13.77$, $p = .37$ (Table S1B, model 1). Controlling for holiday and weekend effects substantially reduced error variance, though the graphic warning label treatment did not reach statistical significance under this specification, $\beta = -12.36$, $SE = 7.01$, $p = .08$ (Table S1B, model 2); the coefficient for the holiday and weekend effects was statistically significant, $\beta = -69.70$, $SE = 3.45$, $p < .001$. When we controlled for historical sales, further reducing error variance, the graphic warning label treatment was significantly different from baseline, $\beta = -19.45$, $SE = 9.39$, $p = .044$ (Table S1B, model 3). The effect approached statistical significance when adding the heat index control,

β = -19.77, SE = 10.96, p = .078 (Table S1B, model 4); the heat index covariate was not significant.

For fountain drinks, the effect of graphic warning labels on units of sugary drinks purchased did not reach statistical significance (Fisher's exact p = .52) as it did for the proportion measure.

Beverage calories purchased

To assess the impact of the labels on beverage calories purchased, we conducted a multivariable regression analysis in which the dependent variable was the average calories per bottled drink purchased in a given day during our treatment, with dichotomous independent variables for each of the three label interventions. We used a robust variance estimator to account for heteroskedasticity.

At baseline, the average calories per bottled drink purchased was 88 calories, 95% CI = [83 calories to 93 calories]; during the graphic warning label treatment, this average declined to 75 calories, 95% CI = [71 calories to 78 calories], p < .001 (Table S2). There was no statistically significant decline in calories per drink purchased during the calorie label treatment or text warning label treatment; the average calories per drink purchased was 86 calories, 95% CI = [81 calories to 90 calories], p = .58, and 85 calories, 95% CI = [81 calories to 89 calories], p = .47, respectively.

Substitution

To assess substitution effects, we ran two analyses. First, to determine whether the labels caused people to refrain from buying drinks, we ran a multivariable linear regression in which the dependent variable was total bottled drinks purchased, with dichotomous independent variables for each of the three label interventions. We used a robust variance estimator to account

for heteroskedasticity. The unit of observation was one day. There were no significant

differences in overall bottled drink sales by treatment.

Next, for any labels that reduced sugary drink purchases, we assessed whether, within

bottled drink purchases, participants switched from sugary drinks to other types of drinks. We

divided bottled drinks into four categories: water (including zero calorie sparkling and zero

calorie flavored), non-sugary drinks with fewer than 20 calories (diet drinks), non-sugary drinks

with at least 20 calories (e.g., unflavored milk), and sugary drinks. We ran a similar regression as

above, but the dependent variable was the share of bottled drinks purchased corresponding to a

given category. The daily proportion of water drinks purchased increased during the graphic

warning intervention, from 24.9% at baseline to 28.1%, $\beta = 0.032$, $SE = 0.001$, $p < .001$, while

purchasing of other drink types was unchanged. Therefore it seems that graphic warning labels

led some consumers to buy water in lieu of sugary drinks.

Duration of Treatment Effect

Lastly, we considered how the effectiveness of a label might change over time, both

while in effect and once removed. We conducted an exploratory analysis that plotted the daily

proportion of sugary drinks purchased and examined it for discernible patterns (Fig. S4). There

was no discernible pattern, suggesting that label impact did not change throughout the two-week

intervention periods. Notably, during the graphic warning label intervention – the only

intervention that was effective – the decrease in sugary drink purchasing was observed

consistently throughout the two-week period. In other words, it was not the case that a large

immediate effect dissipated over the two-week period. After removing these graphic labels,

sugary drink purchases rebounded to baseline levels. Specifically, the average daily proportion of

drinks purchased that were sugary drinks was 21.9% during baseline, 18.5% in the graphic

warning label intervention, and 21.6% in the two-week period following this intervention, a significant rebound ($p = .01$).

Study 2: Graphic Warning Label Mechanism Study

Methods

Study 2 investigated a psychological mechanism underlying the effect identified in Study 1, namely that graphic warning labels led some consumers to buy water instead of sugary drinks. Informed by previous research and theorizing (Evans et al., 2015; Peters, 2006), we tested a 2-stage process model. Specifically, we tested whether graphic warning labels heighten negative affect, in turn prompting consideration of the information conveyed by the label (which, as described below, we operationalize as a person's consideration of health over taste when making their drink decision).

Sample

Study 2 was an online survey in which we recruited participants who indicated that they consumed at least one full calorie soda per month. We pre-specified a sample size of 200 respondents, informed by current guidelines for behavioral research (e.g., Simmons, 2014; Simmons, Nelson, & Simonsohn, 2011). Participants ($N = 202$; 48.8% female; $M_{age} = 33.86$ years, $SD = 9.74$; 80.6% Caucasian; *median* annual income = \$50,000 - \$74,999; 82.6% attended at least some college; all *NS* between conditions) were recruited through Amazon's MTurk.

Procedure

Participants imagined that they were at a cafeteria and had decided to buy a drink with lunch. Participants reported the brand of soda they typically choose (e.g., Coca-Cola, Pepsi, Mountain Dew, Sprite, etc.) and were directed to a screen displaying a label. Half of participants

were randomly assigned to the control condition and half were randomly assigned to the experimental condition. In the control condition, this was simply the logo for their reported drink. In the experimental condition, a graphic warning label (the same one as in Study 1) appeared below the logo (see Fig. S5).

Participants were then asked a series of questions. First, we assessed affective response by asking participants: "How does this label make you feel about drinking *[participant's preferred brand]*" on a scale from -4 (*Extremely Negative*) to +4 (*Extremely Positive*) (cf. Peters et al., 2007). Next, we measured consideration of health information conveyed by the label by asking participants to rate two statements: "I am considering how my drink selection will impact my health" on a scale from 1 (*Not at All*) to 7 (*A Great Deal*); and "I am thinking of choosing a drink that will maximize my…" on a scale from 1 (*Taste Preferences*) to 7 (*Health*) scale. We created a composite measure averaging these two items, $r = .65$, $p < .001$.

Finally, we assessed whether participants would buy water instead of their preferred sugary drink by asking them to indicate "which of these two drinks you would be inclined to buy" on a scale from 1 (*Definitely [participant's preferred brand]*) to 7 (*Definitely Water*).

The study was preregistered: https://osf.io/wqk65/register/5771ca429ad5a1020de2872e.

