# The Influence of Food Environments on Chronic Disease: Evidence for Policy Change

# THE INFLUENCE OF FOOD ENVIRONMENTS ON CHRONIC DISEASE: EVIDENCE FOR POLICY CHANGE

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## ABSTRACT

The environment in which we make food choices has a powerful influence on eating behavior, which in turn impacts health. This dissertation builds quantitative evidence for policies that can make it easier for consumers to make healthier choices across a variety of settings, including restaurants, schools, workplaces, and supermarkets.

In Chapter 1, we examined the influence of sodium warning labels on consumers' hypothetical choices, meal perceptions, and knowledge using four sequential randomized controlled online experiments. Traffic light and red stop sign warning labels significantly reduced sodium ordered compared with a control by 3–5%. Warning labels also increased knowledge about high sodium content in restaurant meals. Designs with warning text were more effective than those without text.

In Chapter 2, we assessed the national prevalence and nutritional quality of free food acquired by children at school and employees at work, stratified by participation in the Supplemental Nutrition Assistance Program (SNAP). Across all households, over one fifth of all food was acquired for free, and SNAP households had higher rates of free food acquisition compared to non-SNAP households. The nutritional quality of free food at school and work was relatively low across household SNAP status. For children participating in SNAP, free food acquired at school had higher nutritional quality. Improvements in dietary quality of free food acquired at school and work could contribute to the overall health of families, especially those participating in SNAP.

In Chapter 3, we conducted a content analysis to assess the prevalence of front-of-package (FOP) claims and imagery on fruit drinks, 100% juices, and flavored waters purchased by households with 0-5-year-olds, and examined differential exposure based on purchased units between household demographic groups in a nationally representative sample. The majority of beverages contained FOP claims and imagery implying that the products were healthy and natural. Households across racial/ethnic groups, levels of income, and SNAP and WIC participation were widely exposed to these marketing tactics. Given the potential for these marketing elements to increase health perceptions and potentially mislead parents into purchasing sugary beverages for their young children, the FDA should consider updating regulations for FOP claims and imagery.

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INTRODUCTION

The environment in which we make food choices has a powerful influence on eating behaviors, which in turn impact health.[1-6] Ecological models of health behavior suggest that such influence is multilevel and includes physical factors in addition to intrapersonal, social, and cultural factors.[7-9] Changes to eating behavior thus require interventions at multiple levels and across a variety of settings and sectors.

To help policymakers understand which interventions may be most impactful, researchers can conduct strategic science, a research approach designed to build evidence for policy change.[10] This dissertation is grounded in the strategic science approach, which involves working with change agents (e.g., policymakers, advocates) to co-create research questions that are both scientifically meaningful and politically relevant. Scientists then communicate research results back to their change agent partners to ensure that their work can directly influence policy. This process ultimately creates a feedback loop in which policy can inform research and research can inform policy.

The goal of this dissertation is to use strategic science to build quantitative evidence for policies that can make it easier for consumers to make healthy choices across a variety of settings, including restaurants, schools, workplaces, and supermarkets. It specifically addresses knowledge gaps around sodium reduction strategies, the prevalence and nutritional quality of free food in institutions, and exposure to sugary drink front-of-package (FOP) marketing nationwide.

To address this dissertation goal, we first evaluated an intervention to reduce sodium in the restaurant setting. In 2016, New York City became the only U.S. city to require chain restaurants with 15 or more locations nationwide to post sodium warning labels next to menu items containing more sodium than the recommended daily limit (2,300 mg).[11] The rationale for this type of policy is that sodium warnings could help consumers make informed decisions when eating out, and could also prompt restaurants to lower the sodium content in their saltiest items to avoid labels. When we began our study, there was no evidence on the effectiveness of sodium warning label policies, but there was growing interest in similar policies in cities across the United States, including in Philadelphia. To build evidence to inform the city's policy, we collaborated with the Philadelphia Department of Public Health to evaluate the effects of sodium warning labels on restaurant menus. Chapter 1 specifically examines the influence of sodium warning label design on consumers' hypothetical choices, meal perceptions, and knowledge.

Second, the dissertation examined the prevalence and nutritional quality of free foods and beverages offered in institutional settings. A recent U.S. Department of Agriculture (USDA) report found that over one fifth of foods in the American diet are acquired at no cost, with higher rates of free food acquisition among participants in the Supplemental Nutrition Assistance Program (SNAP) and at school and work.[12] Free food in institutional settings like these is of particular interest from a public health perspective, because institutional-level policies can improve the nutritional quality of their offerings. Free food in institutions also offers a unique opportunity to modify food preferences by allowing price-sensitive populations to try new foods without any monetary risk, and may promote the development of healthy eating as normative behavior.[13-17] Very little is known about the nutritional quality of free food in America, but it could have a substantial impact on overall diet quality, especially for lower-income Americans. Chapter 2 assessed the national prevalence and nutritional quality of free food acquired by children at school and employees at work, stratified by SNAP status.

Lastly, the dissertation examined household exposure to front-of-package (FOP) beverage marketing, which is an aspect of the supermarket food environment that may affect dietary choices and subsequently impact health. Fruit drinks are the most widely consumed sugar-sweetened beverage (SSB) by 0-5-year-olds, accounting for nearly 10% of their daily energy intake.[18,19] SSB consumption in early life is tightly linked to adverse health outcomes later in life.[20-26] Parents purchase fruit drinks for their children in part due to misperceptions that they are healthful, which may be driven by FOP health claims and imagery.[27] Because the majority of SSB calories consumed by children are in the home,[28] correcting parent misperceptions by mitigating or removing deceptive aspects of FOP marketing could substantially reduce consumption and diminish the impact of SSBs on childhood obesity. The Food and Drug Administration (FDA) has indicated interest in changing FOP marketing regulations to better inform consumers, but lacks data on the current landscape of FOP marketing and which demographic groups are most exposed to various aspects of on-package advertising.[29] Chapter 3 was designed to inform FDA regulatory change, and conducted in communication with the FDA and in collaboration with advocates and lawyers at the Center for Science in the Public Interest. We worked together to evaluate the prevalence of and differential U.S. household exposure to FOP claims and imagery on sugary drinks.

**CHAPTER 1:** Online randomized-controlled trials of restaurant sodium warning labels

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**Abstract**

Introduction: Policymakers are interested in requiring chain restaurants to display sodium warning labels on menus to reduce sodium consumption. This study examined the influence of label design on consumers' hypothetical choices, meal perceptions, and knowledge.

Study design: Four sequential, randomized, controlled online experiments were conducted.

Setting/participants: Across all four experiments, 10,412 socio-demographically diverse participants were recruited online through Survey Sampling International and Amazon Mechanical Turk.

Intervention: Participants were randomized to view restaurant menus with either no sodium label (control) or one of 13 sodium warning labels that varied the text (e.g., "sodium warning" versus "high sodium"), icons (e.g., stop sign), and colors (red/black) used. Participants placed a hypothetical meal order and rated restaurant meal perceptions. Data were collected and analyzed in 2016–2019.

Main outcome measures: The primary outcome was sodium content of hypothetical restaurant choices. Secondary outcomes included restaurant meal perceptions and sodium knowledge.

Results: In Experiments 1–3, all warning labels reduced average sodium ordered across both restaurants (by 19–81 mg) versus controls, with some of the largest reductions from traffic light and stop sign labels, but results were not statistically significant. In a larger, preregistered replication (Experiment 4) testing traffic light and red stop sign labels versus control, traffic light and red stop sign labels significantly reduced average sodium ordered across both restaurants (–68 mg, $p$=0.002 and –46 mg, $p$=0.049, respectively). Warnings also significantly increased participants' knowledge of sodium content and perceived health risks associated with high-sodium meals compared with no label.

Conclusions: Traffic light and red stop sign warning labels significantly reduced sodium ordered compared with a control. Warning labels also increased knowledge about high sodium content in restaurant meals. Designs with warning text are likely to improve consumer understanding.

## Introduction

Almost half of Americans have high blood pressure,[30] which is a major risk factor for heart disease and stroke.[31,32] High sodium intake contributes to high blood pressure, and 89% of American adults consume more than the sodium upper limit (2,300 mg) recommended by the *2015–2020 Dietary Guidelines for Americans*.[33] One quarter of dietary sodium comes from restaurant foods,[34] compared with only 11% from adding salt at home during cooking or at the table.[35] Although there are many factors that contribute to overconsumption of sodium-rich foods, one barrier to lowering sodium intake is that consumers are largely unaware of the sodium content of restaurant foods, underestimating it by an average of 1,000 mg per meal.[36,37]

In 2016, New York City (NYC) became the first U.S. city to require chain restaurants with 15 or more locations nationwide to post sodium warning labels next to menu items and combination meals containing more sodium than the recommended daily limit (2,300 mg).[11] Philadelphia has since passed a similar law.[38] This policy aims to inform consumers about items with excessive sodium content at the point of sale, and may prompt restaurants to reduce sodium content to avoid labels. Warning labels on tobacco products and sugar-sweetened beverages have been shown to increase risk perceptions, improve knowledge, and affect behavior.[39-44] In restaurants, purely informational labels (e.g., milligrams of sodium, number of calories) have had mixed behavioral effects, so an explicit warning label that provides information on health consequences and makes that information more salient may be more effective.[36,45-49] No studies, to the authors' knowledge, have evaluated how consumers react to a range of sodium warning labels on restaurant menus or which label designs are likely to be most influential in the restaurant setting. The primary aim of this study was to assess the extent to which sodium warning labels using different words, icons, and colors influence the sodium content of hypothetical restaurant choices (primary outcome), restaurant meal perceptions, and sodium knowledge (secondary outcomes).

## Methods

### Study Sample

Four randomized, controlled online experiments were conducted sequentially using similar designs. The first two experiments aimed to identify the best-performing warning text, the third tested that text in combination with different icons and colors to determine the most influential overall design, and the fourth was a preregistered, sufficiently powered, replication trial to test the two best-performing designs against a control. Separate samples of U.S. residents aged ≥18 years were recruited through Amazon Mechanical Turk (MTurk), an online marketplace where people are paid to complete tasks. This platform has been shown to provide reliable responses, especially when a data integrity question is included.[50,51] For Experiment 3, an additional sample of participants with a demographic composition similar to the city of Philadelphia was recruited through Survey Sampling International, an online panel of U.S. consumers, to inform Philadelphia's warning label bill (Figures 1.1 & 1.2, Appendix Figures 1.1–1.3). Data were collected and analyzed in October 2016–May 2019. The University of Pennsylvania and Harvard T.H. Chan School of Public Health IRBs approved this study.

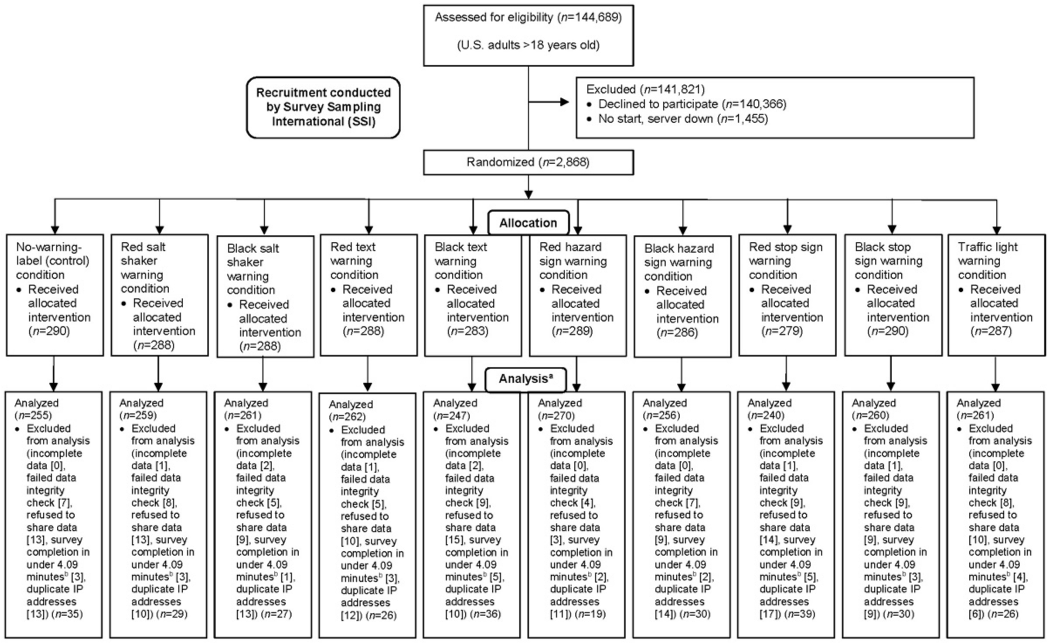


**Figure 1.1: Experiment 3 CONSORT diagram for Survey Sampling International sample**
[a]This sample was combined with the MTurk sample shown in Figure 1.2 for all experiment 3 analyses. Some participants met multiple exclusion criteria, so final *n* excluded does not always equal the sum of each separate exclusion criterion *n*. [b]One-third of the median completion time, 12.27 minutes.

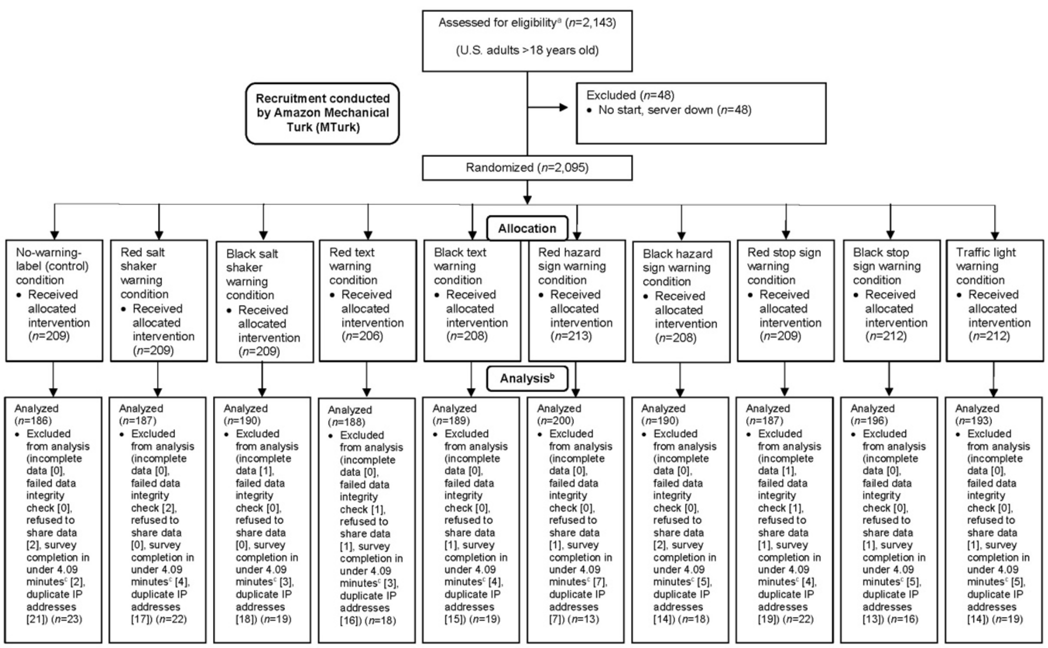


**Figure 1.2: Experiment 3 CONSORT diagram for MTurk sample**
[a]Number approached to take study unknown. [b]This sample was combined with the Survey Sampling International sample shown in Figure 1.1 for all experiment 3 analyses. Some participants met multiple exclusion criteria, so final *n* excluded does not always equal the sum of each separate exclusion criterion *n*. [c]One-third of the median completion time, 12.27 minutes.

Measures

| Experiment | Aims | Hypothesis | Label conditions<br>*All non-control conditions featured warning labels next to any menu item that contained more than 2,300 mg of sodium* |
|---|---|---|---|
| 1 | • Determine the extent to which text-based sodium warning labels would reduce the average sodium content of hypothetical restaurant purchases and influence restaurant item perceptions, knowledge, and label use compared to no label<br>• Determine the extent to which the words "salt", "sodium", or "warning" have differential effects on outcomes | • All warning labels would reduce average sodium content ordered, but the "salt" label would be most influential because people are more familiar with the word "salt" compared to "sodium" | A. No-warning-label control<br>B. High Salt label<br>HIGH SALT<br>C. High Sodium label<br>HIGH SODIUM<br>D. Sodium Warning label<br>SODIUM WARNING |
| 2 | • Determine the extent to which different phrases would influence consumers' hypothetical restaurant orders and health-related perceptions of menu items | Based on results from experiment 1:<br>• "Salt warning" will result in a similar average sodium content ordered compared to "sodium warning", and may increase perceptions of saltiness. However, differences between the two warning labels are unlikely to be practically meaningful | A. Sodium Warning label<br>SODIUM WARNING<br>B. Salt Warning label<br>SALT WARNING |
| 3 | • Determine the extent to which sodium warning labels would reduce the average sodium content of hypothetical restaurant purchases and influence restaurant item perceptions, knowledge, and label use compared to no label<br>• Compare the effects of different label designs and colors (red versus black) | Based on the first two experiments:<br>• Labels with "sodium warning" text would reduce average sodium content ordered<br>• All labels would increase estimates of sodium content and consumer perceptions of saltiness and decrease likelihood of ordering<br>• The presence of any sodium warning label would decrease perceptions of healthfulness and increase perceptions of an association with weight gain and high blood pressure | A. No-warning-label control<br>B. Red Salt Shaker label<br>C. Black Salt Shaker label (in use in NYC)<br>D. Red Hazard Sign label<br>⚠SODIUM WARNING<br>E. Black Hazard Sign label<br>⚠SODIUM WARNING<br>F. Red Stop Sign label<br>● SODIUM WARNING<br>G. Black Stop Sign label<br>● SODIUM WARNING<br>H. Red Text label<br>SODIUM WARNING<br>I. Black Text label<br>SODIUM WARNING<br>J. Traffic Light label<br>*Red: items >2,300 mg sodium*<br>SODIUM WARNING<br>*Yellow: items >1,500 mg and ≤2,300 mg sodium*<br>HIGH SODIUM<br>*Green: items ≤140 mg sodium per 100g (per FDA health claim regulations for "low sodium")*<br>LOW SODIUM |
| 4 | • Use a pre-registered, sufficiently-powered replication trial to determine the extent to which a red stop sign label, traffic light label, and control would influence consumers' hypothetical restaurant orders | Based on the first three experiments:<br>• The traffic light and red stop sign labels would significantly reduce average sodium ordered compared to the control | A. No-warning-label control<br>B. Red Stop Sign label<br>● SODIUM WARNING<br>C. Traffic Light label (see 3J above for description)<br>SODIUM WARNING, HIGH SODIUM, LOW SODIUM |