Results

Participants who were shown the graphic warning label reported significantly greater negative affect ($M_{graphic\_warning} = -2.13$, $SD = 1.63$; $M_{no\_warning} = 2.29$, $SD = 1.47$); $t(200) = 20.18$, $p < .001$, $d = 2.84$; health consideration ($M_{graphic\_warning} = 3.84$, $SD = 1.66$; $M_{no\_warning} = 2.89$, $SD = 1.62$); $t(200) = 4.15$, $p < .001$, $d = 0.58$; and intention to purchase water ($M_{graphic\_warning} = 4.24$, $SD = 2.04$; $M_{no\_warning} = 2.72$, $SD = 1.72$); $t(200) = 5.71$, $p < .001$, $d = 0.80$, relative to those not exposed to this label.

We used the SPSS PROCESS Macro, model 6 (Hayes & Preacher, 2014) to test for sequential mediation. We found support for the hypothesized two-stage mediation process: graphic warning labels increased negative affect, leading to greater health consideration, in turn increasing intention to purchase water instead of a sugary drink (Fig. 2) (0.55 [$SE = 0.27$], 95% CI = [0.07, 1.11]).
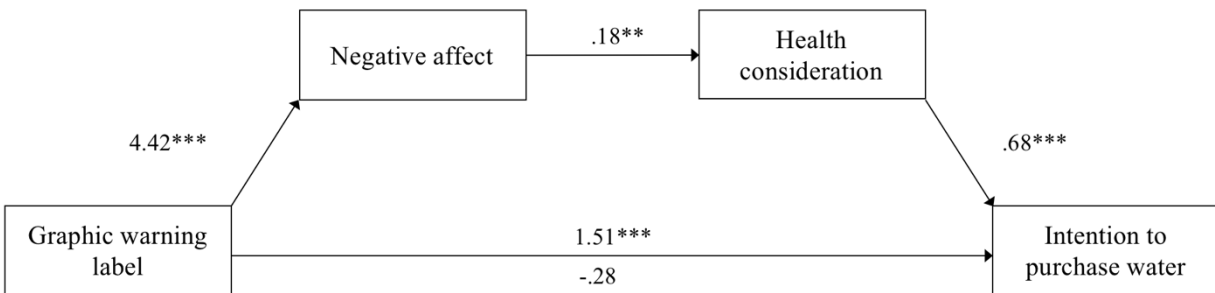

Fig. 2. Sequential mediation of the effect of graphic warning label on the increased intention to purchase water instead of a sugary drink via negative affect and health consideration. Path coefficients are standardized regression weights. The path coefficient above the line from graphic warning label to intention to purchase water represents the direct effect without the mediators in the model. The path coefficient below the line from graphic warning label to intention to purchase water represents the direct effect with the mediators in the model. Statistical significance of the coefficients is indicated, **$p < .01$, *** $p < .001$.

Study 3: Nationally Representative Survey

Methods

Study 3 assessed public sentiment toward graphic warning labels, comparing it to

two relevant benchmarks: calorie labels, a policy that has been implemented in several U.S.

cities and states; and text warnings, a policy currently being appealed in San Francisco. Relative

to these benchmarks, we expected support for graphic warning labels to be lower; however, we

hypothesized that support for graphic warnings would be increased when conveying

effectiveness information (i.e., the results of Study 1).

Sample

We conducted a nationally representative online survey with participants ($N = 402$;

49.8% female; *median* age = 45-54 years; 74.6% Caucasian; *median* annual income = $25,000 -

$49,999; 55.5% attended at least some college; 28.3% consumed at least 1 sugary drink per day;

$M_{BMI} = 28.51$, $SD = 7.57$ (excluding missing or implausible values); all *NS* between conditions;

full demographics are in Table S2) recruited through a survey company. The company obtains

nationally representative samples by taking the pre-specified sample size and determining the

required quotas for demographic variables (i.e., age, gender, ethnicity, Hispanic, income,

education), and then recruits based on these quotas. We pre-specified a sample size of 400 based

on both current suggested guidelines for sample size in behavioral research (Simmons, 2014;

Simmons et al., 2011) and a power analysis using the parameters: power set to 90% ($\beta = 0.10$),

Type I error rate of 5% ($\alpha = 0.05$), and a small effect (Cohen's $d = 0.10$).

Procedure

Participants viewed the three labels from Study 1 in a counterbalanced order. For each,

they answered: "Do you support putting this label on sugar-sweetened beverages?" on a 7-point

scale from 1 (*Strongly Oppose*) to 7 (*Strongly Support*) (VanEpps & Roberto, 2016). Half of

participants were randomly assigned to see effectiveness information accompanying the label.

Specifically, for the calorie and text warning labels, participants were told that a recent study

found that the label did not affect sugary drink purchasing. For the graphic warning label, participants were told that a recent study found the label reduced sugary drink purchasing and were informed of the magnitude of this effect.

Prior to running this study with a nationally representative sample, we conducted a pilot version using a large convenience sample and obtained the same result as that reported below (Supplement). In addition, in the pilot study, we manipulated whether participants rated only one label versus all three. The results did not depend on this factor; therefore to reduce costs for the main, nationally representative survey, each participant rated the three labels, with the order counterbalanced between-subjects. In the main study reported here, there were no order effects; hence the reported results collapse across order.

The study was preregistered at ClinicalTrials.gov (NCT02947802).

Results

A repeated-measures ANOVA using label type as a within-subjects factor and effectiveness information as a between-subjects factor revealed a significant main effect of label type, $F(1.67, 669.26) = 12.06$, $p < .001$, which was qualified by a significant interaction, $F(1.67, 669.26) = 8.45$, $p = .001$ (Fig. 3). (Mauchly's test indicated that the sphericity assumption was violated; therefore we use Greenhouse-Geisser estimates). Follow-up tests indicated that in the absence of effectiveness information, support for graphic warnings was significantly lower than both calorie labels, $t(201) = -3.80$, $p < .001$, $d = 0.53$, and text warnings, $t(201) = -6.31$, $p < .001$, $d = 0.89$. However, this effect was buffered by the provision of effectiveness information. Specifically, when effectiveness information was given, support of graphic warnings was equivalent to both calorie labels, $t(199) = -0.07$, $p = .95$, $d = 0.01$, and text warnings, $t(199) = -0.62$, $p = .54$, $d = 0.09$.