**Figure 1.3: Experiment aims, hypotheses, and label conditions**

Figure 1.3 summarizes each experiment's aims and hypotheses and displays images of each label condition. In each experiment, participants completed an online survey in which they were randomized through the Qualtrics survey platform using simple randomization to view two restaurant menus (Dairy Queen [fast food] and TGI Friday's [full service]) with either calorie labels only next to all menu items (control group) or calorie labels next to all menu items plus one of several sodium warning labels next to items exceeding 2,300 mg of sodium. One fast food and one full-service chain restaurant were selected because sodium warnings may, like calorie labels, have larger effects in full-service restaurants compared with fast food because sodium (and calorie) content tends to be higher and there is more time to view the menu.[47] Both restaurants are subject to the NYC and Philadelphia laws and have multiple menu items with

>2,300 mg of sodium. Calorie labels were included in the control condition because U.S. chain restaurants are required to post calories on menus.[52] Restaurant menus included the required daily calorie recommendation statement, and those with sodium warnings also displayed the following text required by NYC law:[11] "Warning: [sodium warning label] indicates that the sodium (salt) content of this item is higher than the total daily recommended limit (2,300 mg). High sodium intake can increase blood pressure and risk of heart disease and stroke." Sodium information was obtained from the restaurants' websites.

After providing informed consent, participants made hypothetical meal choices from two restaurant menus and answered survey questions. All outcomes are described below.

**Restaurant meal choices.** Participants first rated their hunger levels. They were then shown a fast food and full-service restaurant menu in random order and asked to order a meal from each as if they were at the restaurant at that moment for dinner. Menus were from restaurant websites and displayed a subset of items. The primary outcome was average sodium (mg) ordered across both menus. Average sodium ordered at each restaurant and the percentage of participants choosing at least one high-sodium (>2,300 mg) meal were also examined.

**Perceptions and knowledge of restaurant meals.** After ordering meals, participants in Experiments 1–3 were shown images of four meals (two from each restaurant) that included meal names, descriptions, and prices. These meals did not appear on the previous menus and were displayed one at a time in random order. Two meals contained >2,300 mg sodium and were labeled with warning labels (except in the control condition). Two meals contained ≤2,300 mg sodium and did not qualify for warning labels. Participants rated their perceptions of the meals' deliciousness, saltiness, healthfulness, and potential contribution to disease risk, and indicated how likely they were to purchase each meal on a 5-point Likert scale. Participants also estimated the meals' sodium and calorie content, on both an ordinal scale from 1 (none) to 4 (a lot) and a continuous scale (open text response restricted to 0–10,000) in mg or calories, respectively. Responses were averaged separately for the meals with >2,300 mg and ≤2,300 mg of sodium. In Experiments 1 and 3, participants also completed a comparison task in which they were shown three sets of two meals side by side and asked to select the meal with more sodium. Two questions showed a meal with ≤2,300 mg sodium (not labeled) compared to a meal with >2,300 mg sodium (labeled). One question showed two meals that both had >2,300 mg sodium (both labeled). Question order and meal position (left or right) were randomized. The two outcome measures were whether participants correctly answered: (1) both questions comparing a labeled to an unlabeled meal and (2) the question comparing two labeled meals.

**Label perceptions and use.** At the end of Experiment 1, participants were shown all three sodium warning labels and asked which was most helpful in conveying a meal had an unhealthy amount of a certain ingredient. At the end of Experiments 1 and 3, participants indicated whether they had seen a warning label next to any menu item and whether it influenced what they ordered.

**Demographics and health.** At the end of the survey, participants reported how often they ate at full-service and fast food restaurants and how much sodium and calories are recommended daily for the average adult. Additional demographics are displayed in Appendix Table 1.1.

## Statistical Analysis

In each experiment, differences in hunger levels and demographics across conditions were tested using ANOVAs for continuous variables and chi-square tests for categorical variables. Linear and logistic regressions were used to respectively compare continuous and categorical outcomes across conditions. Wilcoxon rank sum tests were used to compare the secondary outcome of participants' median sodium content estimates between conditions, as the data contained extreme outliers and were highly skewed. All analyses used the Holm–Bonferroni procedure to correct for multiple comparisons,[53] and all listed *p*-values are corrected. Uncorrected *p*-values are also reported if they were significant but corrected values were not significant. In Experiment 3, labeling arms were collapsed to compare mean responses by label color (control, red labels, black labels, and traffic light labels) and design (control, salt shaker, sodium warning text alone, hazard sign, stop sign, and traffic light), as no significant differences in outcomes between red and black versions of the same labels were found. Using G*Power and the average SD across the first three experiments, assuming an $\alpha$ of 0.05, a post-hoc power analysis showed Experiments 1, 2, and 3 were powered at 80% to detect respective differences of 131 mg, 115 mg, and 99 mg (4%–6% of the recommended daily limit) in average sodium ordered between any two groups. Observed effects were slightly smaller than this, so a sufficiently powered, preregistered, replication trial was conducted (Experiment 4) to test menu choice outcomes for the top-performing labels versus a control.

**Results**

Experiment 1 tested which of three sodium warning label phrasings would be most influential. Participants (N=1,077) were recruited from MTurk and randomized to either a control condition or one of three text-only warning label conditions: "high salt," "high sodium," or "sodium warning." Participants were excluded prior to analysis for providing incomplete data, refusing to share data, completing the survey in less than one third of the median completion time, using a duplicate IP address, or failing the data integrity check (*n*=41) (Appendix Figure

1.1). The final sample (*n*=1,036) was balanced on hunger levels and demographic characteristics across conditions (Appendix Table 1.1).

Detailed Experiment 1 results appear in the supplementary material. In summary, average sodium ordered across both menus did not significantly differ by condition. Stratifying by restaurant, “sodium warning” label participants ordered 151 mg (12%) less sodium than the control group from the fast food menu ($p$=0.030) (Table 1.1). The “high salt” label was significantly more likely to increase consumer perceptions of the health risks of regularly consuming high-sodium meals. Because average sodium ordered was the primary outcome, Experiment 2 tested “salt warning” versus “sodium warning” labels to see which would have a larger influence on behavioral intentions and perceptions.

Experiment 2 tested whether the phrasing “salt warning” versus “sodium warning” would be more likely to influence behavioral intentions and perceptions. Participants (*n*=687) were recruited and randomized to either a “salt warning” or “sodium warning” label. Twenty-two participants were excluded using Experiment 1 criteria (Appendix Figure 1.2). The final sample included 665 participants (Appendix Table 1.1). Although two variables assessed at the end of the survey (“trying to reduce sodium intake” and “doctor advised to reduce sodium intake”) were significantly different between conditions, they were not controlled for because the labels may have differentially influenced responses to these items, as only one label explicitly used the word “sodium.”

**Table 1.1: Experiments 1 and 2: Outcomes by Study Condition, Percentages, and Means (SEs)**

| Variable | Control | High sodium warning | High salt warning | Sodium warning | Salt warning |
|---|---|---|---|---|---|
| **Experiment 1 (n=1,036)** | | | | | |
| **n** | 262 | 259 | 265 | 250 | |
| **Meal choice** | | | | | |
| Average sodium ordered on both menus (mg) | 1,517.37 (33.52) | 1,497.97 (34.00) | 1,448.49 (33.41) | 1,436.54 (32.26) | |
| Average sodium of fast-food meal (mg) | **1,281.30**[d] (42.00) | 1,248.11 (38.16) | 1,210.49 (37.22) | **1,130.60**[a] (31.30) | |
| Average sodium of full-service meal (mg) | 1,753.44 (45.54) | 1,747.84 (45.02) | 1,686.49 (45.39) | 1,742.48 (48.98) | |
| High-sodium item ordered on at least one menu, % | 36.26 (2.98) | 28.96 (2.82) | 26.04 (2.70) | 30.08 (2.93) | |
| **High-sodium meal perceptions and intentions** | | | | | |
| Delicious (1–5) | 3.83 (0.06) | 3.90 (0.06) | 4.01 (0.05) | 3.92 (0.06) | |
| Salty (1–5) | **3.84**[b,c,d] (0.05) | **4.12**[a,c] (0.05) | **4.35**[a,b] (0.04) | **4.19**[a] (0.04) | |
| Healthy (1–5) | 1.86 (0.05) | 1.84 (0.05) | 1.72 (0.04) | 1.78 (0.05) | |
| Purchase intentions (1–5) | 3.05 (0.07) | 3.07 (0.07) | 3.10 (0.07) | 2.94 (0.07) | |
| Median sodium estimate (mg) | **275**[b,c,d] | **600**[a] | **625**[a] | **700**[a] | |
| **High-sodium meal disease risk perceptions** | | | | | |
| High blood pressure (1–5) | **4.07**[c,d] (0.05) | **4.13**[c] (0.04) | **4.30**[a,b] (0.04) | **4.23**[a] (0.05) | |
| Weight gain (1–5) | 4.24 (0.04) | **4.17**[c] (0.05) | **4.33**[b] (0.04) | 4.30 (0.04) | |
| **Lower-sodium meal perceptions and intentions** | | | | | |
| Delicious (1–5) | 3.92 (0.06) | 3.83 (0.06) | 3.94 (0.06) | 3.89 (0.06) | |
| Salty (1–5) | 3.48 (0.05) | 3.33 (0.05) | 3.35 (0.05) | 3.41 (0.04) | |
| Healthy (1–5) | 2.67 (0.05) | 2.75 (0.05) | 2.73 (0.05) | 2.74 (0.05) | |
| Purchase intentions (1–5) | 3.28 (0.06) | 3.19 (0.07) | 3.22 (0.07) | 3.21 (0.07) | |
| Median sodium estimate (mg) | **210**[c,d] | 275 | **325**[a] | **400**[a] | |
| **Lower-sodium meal disease risk perceptions** | | | | | |
| High blood pressure (1–5) | 3.47 (0.05) | 3.35 (0.04) | 3.35 (0.05) | 3.40 (0.05) | |
| Weight gain (1–5) | 3.44 (0.05) | 3.41 (0.05) | 3.45 (0.05) | 3.45 (0.05) | |
| **Knowledge** | | | | | |
| High vs low sodium comparisons both correct, % | **25.19**[b,c,d] (2.69) | **60.23**[a] (3.05) | **56.23**[a] (3.05) | **61.60**[a] (3.08) | |
| High vs high sodium comparison correct, % | **61.83**[b,d] (3.01) | **47.49**[a] (3.11) | 53.58 (3.07) | **48.40**[a] (3.17) | |
| **Label use** | | | | | |
| Noticed non-calorie label, % | **7.63**[b,c,d] (1.64) | **64.48**[a] (2.98) | **64.53**[a] (2.94) | **70.80**[a] (2.88) | |
| Label influenced meal choice on at least one menu, % | **4.96**[b,c,d] (1.34) | **32.05**[a] (2.91) | **31.32**[a] (2.85) | **37.20**[a] (3.06) | |
| **Most helpful label** | | | | | |
| Chose high sodium label, % | **57.63**[b,c,d] (3.06) | **69.88**[a,c,d] (2.86) | **37.74**[a,b] (2.98) | **34.40**[a,b] (3.01) | |
| Chose high salt label, % | **19.47**[c] (2.45) | **13.51**[c] (2.13) | **44.91**[a,b,d] (3.06) | **12.80**[c] (2.12) | |
| Chose sodium warning label, % | **22.90**[d] (2.60) | **16.60**[d] (2.32) | **17.36**[d] (2.33) | **52.80**[a,b,c] (3.16) | |

**Table 1.1: Experiments 1 and 2: Outcomes by Study Condition, Percentages, and Means (SEs) (Continued)**

| | | |
|---|---|---|
| **Experiment 2 (n=665)** | | |
| **n** | 328 | 337 |
| **Meal choice** | | |
| Average sodium ordered on both menus (mg) | 1,432.62 (28.32) | 1,500.83 (28.96) |
| Average sodium of fast-food meal (mg) | 1,178.02 (30.95) | 1,242.85 (32.94) |
| Average sodium of full-service meal (mg) | 1,687.23 (39.24) | 1,758.81 (39.74) |
| High-sodium item ordered on at least one menu, % | 25.00 (2.39) | 29.97 (2.50) |
| **High-sodium meal perceptions and intentions** | | |
| Delicious (1–5) | 4.04 (0.05) | 4.01 (0.04) |
| Salty (1–5) | 4.21 (0.04) | 4.22 (0.04) |
| Healthy (1–5) | 1.73 (0.04) | 1.78 (0.04) |
| Purchase intentions (1–5) | 3.05 (0.06) | 3.01 (0.06) |
| Median sodium estimate (mg) | 800 | 800 |
| **High-sodium meal disease risk perceptions** | | |
| High blood pressure (1–5) | 4.27 (0.04) | 4.20 (0.04) |
| Weight gain (1–5) | 4.22 (0.04) | 4.21 (0.04) |
| **Lower-sodium meal perceptions and intentions** | | |
| Delicious (1–5) | 3.88 (0.05) | 4.00 (0.04) |
| Salty (1–5) | 3.31 (0.04) | 3.23 (0.04) |
| Healthy (1–5) | 2.66 (0.05) | 2.72 (0.04) |
| Purchase intentions (1–5) | 3.16 (0.06) | 3.24 (0.05) |
| Median sodium estimate (mg) | 422.5 | 450 |
| **Lower-sodium meal disease risk perceptions** | | |
| High blood pressure (1–5) | 3.45 (0.05) | 3.40 (0.04) |
| Weight gain (1–5) | 3.43 (0.05) | 3.40 (0.05) |

*Note*: Boldface indicates statistical significance (Holm-Bonferroni-corrected $p<0.05$). Raw statistics are displayed. The high-sodium meal perceptions and intentions and disease risk perception means are averages across menu items with more than 2,300mg of sodium. The lower-sodium meal perceptions and intentions and disease risk perception means are averages across menu items with 2,300mg or less.
Experiment 1 statistically significantly different from: [a]control condition; [b]high sodium warning condition; [c]high salt warning condition; [d]sodium warning condition.
Experiment 2 statistically significantly different from: [e]salt warning condition; [f]sodium warning condition.

There were no significant differences between the two groups on any outcomes in Experiment 2 (Table 1.1). "Sodium warning" participants, however, ordered 68 fewer mg of sodium on average compared with "salt warning" participants. This result combined with "sodium warning" participants ordering significantly less sodium from the fast food menu compared with the control in Experiment 1 led to testing "sodium warning" language in Experiment 3.

Experiment 3 tested the effects of sodium warning design and color. Participants (N=6,466) were recruited (2,143 from MTurk and 4,323 from Survey Sampling International) and randomized to one of ten label conditions (Figure 1.3). The black salt shaker label is currently mandated by NYC law. A large number of participants ($n$=1,503) were excluded because the Amazon server hosting the survey temporarily shut down during data collection. Additional participants ($n$=486) were excluded based on the criteria used in the previous experiments (Figures 1.1, 1.2). The final sample was balanced across conditions and included 4,477 participants (2,571 from Survey Sampling International, 1,906 from MTurk) (Appendix Table 1.1).

Experiment 3 results are presented collapsed across red and black color groups because no statistically significant differences in outcomes between red and black versions of the same labels were found (Appendix Table 1.2).

There were no statistically significant differences in average sodium ordered across the six label conditions (Table 1.2), but all warning label groups ordered lower-sodium meals than the control group (control mean sodium ordered: 1,532 mg, SE=26 mg), with the stop sign label (mean sodium ordered: 1,470 mg, SE=18 mg; versus control uncorrected, $p$=0.045; versus control corrected, $p$=0.630) and traffic light label (mean sodium ordered: 1,457 mg, SE=25 mg, versus control uncorrected, $p$=0.034; corrected, $p$=0.510) leading to the lowest-sodium choices.

Compared with the control group, participants who saw any warning label perceived high-sodium meals to be saltier and reported a stronger belief that eating those meals often would increase their risk of high blood pressure (all $p$<0.001). They also estimated sodium content of high- and lower-sodium meals significantly more accurately (all $p$<0.001) (Table 1.2). Compared with the control group, the salt shaker, text, and stop sign warning labels decreased intentions to order high-sodium meals ($p$=0.017, $p$=0.002, and $p$=0.039, respectively), and the text and hazard sign warning labels increased beliefs that eating those meals often would increase risk of weight gain ($p$=0.035 for both). Salt shaker label participants rated high-sodium meals as significantly less salty than the traffic light, text, and hazard sign labels, and estimated sodium content of high- and lower-sodium meals significantly less accurately than all other warning labels. By contrast, traffic light label participants estimated both types of meals' sodium content significantly more accurately than all other labels. Further, when traffic light label participants saw lower-sodium meals that did not qualify for a warning (but were still high in sodium), they rated them as saltier, higher in sodium, and more likely to increase risk of high blood pressure compared with all other labels. Interestingly, participants who saw any warning labels other than traffic light labels perceived meals without warnings to be less salty than the control.