Perhaps a more intuitive way of characterizing the results is to compare the percent of participants indicating support for the given label (i.e., responded above the neutral midpoint of the 7-point scale) across conditions. Consistent with the means reported above, in the absence of effectiveness information, a significantly smaller percent of participants supported the graphic warnings (50.8%) relative to both calorie labels (61.9%), $z = 2.11$, $p = .03$, and text warnings (66.8%), $z = 3.14$, $p = .002$. However, when effectiveness information was given, the percent of participants who supported the graphic warnings (55.6%) was statistically equivalent to both calorie labels (51.5%), $z = 0.80$, $p = .42$, and text warnings (56.5%), $z = 0.20$, $p = .84$.
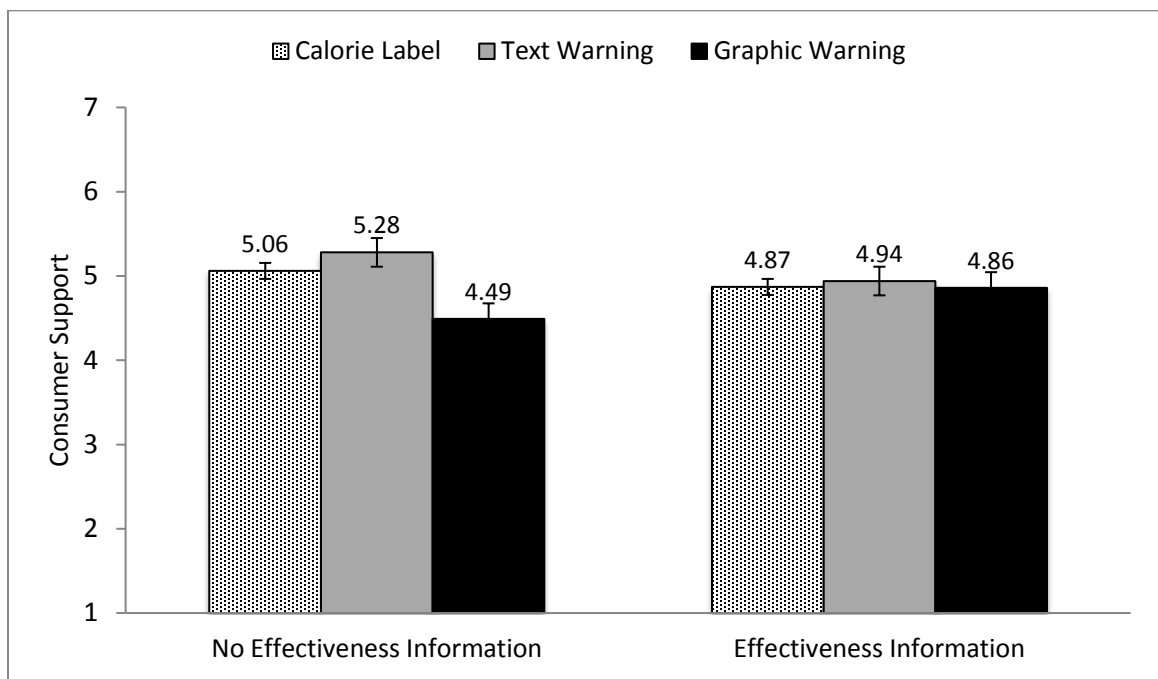

Fig. 3. Consumer support of labels by effectiveness information in Study 3 ($N = 402$; error bars indicate +/- 1 *SE* of the mean)

Finally, an additional, exploratory analysis indicated that the effect of effectiveness information on label support did not depend on whether the given participant indicated that they

drink ($N = 335$) versus do not drink ($N = 67$) sugary drinks. Specifically, the 3-way interaction between label type (*calorie* vs. *text warning* vs. *graphic warning*), effectiveness information (*provided* vs. *not provided*), and sugary drinker status was not significant, $F(1.67, 662.8) = .72$, $p = .46$); nor was the 2-way interaction between effectiveness information and sugary drinker status, $F(1, 398) = .31$, $p = .58$.

Discussion

Our field study suggests that point-of-sale graphic warning labels reduced the proportion of sugary drinks purchased, driving people to buy water instead of sugary drinks, whereas calorie and text warning labels did not. Consistent with this pattern, when the graphic warning labels were removed, sugary drink purchasing rebounded to baseline levels. Study 2 sheds insight into a psychological process underlying Study 1: graphic warning labels elicit negative affect, which increases health consideration, reducing sugary drink selection. Study 3 suggests graphic warning labels are supported more if their effectiveness is conveyed. Although the observed increase in support for graphic warnings was small, support then matched that of the benchmark labels–notably calorie labels, which have been implemented in several jurisdictions. Interestingly, but generally consistent with Sunstein (2016), graphic label support did not surpass support for the other labels.

These findings offer guidance on providing information in a way that prompts healthier drink purchasing. While the text and graphic warning labels conveyed the same facts about health risks, only the more evocative graphic labels were associated with behavior change. Consistent with this finding, a recent lab study in New Zealand found that graphic warning labels decreased sugary drink purchase intentions (Bollard, Maubach, Walker, & Ni Mhurchu, 2016).

As the first field test of the effectiveness of graphic warning labels versus text warnings or calorie labels, our findings have legal implications. A federal attempt to mandate graphic warning labels for cigarettes failed in part due to a lack of field evidence proving that graphic warnings were not "more extensive than necessary" (*R.J. Reynolds Tobacco Co. v. U.S. Food & Drug Administration*, 2012). Our findings may provide necessary evidence to implement graphic sugary drink warning labels.

Labeling, a form of information provision, is one of several strategies in policymakers' "toolbox" to reduce sugary drink purchasing and intake; other strategies include pricing (i.e., taxes and subsidies) and choice architecture (i.e., structuring the environment to encourage better choices). How have these other approaches fared? Evaluations of sugary drink taxes are promising. A one peso per liter tax in Mexico led to a 5.5% decrease in the per capita volume of sugary drinks purchased in year one and 9.7% in year two (Colchero, Rivera-Dommarco, Popkin, & Ng, 2017). A one cent per ounce tax in Berkeley led to a 9.6% decrease in the volume of sugary drinks per transaction (Silver et al., 2017). As for choice architecture, reducing portion sizes can decrease consumption (Hollands et al., 2015; Rolls, Morris, & Roe, 2002), but implementation matters. For example, a portion cap like the one proposed by New York City could increase sugary drink purchasing when free refills are served (John, Donnelly, & Roberto, 2017). Future research might explore potential synergies in combining labeling, pricing, and choice architecture interventions.

This research is subject to several limitations. First, due to practical constraints, the field intervention ran consecutively in a single site. It is difficult to randomize individuals to different (but concurrent) interventions in a real-world cafeteria setting; this would introduce contamination issues and artificiality, threatening validity. We controlled for possible seasonality

effects. Moreover, our design choice paralleled past field research which found that the order in which labels were tested did not matter (Bleich et al., 2012; Bleich et al., 2014). Nonetheless it is possible that the effect of the graphic warning label was a product of the cumulative effect of previous labels. However, our two-week washout periods, along with Study 2's conceptual replication of the effect, minimize this possibility.

Second, we could not assess how sugary drink purchasing might have changed outside the cafeteria. Customers might have foregone a sugary drink in the cafeteria only to buy one elsewhere. We minimized this possibility by posting the labels at the other locations where sugary drinks were sold in the building. Relatedly, we did not measure consumption. The calorie and text warning labels may not have been strong enough to reduce sugary drink purchasing, but they might have caused consumers to drink less of each container.

Future research could test the effect of label placement and design on purchasing and consumption. For example, warnings might be more effective when placed directly on beverage containers, where consumers would have repeated exposure as they drink; by contrast, point-of-sale warnings may be forgotten after purchasing. Interestingly, in contrast to the present investigation which found point-of-sale graphic warnings to be effective, two studies found that such warnings for tobacco did not affect purchasing (Kim et al., 2014; Coady et al., 2013); their warnings may have been less salient because they only used one large sign at the product display or one small sign at each register. With respect to design, we only tested one design for each label type, but many variations could be developed and tested.

Second, future research might also assess habituation in longer intervention periods. While the effect of the graphic warning label was consistent throughout the two-week period,

tobacco warnings are more effective when their wording and design change over time (Borland et al., 2009; Wilson & Gilbert, 2008).

Future research might also investigate additional psychological processes underlying responses to warning labels. For example, do labels incite specific affective responses, such as disgust or stigma? Graphic labels may introduce concerns over negative consequences such as "fat shaming."

Fourth, future research could explore potential synergistic effects of calorie and warning labels, and whether effectiveness is influenced by how calorie information is presented. Understanding the effects of different types of calorie labels across settings is an ongoing area of inquiry; although not our primary focus, Study 1 also offers one data point for this discussion (Bleich et al., 2017; Block & Roberto, 2014).

Finally, studies could explore heterogeneity of effects (for example, by weight or socioeconomic status). Relatedly, although the labels in our field study were very salient, research could explore whether the labels are differentially noticed or persuasive by demographic characteristics. For example, individuals who are female, higher income, or health conscious are particularly attentive to calorie information (Bleich et al., 2017). To test the generalizability of our findings, this intervention could be tested in other retail settings with a large sample of diverse consumers. Our setting was a Northeast hospital where sugary drink purchasing was relatively low at baseline and information about calories or health risks may not have been novel for some consumers, which may have limited our ability to detect changes, particularly for calorie and text warning labels.

In conclusion, this research is the first test of the real-world effectiveness and acceptability of graphic sugary drink warning labels. Graphic warning labels decreased the

proportion of sugary drinks purchased; significant changes were not observed for calorie labels or text warning labels. Consumer support for graphic warning labels can be increased by communicating their effectiveness. Taken together, these studies contribute to the psychology of healthy behavior change and provide evidence to inform policymakers.

References

Bleich, S. N., Barry, C. L., Gary-Webb, T. L., & Herring, B. J. (2014). Reducing sugarsweetened

 beverage consumption by providing caloric information: How Black adolescents alter

 their purchases and whether the effects persist. *American Journal of Public Health*, 104,

 2417-2424. doi:10.2105/ajph.2014.302150

Bleich, S. N., Economos, C. D., Spiker, M. L., Vercammen, K. A., VanEpps, E. M., Block, J. P.,

 . . . Roberto, C. A. (2017). A systematic review of calorie labeling and modified calorie

 labeling interventions: Impact on consumer and restaurant behavior. *Obesity*, 25, 2018-

 2044. doi:10.1002/oby.21940

Bleich, S. N., Herring, B. J., Flagg, D. D., & Gary-Webb, T. L. (2012). Reduction in purchases

 of sugar-sweetened beverages among low-Income black adolescents after exposure to

 caloric information. *American Journal of Public Health*, 102, 329-335.

 doi:10.2105/ajph.2011.300350

Block, J. P., & Roberto, C. A. (2014). Potential benefits of calorie labeling in restaurants.

 Journal of the American Medical Association, 312, 887-888.

 doi:10.1001/jama.2014.9239

Bollard, T., Maubach, N., Walker, N., & Ni Mhurchu, C. (2016). Effects of plain packaging,

 warning labels, and taxes on young people's predicted sugar-sweetened beverage

 preferences: An experimental study. *International Journal of Behavioral Nutrition and

 Physical Activity*, 13, 95. doi:10.1186/s12966-016-0421-7

Borland, R., Wilson, N., Fong, G. T., Hammond, D., Cummings, K. M., Yong, H.-H., . . .

 McNeill, A. (2009). Impact of graphic and text warnings on cigarette packs: Findings

from four countries over five years. *Tobacco Control*, 18, 358-364.

doi:10.1136/tc.2008.028043

Burstein, P. (2003). The impact of public opinion on public policy: A review and an agenda.

Political Research Quarterly, 56, 29-40. doi:10.1177/106591290305600103

Colchero, M. A., Rivera-Dommarco, J., Popkin, B. M., & Ng, S. W. (2017). In Mexico, evidence

of sustained consumer response two years after implementing a sugar-sweetened

beverage tax. *Health Affairs*, 36, 564-571. doi:10.1377/hlthaff.2016.1231

Downs, J. S., Loewenstein, G., & Wisdom, J. (2009). Strategies for promoting healthier food

choices. *American Economic Review*, 99, 159-164. doi:10.1257/aer.99.2.159

Downs, J. S., Wisdom, J., Wansink, B., & Loewenstein, G. (2013). Supplementing menu

labeling with calorie recommendations to test for facilitation effects. *American Journal of

Public Health*, 103, 1604-1609. doi:10.2105/ajph.2013.301218

Emery, L. F., Romer, D., Sheerin, K. M., Jamieson, K. H., & Peters, E. (2014). Affective and

cognitive mediators of the impact of cigarette warning labels. *Nicotine & Tobacco

Research*, 16, 263-269. doi:10.1093/ntr/ntt124

Evans, A. T., Peters, E., Strasser, A. A., Emery, L. F., Sheerin, K. M., & Romer, D. (2015).