**Table 1.2: Experiments 3 (Collapsed Across Colors) and 4: Outcomes by Study Condition, Percentages, and Means (SEs)**

| Variable | Control | Salt shaker warning | Text warning | Hazard warning | Stop warning | Traffic light warning | Red stop warning |
|---|---|---|---|---|---|---|---|
| **Experiment 3 (n=4,477)** | | | | | | | |
| **n** | 441 | 897 | 886 | 916 | 883 | 454 | |
| **Meal choice** | | | | | | | |
| Average sodium ordered on both menus (mg) | 1,531.96 (25.69) | 1,506.93 (18.28) | 1,489.39 (17.33) | 1,487.29 (17.01) | 1,470.13 (17.75) | 1,456.94 (24.83) | |
| Average sodium of fast-food meal (mg) | 1,242.43 (30.33) | 1,243.56 (21.29) | 1,218.86 (20.31) | 1,212.37 (19.46) | 1,190.77 (19.14) | 1,192.09 (26.21) | |
| Average sodium of full-service meal (mg) | 1,821.50 (35.55) | 1,770.30 (24.62) | 1,759.92 (24.84) | 1,762.21 (24.05) | 1,749.48 (25.26) | 1,721.78 (36.17) | |
| High-sodium item ordered on at least one menu, % | 35.60 (2.28) | 33.22 (1.57) | 32.17 (1.57) | 30.90 (1.53) | 31.48 (1.56) | 33.04 (2.21) | |
| **High-sodium meal perceptions and intentions** | | | | | | | |
| Delicious (1–5) | 3.86 (0.04) | 3.83 (0.03) | 3.78 (0.03) | 3.84 (0.03) | 3.85 (0.03) | 3.91 (0.04) | |
| Salty (1–5) | **3.74**$^{b-f}$ (0.04) | **4.00**$^{a,c,d,f}$ (0.03) | **4.12**$^{a,b}$ (0.03) | **4.11**$^{a,b}$ (0.03) | **4.10**$^{a}$ (0.03) | **4.22**$^{a,b}$ (0.04) | |
| Healthy (1–5) | 2.10 (0.04) | 2.01 (0.03) | 1.99 (0.03) | 2.03 (0.03) | 2.01 (0.03) | 2.00 (0.05) | |
| Purchase intentions (1–5) | **3.19**$^{b,c,e}$ (0.05) | **2.98**$^{a}$ (0.04) | **2.94**$^{a}$ (0.04) | 3.01 (0.04) | **2.99**$^{a}$ (0.04) | 2.99 (0.05) | |
| Median sodium estimate (mg) | **200**$^{b-f}$ | **1,000**$^{a,c-f}$ | **1,500**$^{a,b,f}$ | **1,350**$^{a,b,f}$ | **1,450**$^{a,b,f}$ | **1,875**$^{a-e}$ | |
| **High-sodium meal disease risk perceptions** | | | | | | | |
| High blood pressure (1–5) | **3.76**$^{b-f}$ (0.04) | **4.00**$^{a}$ (0.03) | **4.08**$^{a}$ (0.03) | **4.03**$^{a}$ (0.03) | **4.08**$^{a}$ (0.03) | **4.11**$^{a}$ (0.04) | |
| Weight gain (1–5) | **3.92**$^{c,d}$ (0.04) | 4.06 (0.03) | **4.08**$^{a}$ (0.03) | **4.08**$^{a}$ (0.03) | 4.06 (0.03) | 4.09 (0.04) | |
| **Lower-sodium meal perceptions and intentions** | | | | | | | |
| Delicious (1–5) | 3.81 (0.04) | 3.81 (0.03) | 3.84 (0.03) | 3.84 (0.03) | 3.89 (0.03) | 3.92 (0.04) | |
| Salty (1–5) | **3.38**$^{b-e}$ (0.04) | **3.23**$^{a,f}$ (0.03) | **3.22**$^{a,f}$ (0.03) | **3.24**$^{a,f}$ (0.03) | **3.21**$^{a,f}$ (0.03) | **3.50**$^{b-e}$ (0.03) | |
| Healthy (1–5) | 2.87 (0.04) | 2.88 (0.03) | 2.92 (0.03) | 2.91 (0.03) | 2.93 (0.03) | 2.82 (0.04) | |
| Purchase intentions (1–5) | 3.22 (0.05) | 3.20 (0.04) | 3.26 (0.04) | 3.22 (0.04) | 3.33 (0.04) | 3.28 (0.05) | |
| Median sodium estimate (mg) | **137.5**$^{b-f}$ | **365**$^{a,c-f}$ | **500**$^{a,b,f}$ | **500**$^{a,b,f}$ | **500**$^{a,b,f}$ | **975**$^{a-e}$ | |
| **Lower-sodium meal disease risk perceptions** | | | | | | | |
| High blood pressure (1–5) | 3.31 (0.04) | **3.19**$^{f}$ (0.03) | **3.17**$^{f}$ (0.03) | **3.19**$^{f}$ (0.03) | **3.19**$^{f}$ (0.03) | **3.37**$^{b-e}$ (0.04) | |
| Weight gain (1–5) | 3.32 (0.04) | 3.25 (0.03) | 3.25 (0.03) | 3.25 (0.03) | 3.26 (0.03) | 3.36 (0.04) | |

**Table 1.2: Experiments 3 (Collapsed Across Colors) and 4: Outcomes by Study Condition, Percentages, and Means (SEs) (Continued)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| High vs low sodium comparisons both correct, % | **25.40**$^{b-f}$ (2.08) | **45.82**$^{a,e,f}$ (1.66) | **52.26**$^{a}$ (1.68) | **51.97**$^{a}$ (1.65) | **53.57**$^{a,b}$ (1.68) | **57.71**$^{a,b}$ (2.32) | |
| High vs high sodium comparison correct, % | **54.61**$^{c,d,f}$ (2.39) | **48.68**$^{f}$ (1.69) | **43.96**$^{a}$ (1.68) | **45.27**$^{a,f}$ (1.66) | **49.36**$^{f}$ (1.70) | **36.32**$^{a,b,d,e,f}$ (2.28) | |
| **Label use** | | | | | | | |
| Noticed non-calorie label, % | **11.79**$^{b-f}$ (1.54) | **44.26**$^{a,c-f}$ (1.66) | **59.82**$^{a,b}$ (1.65) | **60.92**$^{a,b}$ (1.61) | **59.12**$^{a,b}$ (1.66) | **61.67**$^{a,b}$ (2.28) | |
| Label influenced meal choice on at least one menu, % | **9.98**$^{b-f}$ (1.43) | **28.87**$^{a,c-f}$ (1.51) | **40.97**$^{a,b}$ (1.65) | **41.70**$^{a,b}$ (1.63) | **40.77**$^{a,b}$ (1.65) | **42.07**$^{a,b}$ (2.32) | |
| **Experiment 4 (n=4,234)** | | | | | | | |
| **n** | 1,411 | | | | | 1,412 | 1,411 |
| **Meal choice** | | | | | | | |
| Average sodium ordered on both menus (mg) | **1,505.96**$^{h,i}$ (14.81) | | | | | **1,437.88**$^{g}$ (14.65) | **1,460.27**$^{g}$ (13.54) |
| Average sodium of fast-food meal (mg) | **1,252.24**$^{h}$ (17.15) | | | | | 1,222.68 (16.73) | **1,193.15**$^{g}$ (15.27) |
| Average sodium of full-service meal (mg) | **1,759.67**$^{i}$ (20.10) | | | | | **1,653.07**$^{g,h}$ (20.29) | **1,727.40**$^{i}$ (19.27) |
| High-sodium item ordered on at least one menu, % | **34.87**$^{h,i}$ (1.27) | | | | | **30.81**$^{g}$ (1.23) | **28.49**$^{g}$ (1.20) |

*Note*: Boldface indicates statistical significance (Holm-Bonferroni-corrected $p$<0.05). Raw statistics are displayed. The high-sodium meal perceptions and intentions and disease risk perception means are averages across menu items with more than 2,300mg of sodium. The lower-sodium meal perceptions and intentions and disease risk perception means are averages across menu items with 2,300mg or less. Experiment 3 statistically significantly different from: [a]control condition; [b]salt shaker warning condition; [c]text warning condition; [d]hazard warning condition; [e]stop warning condition; [f]traffic light warning condition.
Experiment 4 statistically significantly different from: [g]control condition; [h]red stop warning condition; [i]traffic light warning condition.

When comparing high- versus low-sodium meals, all warning label participants correctly identified the higher-sodium meal more often than control participants (all $p<0.001$). However, compared with all other warnings, the salt shaker label reduced participants' ability to correctly identify the higher-sodium meal. By contrast, when comparing two high-sodium meals (both with warning labels), participants who saw the traffic light, text, or hazard sign labels correctly identified the meal higher in sodium significantly less often than control participants. Further, when both meals had warning labels, participants viewing traffic lights versus other labels correctly identified the higher-sodium meal less often.

As expected, all warning label participants reported seeing a non-calorie label significantly more often than control participants, but salt shaker label participants remembered seeing warning labels significantly less often than the other warning label groups.

In summary, although all warning labels reduced average sodium ordered compared with the control, none of these differences were statistically significant. All warning labels improved consumer understanding of sodium content and health risks associated with overconsuming sodium. The traffic light label appeared to be most influential, whereas the salt shaker label was least influential.

To determine whether the observed sodium reductions would replicate and reach statistical significance in a larger sample powered to detect effect sizes from Experiment 3, Experiment 4 was preregistered and conducted to test the top-performing labels (traffic light and red stop sign) compared with a control. Participants (N=4,601) were recruited and randomized to a control, red stop sign, or traffic light label (Figure 1.3). Participants were excluded ($n$=367) based on criteria used in the previous experiments, and for failing a cultural data integrity check included due to recent concerns about intentionally masked geolocations on MTurk (Appendix

Figure 1.3).[54] The final sample was balanced across conditions and included 4,234 participants (Appendix Table 1.1).

Compared with the control, average sodium ordered in Experiment 4 across both restaurants was reduced in the traffic light (–68 mg [–4.5%], *p*=0.002) and red stop sign (–46 mg [–3.0%], *p*=0.049) groups. The traffic light and red stop sign labels also reduced the percentage of participants choosing a high-sodium item on at least one menu (31%, *p*=0.043 and 28%, *p*=0.001, respectively) (Table 1.2).

Stratifying by restaurant, traffic light label participants ordered significantly less sodium from the full-service restaurant compared with control (–107 mg [–6.1%], *p*<0.001) and red stop sign label participants (–74 mg [–4.3%], *p*=0.016). Red stop sign label participants ordered significantly less sodium from the fast food restaurant versus control participants (–59 mg [–4.7%], *p*=0.033).