Graphic warning labels elicit affective and thoughtful responses from smokers: Results of

a randomized clinical trial. *PLOS One*, 10, e0142879.

doi:https://doi.org/10.1371/journal.pone.0142879

Fagerlin, A., Zikmund-Fisher, B. J., & Ubel, P. A. (2011). Helping patients decide: Ten steps to

better risk communication. *Journal of the National Cancer Institute*, 103, 1436-1443.

doi:https://doi.org/10.1093/jnci/djr318

FDA. (2014). Food labeling: Nutrition labeling of standard menu items in restaurants and similar

retail food establishments. Final regulatory impact analysis. Retrieved from

https://www.fda.gov/downloads/Food/IngredientsPackagingLabeling/LabelingNutrition/

UCM423985.pdf

FDA. (2016). A labeling guide for restaurants and retail establishments selling away-from-home

foods—Part II (menu labeling requirements in accordance with the patient protection

affordable care act of 2010). Retrieved from

https://www.fda.gov/downloads/Food/GuidanceRegulation/GuidanceDocumentsRegulato

ryInformation/UCM461963.pdf

Fung, T. T., Malik, V., Rexrode, K. M., Manson, J. E., Willett, W. C., & Hu, F. B. (2009).

Sweetened beverage consumption and risk of coronary heart disease in women. *The

American Journal of Clinical Nutrition*, 89, 1037-1042. doi:10.3945/ajcn.2008.27140

Hayes, A. F., & Preacher, K. J. (2014). Statistical mediation analysis with a multicategorical

independent variable. *British Journal of Mathematical and Statistical Psychology*, 67,

451-470. doi:10.1111/bmsp.12028

Hollands, G. J., Shemilt, I., Marteau, T. M., Jebb, S. A., Lewis, H. B., Wei, Y., . . . Ogilvie, D.

(2015). Portion, package or tableware size for changing selection and consumption of

food, alcohol and tobacco. *The Cochrane Database of Systematic Reviews*, CD011045.

doi:10.1002/14651858.CD011045.pub2

John, L. K., Donnelly, G. E., & Roberto, C. A. (2017). Psychologically informed

implementations of sugary-drink portion limits. *Psychological Science*, 28, 620-629.

doi:10.1177/0956797617692041

Korfage, I. J., Fuhrel-Forbis, A., Ubel, P. A., Zikmund-Fisher, B. J., Greene, S. M., McClure, J.

    B., . . . Fagerlin, A. (2013). Informed choice about breast cancer prevention: Randomized

    controlled trial of an online decision aid intervention. *Breast Cancer Research*, 15, R74-

    R74. doi:10.1186/bcr3468

Loewenstein, G. (1996). Out of control: Visceral influences on behavior. *Organizational*

    Behavior and Human Decision Processes, 65, 272-292.

    doi:https://doi.org/10.1006/obhd.1996.0028

Loewenstein, G., Read, D., & Baumeister, R. F. (2003). Time and decision: Economic and

    psychological perspectives of intertemporal choice: Russell Sage Foundation.

Loewenstein, G. F., Weber, E. U., Hsee, C. K., & Welch, N. (2001). Risk as feelings.

    Psychological Bulletin, 127, 267-286. doi:10.1037/0033-2909.127.2.267

Ludwig, D. S., Peterson, K. E., & Gortmaker, S. L. (2001). Relation between consumption of

    sugar-sweetened drinks and childhood obesity: a prospective, observational analysis. *The*

    Lancet, 357(9255), 505-508. doi:https://doi.org/10.1016/S0140-6736(00)04041-1

Noar, S. M., Francis, D. B., Bridges, C., Sontag, J. M., Brewer, N. T., & Ribisl, K. M. (2017).

    Effects of strengthening cigarette pack warnings on attention and message processing: A

    systematic review. *Journalism & Mass Communication Quarterly*, 94, 416-442.

    doi:10.1177/1077699016674188

Noar, S. M., Francis, D. B., Bridges, C., Sontag, J. M., Ribisl, K. M., & Brewer, N. T. (2016a).

    The impact of strengthening cigarette pack warnings: Systematic review of longitudinal

    observational studies. *Social Science & Medicine*, 164, 118-129.

    doi:https://doi.org/10.1016/j.socscimed.2016.06.011

Noar, S. M., Hall, M. G., Francis, D. B., Ribisl, K. M., Pepper, J. K., & Brewer, N. T. (2016b). Pictorial cigarette pack warnings: A meta-analysis of experimental studies. *Tobacco Control*, 25, 341-354. doi:10.1136/tobaccocontrol-2014-051978

Peters, E. (2006). The functions of affect in the construction of preferences. In S. Lichtenstein & P. Slovic (Eds.), The construction of preference (pp. 454-463). New York: Cambridge University Press.

Peters, E., Lipkus, I., & Diefenbach, M. A. (2006). The functions of affect in health communications and in the construction of health preferences. *Journal of Communication*, 56, S140-S162. doi:10.1111/j.1460-2466.2006.00287.x

Peters, E., Romer, D., Slovic, P., Jamieson, K. H., Wharfield, L., Mertz, C. K., & Carpenter, S. M. (2007). The impact and acceptability of Canadian-style cigarette warning labels among U.S. smokers and nonsmokers. *Nicotine & Tobacco Research*, 9, 473-481. doi:10.1080/14622200701239639

Purmehdi, M., Legoux, R., Carrillat, F., & Senecal, S. (2017). The effectiveness of warning labels for consumers: A meta-analytic investigation into their underlying process and contingencies. *Journal of Public Policy & Marketing*, 36, 36-53. doi:10.1509/jppm.14.047

R.J. Reynolds Tobacco Co. v. U.S. Food & Drug Administration, (2012).

Roberto, C. A., Wong, D., Musicus, A., & Hammond, D. (2016). The influence of sugar-sweetened beverage health warning labels on parents' choices. *Pediatrics*, 137, e20153185. doi:10.1542/peds.2015-3185

Rolls, B. J., Morris, E. L., & Roe, L. S. (2002). Portion size of food affects energy intake in normal-weight and overweight men and women. *The American Journal of Clinical Nutrition*, 76, 1207-1213.

Schulze, M. B., Manson, J. E., Ludwig, D. S., Graham, A. C., Meir, J. S., Walter, C. W., & Frank, B. H. (2004). Sugar-sweetened beverages, weight gain, and incidence of type 2 diabetes in young and middle-aged women. *Journal of the American Medical Association*, 292, 927-934. doi:10.1001/jama.292.8.927

Silver, L. D., Ng, S. W., Ryan-Ibarra, S., Taillie, L. S., Induni, M., Miles, D. R., . . . Popkin, B. M. (2017). Changes in prices, sales, consumer spending, and beverage consumption one year after a tax on sugar-sweetened beverages in Berkeley, California, US: A before-and-after study. *PLOS Medicine*, 14, e1002283. doi:10.1371/journal.pmed.1002283

Simmons, J. (2014). MTurk vs. the lab: Either way we need big samples, Data Colada.