**Discussion**

Four experiments were conducted to test the influence of different sodium warning label designs. In the sufficiently powered, preregistered replication (Experiment 4), traffic light and red stop sign labels significantly reduced average sodium ordered across both restaurants (by 68 mg and 46 mg, respectively), and a significantly lower percentage of traffic light and red stop sign participants ordered a high-sodium item on at least one menu compared with the control. In the other experiments, all warning labels consistently reduced average sodium ordered (by 19–81 mg) versus the control, but these results were not statistically significant (possibly owing to limited statistical power). Based on the consistent replication of effects across all experiments, sodium warning labels appear to reduce average sodium ordered from restaurant menus by 3%–

5%. Although such effects may appear relatively small, they may be meaningful at the population level.

Warnings also significantly changed perceptions and knowledge. All warnings improved accuracy of estimated sodium content for labeled and unlabeled meals, increased health risk and saltiness perceptions, and improved participants' ability to identify a high- versus low-sodium meal compared with no label. Some warnings also increased perceived risk of weight gain, despite no direct link between sodium levels and weight. This may simply be because participants generalized the warning message to a range of negative health outcomes. Given that Americans are advised to reduce their sodium intake[55] but poorly understand food sodium content,[36,37] these educational outcomes are promising.

These findings align with tobacco and sugary drink research showing that text warnings affect perceptions and knowledge,[42-44] which in turn can affect behavior. Data suggest disease risk perceptions are a critical determinant of behavior for diet, alcohol consumption, sun protection, and vaccines.[56-58] Additionally, evidence from restaurant calorie labeling and sugary drink warning label studies suggests nutrition labels tend to change behavioral intentions when the provided information violates expectations (e.g., learning that a salad has 1,500 calories is more influential than learning that a brownie sundae has 1,500 calories).[36,59] Given consumers' documented lack of knowledge about sodium content,[36,37] sodium warnings may surprise consumers and subsequently affect their behavior.

There may also be ways to increase the impact of warnings on behavior. Tobacco research suggests graphic warnings could be more impactful than text warnings by increasing negative affect and cognitive elaboration,[60-63] suggesting larger sodium warnings with icons or other graphic images might be more effective. Text sodium warning labels may also more effectively change meal orders if more items were labeled (e.g., if the label threshold were 1,500 mg versus 2,300 mg). Lowering the threshold could also provide more incentive for industry reformulation, but could be legally challenging in the absence of sufficient research to justify a lower threshold.[64]

Regarding differences between label designs, traffic light and red stop sign labels significantly reduced average sodium ordered compared with the control, and consistently showed the largest reductions in average sodium ordered (46–76 mg). The traffic light label was also most effective at educating consumers and elicited the most accurate sodium estimates. By contrast, the salt shaker label elicited the least-accurate sodium estimates, worst performance on the labeled versus unlabeled comparison task, lowest reported noticing and use of the label, and lowest (non-significant) reduction in sodium ordered (25 mg). This makes intuitive sense, as the salt shaker label had the least amount of information (no warning text next to the symbol, unlike all other designs) whereas the traffic light had the most information (two thresholds for sodium). This tracks with front-of-package studies that have found traffic light labels to be particularly effective at increasing attention and identification of healthier options.[65-68] It is also possible that the intuitive nature of the traffic light design (red means stop, green means go) was easier for participants to understand. The stop sign label's strong performance could be similarly explained by automatic associations with stopping.[69] These results are consistent with a recent study that found octagonal sugary drink warning labels with the word "warning" increased perceived message effectiveness compared with labels without these characteristics.[70] Although the traffic light design appears to be most effective overall, there may be legal barriers and implementation challenges in mandating a design with multiple thresholds.[64]

The results suggest that adding warning text next to a symbol is likely to improve consumer understanding of the label, as illustrated by the salt shaker label—the only one without explanatory text—performing worse than other labels on secondary outcomes. This was true even when compared directly to the hazard sign symbol with text, which had the same shape as the salt shaker label. Results from the first experiment suggest that "sodium warning" text may be more effective than "high salt" or "high sodium," potentially because "high in…" is frequently used in positive health claims,[71] but this requires further study. The experiments did not reveal meaningful differences in using the word "salt" versus "sodium" on a warning label, and there were no statistically significant differences between red and black labels across outcomes. This is not entirely surprising, as prior research has found contradictory results on the effectiveness of red versus black warnings for food, alcohol, road signs, and chemical hazards.[71-74]

Although warning labels generally improved consumer knowledge, there were two instances in which they may have confused participants. First, all Experiment 3 label groups (except traffic light) rated unlabeled items as less salty than the control, despite these items containing large amounts of sodium. Nonetheless, there was no evidence that these participants ordered meals higher in sodium. Second, when participants in any warning condition had to choose between two meals—one labeled and one unlabeled—they were typically able to correctly identify which was higher in sodium based on the presence of a label. When both meals were labeled, however, warning label participants were worse at identifying the higher-sodium meal compared with control participants who never saw warning labels. This might be because warning label participants were more likely than control participants to notice calorie labels because they appeared near the sodium warnings, and to use calories as a proxy for sodium because the warnings no longer conveyed enough information to distinguish between the two meals. It is possible that warning label participants—who were more likely to notice calorie labels—assumed the meal with more calories was higher in sodium, which is usually a good rule of thumb, but in this instance was not true. Further research is needed to understand whether sodium warning labels promote the use of calorie labels.

This study had several strengths. This is the first study, to the authors' knowledge, to examine the influence of a range of sodium warning labels on behavioral intentions and perceptions. Effects were replicated across experiments with demographically different samples. The third experiment's sample was racially, ethnically, and educationally diverse. Finally, a variety of label designs were tested across a range of outcomes.

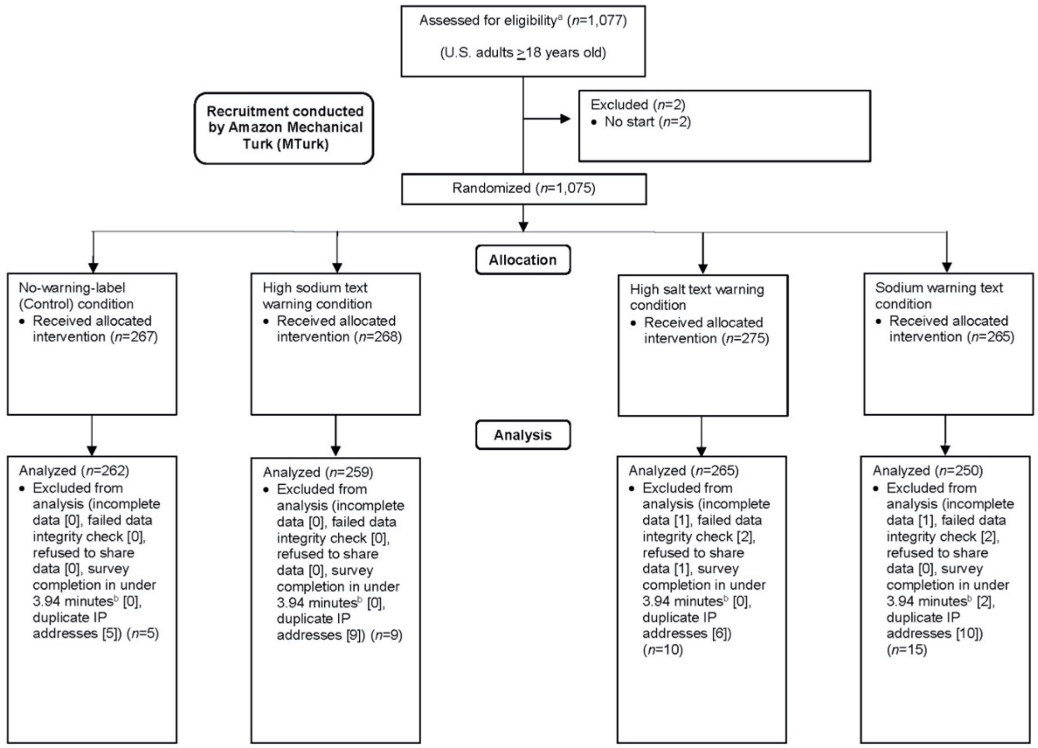
## Limitations

This study has several limitations. First, it measured hypothetical (not actual) choices, and warning labels might have been more salient when viewing a menu in an online context. This setting may have also introduced a social desirability bias to select healthier options, although this is unlikely given participant anonymity. These experiments also only examined a one-time exposure to the labels. Future research should test the study's best-performing warning labels within high-risk subpopulations trying to reduce sodium intake; explore how in-person, repeated exposure to warning labels influences behavior and perceptions; and evaluate the effect of sodium warning labels on industry reformulation, which could greatly influence sodium consumption.[75]

## Conclusions

Traffic light and red stop sign sodium warning labels significantly reduced sodium ordered by 3%–5% in a hypothetical menu choice task. Although small, effects of this size may be beneficial at a population level. Warning labels also increased knowledge about high sodium content in restaurant meals. Designs with "sodium warning" text are likely to improve consumer understanding.