Simmons, J. P., Nelson, L. D., & Simonsohn, U. (2011). False-positive psychology: Undisclosed flexibility in data collection and analysis allows presenting anything as significant. *Psychological Science*, 22, 1359-1366. doi:10.1177/0956797611417632

Slovic, P., Finucane, M. L., Peters, E., & MacGregor, D. G. (2002). The affect heuristic. In T. Gilovich, D. Griffin, & D. Kahneman (Eds.), Heuristics and biases: The psychology of intuitive judgment (pp. 397-421). New York: Cambridge University Press.

Stroebe, W., van Koningsbruggen, G. M., Papies, E. K., & Aarts, H. (2013). Why most dieters fail but some succeed: A goal conflict model of eating behavior. *Psychological Review*, 120, 110-138. doi:10.1037/a0030849

Sunstein, C. R. (2016). People prefer system 2 nudges (kind of). *Duke Law Journal*, 66(121), 122-168.

VanEpps, E. M., & Roberto, C. A. (2016). The influence of sugar-sweetened beverage warnings: A randomized trial of adolescents' choices and beliefs. *American Journal of Preventive Medicine*, 51, 664-672. doi:https://doi.org/10.1016/j.amepre.2016.07.010

Wiener, S., Mar, E., Cohen, M., & Avalos, J. (2015). Sugar-sweetened beverage warning for advertisements San Francisco: San Francisco Board of Supervisors. Retrieved from http://www.sfbos.org/ftp/uploadedfiles/bdsupvrs/ordinances15/o0100-15.pdf.

Wilson, T. D., & Gilbert, D. T. (2008). Explaining away: A model of affective adaptation. *Perspectives on Psychological Science*, 3, 370-386. doi:10.1111/j.1745-6924.2008.00085.x

Supplemental Material

Study 1 Fountain Drink Purchases

Our intervention included warning labels on a soda fountain machine, and we tested whether our results replicated for these drinks. For fountain drinks however, purchase data only included the size of the fountain cup purchased, not the flavor or type of beverage. To solve this problem, we measured changes in the amount of syrup used for each drink type by weighing the boxes of syrup once a week. Hence, if the box of Coca-Cola syrup saw a drop of 14 pounds, but the box of Diet Coke syrup saw a drop of 21 pounds, we could conclude that more Diet Coke syrup was dispensed.

Each drink used a unique ratio of water to syrup when dispensing a drink, written on the fountain machine itself. We used this ratio to convert the weight of syrup dispensed into number of fluid ounces dispensed. Finally, using data on number of fountain cups purchased, we divided the total number of fluid ounces by the average cup size purchased (21.8 ounces) to construct a proxy for the units of each drink that were purchased.

Fig. S6 shows the estimated proportion of sugary fountain drinks versus non-sugary fountain drinks purchased for the baseline period and each intervention period. We found the same results as for bottled beverage purchases. During the baseline period, 58% of the drinks purchased were sugary drinks. This was roughly unchanged during the calorie label intervention (57%, $p = .76$) and during the text warning label intervention (54%, $p = .23$). By contrast, the proportion of sugary drinks purchased dropped to 50% during the graphic warning labels intervention, a statistically significant drop when compared to baseline ($p = .01$) and the calorie warning label intervention ($p = .02$) but not the text warning label intervention ($p = .20$). This change during the graphic warning label period represents a 14% drop from baseline, almost precisely mirroring the drop in bottled sugary drinks purchased.

Consumer Support for Label: Pre-Test with Convenience Sample

The nationally representative survey reported in the main text is a replication of pre-test which we conducted with a convenience sample ($N = 254$; 44.1% female; 83.5% White). Specifically, as in the nationally representative sample, participants rated the extent to which they supported each label using the same scale. Participants were randomized to view and rate only one of the three labels (separate evaluation condition), or to view and rate all three (in which case order of presentation was randomized between-participants; joint evaluation condition). As in the nationally representative survey reported in the main text, for half of participants, effectiveness information accompanied the label (for the other half, effectiveness information was not provided).

Joint evaluation. A repeated-measures ANOVA using label type as a within-subjects factor and effectiveness information as a between-subjects factor revealed a significant main effect of label type, $F(1.72, 106.33) = 6.08$, $p = .005$, no effect for effectiveness information, $F(1, 62) = 0.14$, $p = .71$, but a significant interaction, $F(1.72, 106.33) = 10.55$, $p < .001$. [2] Follow-up tests revealed that when effectiveness information was provided, people were equally accepting of graphic warning labels relative to both calorie, $t(30) = 1.92$, $p = .07$, and text warning labels, $t(30) = 1.03$, $p = .31$. However, in the absence of such information, people were less accepting of graphic warning labels relative to text warning labels, $t(32) = 5.65$, $p < .001$,

---

[2] Mauchly's test indicated that the assumption of sphericity had been violated for the main effect of label type, $\chi^2 (2) = 11.09$, $p = .004$. There was greater variance in support for the graphic label relative to the calorie and text warning label. Therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .86$).

and equally accepting to calorie labels, $t(32) = 1.69$, $p = .10$. In sum, in the absence of effectiveness information, consumers were neutral about graphic warning labels; however, this indifference can be turned into support by providing effectiveness information.

Separate evaluation. As noted, the other half of our sample evaluated only one label. A 2x2 ANOVA revealed a marginal main effect of label, $F(2, 184) = 3.84$, $p = .02$, as well as a significant main effect of effectiveness information, $F(1,184) = 3.97$, $p = .048$. Importantly however, these main effects were qualified by a marginally significant interaction, $F(2, 184) = 2.80$, $p = .06$. Pairwise comparisons revealed that in the absence of effectiveness information, support for the graphic warning was lower relative to both the calorie label, $t(56) = 2.05$, $p = .045$, and marginally lower than the text warning label, $t(64) = 1.70$, $p = .09$. However, when effectiveness information was provided, respondents were just as supportive of the graphic warning as they were the calorie label, $t(66) = -0.58$, $p = .63$, although support was still significantly lower than the text warning, $t(61) = 2.02$, $p = .048$. These results are broadly consistent with those of the joint evaluation condition; therefore, in the main study to maximize power (and reduce costs, since the nationally-representative survey was conducted through a survey panel company which charged per respondent), all participants rated all three labels (i.e., we only ran the joint evaluation mode conditions).