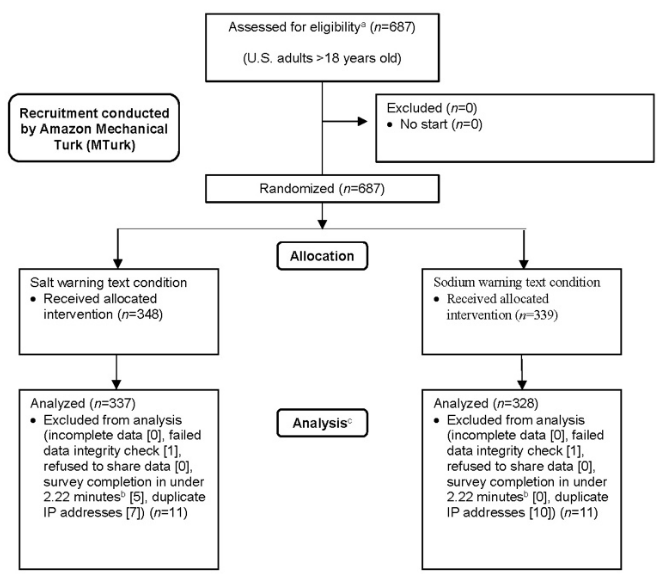
## Appendix




**Appendix Figure 1.1: Experiment 1 CONSORT diagram for MTurk sample**

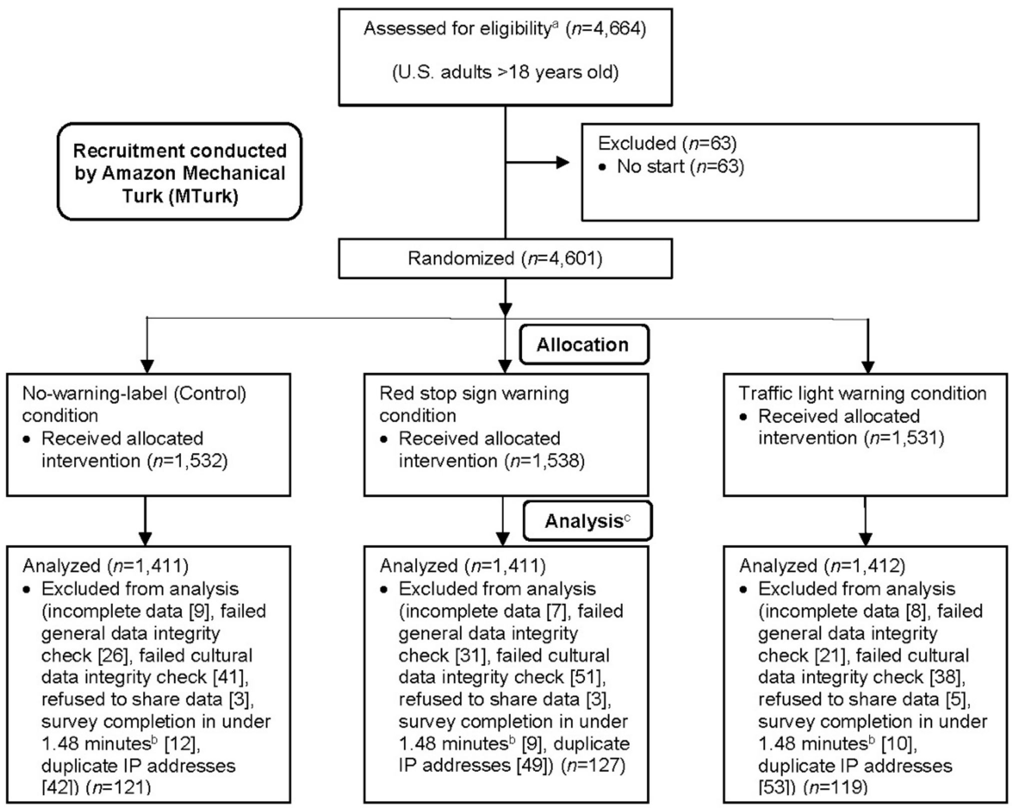
[a]Number approached to take study unknown.

[b]One-third of the median completion time, 11.83 minutes.




**Appendix Figure 1.2: Experiment 2 CONSORT diagram for MTurk sample**

[a]Number approached to take study unknown. [b]One-third of the median completion time, 6.67 minutes. [c]Some participants met multiple exclusion criteria, so final *n* excluded does not always equal the sum of each separate exclusion criterion *n*.




**Appendix Figure 1.3: Experiment 4 CONSORT diagram for MTurk sample**
[a]Number approached to take study unknown. [b]One-third of the median completion time, 4.44 minutes. [c]Some participants met multiple exclusion criteria, so final *n* excluded does not always equal the sum of each separate exclusion criterion *n*.

**Appendix Table 1.1: Sociodemographic Characteristics of All Samples**

| Demographic characteristic | Experiment 1, %[b] | Experiment 2, %[b] | Experiment 3, %[b] | Experiment 4, %[b] |
|---|---|---|---|---|
| N | 1,036 | 665 | 4,477 | 4,234 |
| Female | 55.7 | 47.5 | 58.7 | 54.9 |
| Average age, years | 36.7 | 36.2 | 42.9 | 37.7 |
| Average BMI ($kg/m^2$) | 27.2 | 26.7 | 27.5 | 27.1 |
| Hispanic | 8.7 | 8.6 | 8.9 | 9.3 |
| Dietary restrictions (e.g., vegetarian, vegan, pescatarian, gluten-free, dairy-free, Kosher/Halal) | 22.2 | 12.9 | 18.3 | 16.9 |
| High blood pressure | 18.4 | 17.4 | 27.1 | 21.1 |
| Taking medication for high blood pressure | 10.1 | 8.9 | 18.3 | 11.5 |
| Watching sodium intake | 26.8 | **25.9**[a] | 41.8 | 30.3 |
| Doctor advised to reduce sodium | 15.2 | **15.7**[a] | 20.9 | 15.3 |
| Race | | | | |
| White | 78.2 | 79.1 | 72.0 | 77.5 |
| Black | 9.1 | 9.3 | 16.6 | 10.8 |
| Asian/Hawaiian | 7.0 | 7.4 | 6.6 | 7.9 |
| Native American | 0.5 | 0.8 | 0.6 | 0.9 |
| Other | 5.4 | 3.5 | 4.3 | 2.8 |
| Education | | | | |
| High school degree or less | 12.3 | 12.6 | 34.0 | 13.2 |
| Associate degree/some college | 34.9 | 37.7 | 34.3 | 33.4 |
| College or graduate degree | 52.9 | 49.6 | 31.8 | 53.4 |
| Income | | | | |
| ≤$25,000 | 26.7 | 28.4 | 30.1 | 26.7 |
| $25,001–$50,000 | 34.2 | 33.8 | 29.7 | 31.2 |
| $50,001–$75,000 | 22.7 | 22.6 | 20.4 | 22.0 |
| $75,001–$100,000 | 9.3 | 9.3 | 9.7 | 12.0 |
| $100,001–$125,000 | 4.3 | 3.2 | 4.5 | 4.3 |
| $125,001–$150,000 | 1.5 | 1.7 | 2.6 | 2.0 |
| >$150,000 | 1.5 | 1.1 | 2.9 | 1.8 |
| Frequency of eating out at full-service sit-down chain restaurants | | | | |
| Never | 4.7 | 7.5 | 6.1 | 5.4 |
| A few times a year | 48.3 | 48.4 | 45.8 | 44.2 |
| A few times a month | 39.8 | 35.2 | 39.1 | 41.1 |
| A few times a week | 6.8 | 8.1 | 7.8 | 8.6 |
| Once or more a day | 0.5 | 0.8 | 1.2 | 0.7 |
| Frequency of eating out at fast-food restaurants | | | | |
| Never | 8.6 | 9.2 | 9.3 | 7.3 |
| A few times a year | 32.4 | 30.4 | 30.8 | 29.2 |
| A few times a month | 42.9 | 45.0 | 41.9 | 45.8 |
| A few times a week | 15.1 | 14.3 | 16.2 | 16.0 |
| Once or more a day | 1.1 | 1.2 | 1.8 | 1.7 |

*Note*: Boldface indicates statistical significance ($p<0.05$).
[a]Statistically significant difference between salt warning and sodium warning conditions.
[b]% unless otherwise noted (Average Age, Average BMI).