Supplemental Figures and Tables

Fig. S1. Study 1: Bottled beverage cooler with sugary drinks on the top left during the calorie label intervention, and non-sugary drinks on the right and bottom shelves.

Fig. S2. Study 1: Bottled beverage cooler depicting the sugary drinks during the graphic warning label intervention.

Fig. S3. Study 1: Fountain drink machine depicting sugary drinks during the text warning label treatment and non-sugary drinks.
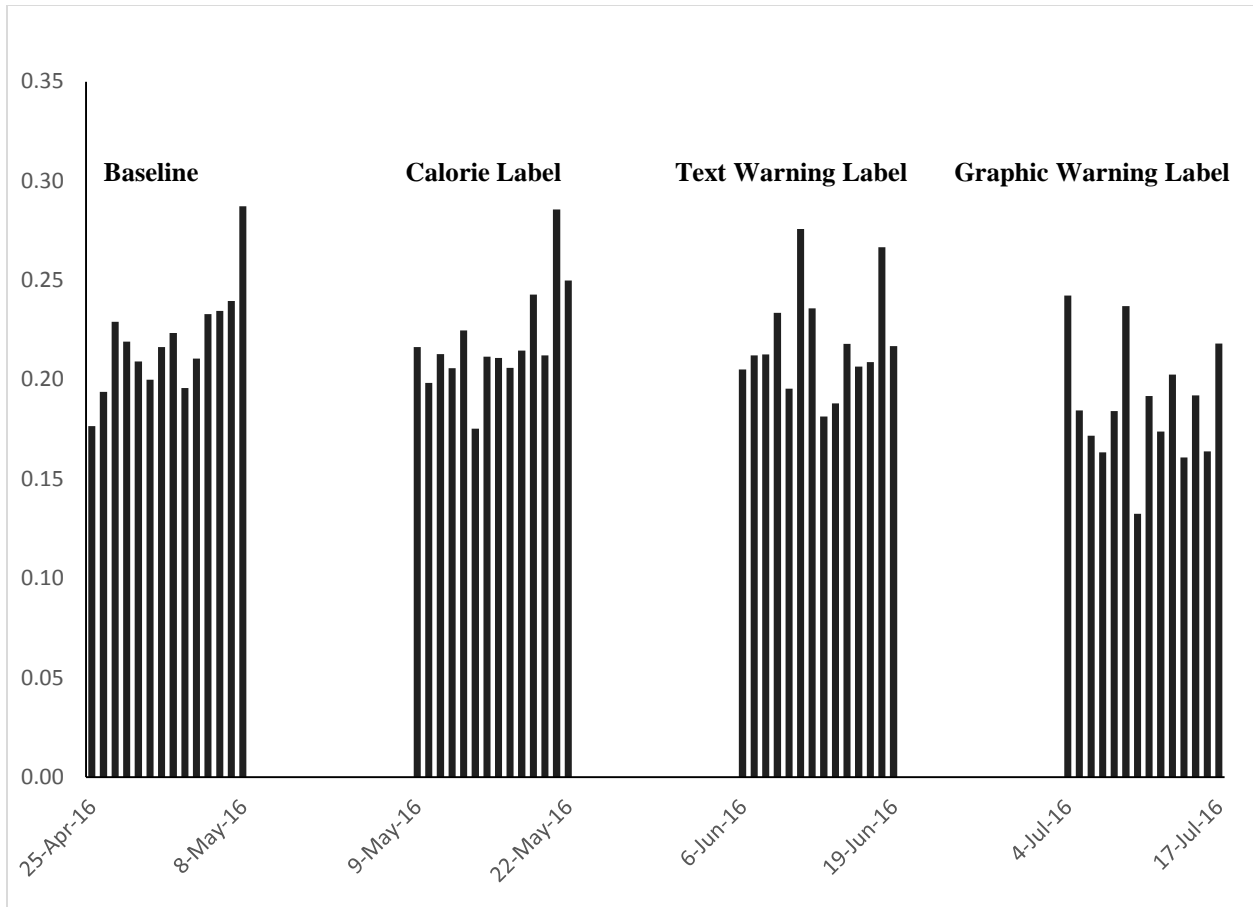
Fig. S4 Proportion of bottled drinks purchased per day that were sugary drinks, by condition, in Study 1.

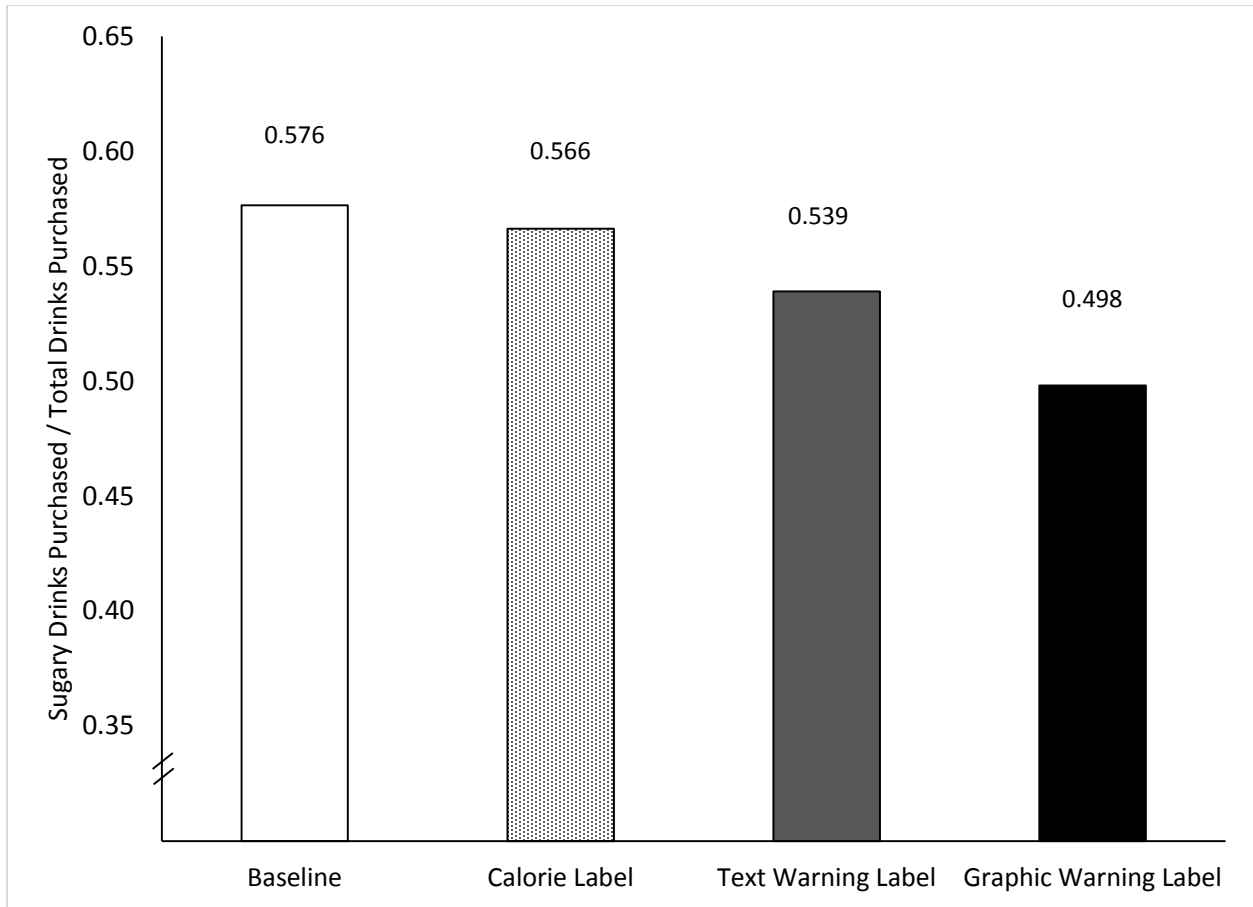**Fig. S5** Example of stimulus for Study 2, experimental condition.

Fig. S6. Sugary drink fountain purchases by condition in Study 1.
The proportion of all fountain drinks purchased that were sugary drinks. Fisher's exact tests were used to assess statistical significance, where the unit of observation is a proxy for total drinks purchased: total ounces divided by the average drink size, in ounces. The graphic warning label period resulted in a statistically significant drop relative to baseline ($p = .01$) and the calorie warning label ($p = .02$), but not the text warning label ($p = .20$). No other comparisons are statistically significant (calorie label to baseline: $p = .76$; text warning label to baseline: $p = .23$, calorie label to text warning label: $p = .38$

Table S1A

Effect of interventions on daily proportion of sugary drinks purchased, unadjusted and controlling for seasonality (Study 1).

	Model 1	Model 2	Model 3
Calorie Label	-0.001	0.002	-0.007
	(0.010)	(0.009)	(0.012)
Text Warning	-0.001	-0.010	-0.006
	(0.010)	(0.012)	(0.021)
Graphic Warning	-0.034**	-0.059**	-0.063**
	(0.010)	(0.023)	(0.022)
Calendar Week	---	1.265	0.811
		(0.927)	(1.042)
Heat Index	---	--	-0.001
			(0.001)
Constant	0.219***	-0.041	0.112
	(0.01)	(0.007)	(0.248)
Observations	56	56	56
Adj. R-squared	0.21	0.22	0.22

Note. Each column presents a linear regression estimating the daily proportion of sugary drinks purchased out of all bottled drinks purchased. Robust standard errors are in parentheses. Model 1 is unadjusted. Model 2 controls for calendar week effects. Model 3 further controls for daily heat index. ** $p < .01$, *** $p < .001$

Table S1B
Effect of interventions on daily unit sugary drink purchases (number of bottles), unadjusted and controlling for seasonality (Study 1).

	Model 1	Model 2	Model 3	Model 4
Calorie Label	5.64	5.64	0.79	0.58
	(14.22)	(4.63)	(5.82)	(6.85)
Text Warning	-4.71	-4.71	-14.52	-14.82
	(13.23)	(5.25)	(8.16)	(9.61)
Graphic Warning	-12.36	-12.36†	-19.45*	-19.77†
	(13.77)	(7.01)	(9.39)	(10.96)
Holiday or Weekend Day	--	-69.70***	-69.70***	-69.75***
		(3.45)	(3.48)	(2.88)
Calendar Week	--	--	0.13†	0.13†
			(0.07)	(0.075)
Heat Index	--	--	--	-0.01
				(0.17)
Constant	77.64***	97.55***	32.92**	34.30*
	(9.87)	(4.33)	(36.70)	(36.64)
Observations	56	56	56	56
Adj. R-squared	-0.02	0.81	0.82	0.82

Note. Each column presents a linear regression estimating the units of sugary drinks purchased each day. Robust standard errors are in parentheses. Model 1 is unadjusted. Model 2 controls for whether it is a weekday versus holiday or weekend day. Model 3 adds a control for calendar week effects. Model 4 further controls for daily heat index.
† $p < .10$; * $p < .05$; ** $p < .01$, *** $p < .001$

Table S2
Descriptive Statistics of Nationally Representative Sample for Study 3 (N = 402)

Demographic Characteristic	Categories	Percentage of Respondents
Age (years)	18 – 24	13.4
	25 – 34	17.9
	35 – 44	16.2
	45 – 54	19.2
	55 – 64	15.9
	65 and older	17.4
Gender	Female	49.8
	Male	50.2
Ethnicity	White	74.6
	Black	13.4
	Asian	5
	Other	7
Hispanic	Yes	18.4
	No	81.6
Income	Less than $25,000	25.6
	$25,000 - $49,999	26.1
	$50,000 - $74,999	17.9
	$75,000 - $99,999	11.2
	$100,000 - $149,999	8.7
	$150,000 or more	10.4
Education	Less than high school	6.7
	High school degree	31.1
	Associates degree	19.2
	Some college	9.7
	College degree	20.6
	At least some graduate school	12.7
Political Ideology	Democrat	37.3
	Republican	26.6
	Independent	27.9
	Other	2.2
	No preference	6
Sugary Drink Consumption	Never	16.7
	1 time per month	7.7
	2 – 3 times per month	11.7
	1 – 2 times per week	13.7
	3 – 4 times per week	13.7
	5 – 6 times per week	8.2
	1 time per day	7.2
	2 times per day	10.2
	3 or more times per day	10.9
BMI (kg/m^2, WHO Classification)	Less than 18.49 (underweight)	4.3
	18.5 – 24.9 (normal)	30.9
	25 – 29.9 (over weight)	31.6
	30 – 34.9 (moderately obese)	17.5
	35 – 39.9 (severely obese)	7.9
	40 and above (very severely obese)	7.8