## Appendix Table 1.2: Experiment 3 Outcomes by Study Condition, Percentages and Means (SEs) (n=4,477)

| Variable | Control (n=441) | Salt shaker red warning (n=446) | Salt shaker black warning (n=451) | Text red warning (n=450) | Text black warning (n=436) | Hazard red warning (n=470) | Hazard black warning (n=446) | Stop red warning (n=427) | Stop black warning (n=456) | Traffic light warning (n=454) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Meal choice** | | | | | | | | | | |
| Average sodium ordered on both menus (mg) | 1531.96 (25.69) | 1483.92 (25.49) | 1529.68 (26.18) | 1498.66 (23.75) | 1479.83 (25.31) | 1476.90 (23.93) | 1498.23 (24.21) | 1456.27 (24.39) | 1483.10 (25.70) | 1456.94 (24.83) |
| Average sodium of fast-food meal (mg) | 1242.43 (30.33) | 1234.31 (29.52) | 1252.71 (30.69) | 1225.71 (28.35) | 1211.79 (29.14) | 1208.60 (27.28) | 1216.35 (27.79) | 1157.66 (25.20) | 1221.78 (28.54) | 1192.09 (26.21) |
| Average sodium of full-service meal (mg) | 1821.50 (35.55) | 1733.54 (34.43) | 1806.65 (35.14) | 1771.60 (35.09) | 1747.87 (35.20) | 1745.21 (34.22) | 1780.11 (33.76) | 1754.87 (35.99) | 1744.43 (35.50) | 1721.78 (36.17) |
| High-sodium item ordered on at least one menu, % | 35.60 (2.28) | 32.06 (2.21) | 34.37 (2.24) | 34.22 (2.24) | 30.05 (2.20) | 31.91 (2.15) | 29.82 (2.17) | 30.68 (2.23) | 32.24 (2.19) | 33.04 (2.21) |
| **High-sodium meal perceptions and intentions** | | | | | | | | | | |
| Delicious (1–5) | 3.86 (0.04) | 3.80 (0.05) | 3.85 (0.05) | 3.77 (0.05) | 3.79 (0.04) | 3.87 (0.05) | 3.80 (0.05) | 3.85 (0.05) | 3.85 (0.05) | 3.91 (0.04) |
| Salty (1–5) | **3.74**[b-j] (0.04) | **4.03**[a,j] (0.04) | **3.96**[a,j] (0.04) | **4.11**[a] (0.04) | **4.13**[a] (0.04) | **4.14**[a] (0.04) | **4.09**[a] (0.04) | **4.09**[a] (0.04) | **4.10**[a] (0.04) | **4.22**[a,b,c] (0.04) |
| Healthy (1–5) | 2.10 (0.04) | 2.01 (0.04) | 2.01 (0.04) | 1.99 (0.05) | 1.98 (0.04) | 2.06 (0.04) | 1.99 (0.04) | 1.99 (0.04) | 2.04 (0.05) | 2.00 (0.05) |
| Purchase intentions (1–5) | **3.19**[d] (0.05) | 2.95 (0.05) | 3.00 (0.05) | **2.94**[a] (0.05) | 2.94 (0.05) | 3.02 (0.05) | 3.00 (0.05) | 2.95 (0.05) | 3.04 (0.06) | 2.99 (0.05) |
| Median sodium estimate (mg) | **200**[b-j] | **1037.5**[a,e,j] | **950**[a,e,f,i,j] | **1362.5**[a,j] | **1,530**[a,b,c] | **1500**[a,c] | **1262**[a,j] | **1500**[a] | **1400**[a,c] | **1875**[a,b,c,d,g] |
| **High-sodium meal disease risk perceptions** | | | | | | | | | | |
| High blood pressure (1–5) | **3.76**[b,d-j] (0.04) | **4.05**[a] (0.04) | 3.95 (0.04) | **4.05**[a] (0.05) | **4.11**[a] (0.04) | **4.00**[a] (0.04) | **4.05**[a] (0.04) | **4.11**[a] (0.04) | **4.05**[a] (0.04) | **4.11**[a] (0.04) |
| Weight gain (1–5) | **3.92**[g] (0.04) | 4.08 (0.04) | 4.04 (0.04) | 4.04 (0.05) | 4.12 (0.04) | 4.03 (0.04) | **4.13**[a] (0.04) | 4.04 (0.04) | 4.08 (0.04) | 4.09 (0.04) |
| **Lower-sodium meal perceptions and intentions** | | | | | | | | | | |
| Delicious (1–5) | 3.81 (0.04) | 3.81 (0.05) | 3.80 (0.05) | 3.86 (0.04) | 3.82 (0.04) | 3.83 (0.04) | 3.85 (0.05) | 3.87 (0.05) | 3.90 (0.04) | 3.92 (0.04) |
| Salty (1–5) | **3.38**[d,h] (0.04) | **3.23**[j] (0.04) | **3.24**[j] (0.04) | **3.19**[a,j] (0.04) | **3.26**[j] (0.04) | **3.21**[j] (0.04) | **3.27**[j] (0.04) | **3.17**[a,j] (0.04) | **3.24**[j] (0.04) | **3.50**[b-i] (0.03) |
| Healthy (1–5) | 2.87 (0.04) | 2.89 (0.04) | 2.87 (0.04) | 2.93 (0.04) | 2.92 (0.04) | 2.93 (0.04) | 2.90 (0.04) | 2.99 (0.04) | 2.88 (0.04) | 2.82 (0.04) |
| Purchase intentions (1–5) | 3.22 (0.05) | 3.20 (0.05) | 3.20 (0.05) | 3.26 (0.05) | 3.25 (0.05) | 3.20 (0.05) | 3.25 (0.05) | 3.33 (0.05) | 3.33 (0.05) | 3.28 (0.05) |
| Median sodium estimate (mg) | **137.5**[b-j] | **360**[a,j] | **365**[a,j] | **500**[a,j] | **500**[a,j] | **450**[a,j] | **500**[a,j] | **475**[a,j] | **500**[a,j] | **975**[a-i] |
| **Lower-sodium meal disease risk perceptions** | | | | | | | | | | |
| High blood pressure (1–5) | **3.31**[d] (0.04) | 3.21 (0.04) | **3.18**[j] (0.04) | **3.13**[a,j] (0.04) | 3.22 (0.04) | **3.17**[j] (0.04) | 3.20 (0.04) | 3.19 (0.04) | 3.19 (0.04) | **3.37**[c,d,f] (0.04) |
| Weight gain (1–5) | 3.32 (0.04) | 3.25 (0.05) | 3.26 (0.04) | 3.24 (0.04) | 3.26 (0.04) | 3.22 (0.04) | 3.29 (0.04) | 3.25 (0.04) | 3.27 (0.04) | 3.36 (0.04) |

## Appendix Table 1.2: Experiment 3 Outcomes by Study Condition, Percentages and Means (SEs) (n=4,477) (Continued)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Knowledge** | | | | | | | | | | |
| High vs low sodium comparisons both correct, % | **25.40**[b-j] (2.08) | **47.09**[a,j] (2.37) | **44.57**[a,h,j] (2.34) | **53.78**[a] (2.35) | **50.69**[a] (2.40) | **52.55**[a] (2.31) | **51.35**[a] (2.37) | **57.38**[a,c] (2.40) | **50.00**[a] (2.34) | **57.71**[a,b,c] (2.32) |
| High vs high sodium comparison correct, % | **54.61**[d,g,j] (2.39) | **50.58**[j] (2.41) | 46.82 (2.38) | **42.92**[a] (2.37) | 45.01 (2.40) | **47.92**[j] (2.34) | **42.53**[a] (2.35) | **50.48**[j] (2.45) | **48.32**[j] (2.37) | **36.32**[a,b,f,h,i] (2.28) |
| **Label use** | | | | | | | | | | |
| Noticed labels, % | **11.79**[b-j] (1.54) | **45.96**[a,d-j] (2.36) | **42.57**[a,d-j] (2.33) | **60.67**[a,b,c] (2.31) | **58.94**[a,b,c] (2.36) | **60.21**[a,b,c] (2.26) | **61.66**[a,b,c] (2.30) | **56.67**[a,b,c] (2.40) | **61.40**[a,b,c] (2.28) | **61.67**[a,b,c] (2.28) |
| Label influenced meal choice on at least one menu, % | **9.98**[b-j] (1.43) | **30.72**[a,d,e,g,i,j] (2.19) | **27.05**[a,d-j] (2.09) | **40.89**[a,b,c] (2.32) | **41.06**[a,b,c] (2.36) | **40.00**[a,c] (2.26) | **43.50**[a,b,c] (2.35) | **41.92**[a,c] (2.39) | **39.69**[a,b,c] (2.29) | **42.07**[a,b,c] (2.32) |

*Note*: Boldface indicates statistical significance (Holm-Bonferroni-corrected $p<0.05$). Raw statistics are displayed. The high- and lower-sodium meal perceptions and intentions and disease risk perception means are averages across menu items with respectively >2,300 mg and ≤2,300 mg of sodium.

Statistically significantly different from: [a]control condition; [b]salt shaker red warning condition; [c]salt shaker black warning condition; [d]text red warning condition; [e]text black warning condition; [f]hazard red warning condition; [g]hazard black warning condition; [h]stop red warning condition; [i]stop black warning condition; [j]traffic light warning condition.

**CHAPTER 2:** Prevalence and nutritional quality of free foods and beverages at school and work by SNAP status

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**Abstract**

Objective: To determine the national prevalence and nutritional quality of free food acquired by children at school and employees at work, stratified by participation in the Supplemental Nutrition Assistance Program (SNAP).

Methods: Using data from the National Household Food Acquisition and Purchase Survey (2012–2013; N=4,826 U.S. households representing 14,317 individuals), we used survey-weighted proportions to describe free food acquisition and survey-weighted linear regression to compare the 2010 Healthy Eating Index (HEI-2010) for free and non-free food acquisitions across 3 groups: SNAP participants, SNAP non-participants at ≤185% federal poverty level (FPL), and SNAP non-participants >185% FPL.

Results: SNAP households acquired significantly more free food (26.8%) compared to non-SNAP households ≤185% FPL (23.3%; p=0.017) and >185% FPL (21.1%; p<0.001). For children in SNAP households, free food from school had a higher HEI-2010 compared to non-free food (50.3 vs 43.8, p=0.033) and compared to free food acquired by non-SNAP children >185% FPL (50.3 vs. 38.0, p=0.001). Nutritional quality of free and non-free food acquired at work was relatively lower, with no significant differences by SNAP status.

Conclusions: Over one fifth of all food was acquired for free, but the nutritional quality of free food at school and work was relatively low. For children participating in SNAP, free food acquired at school had higher nutritional quality. Improvements in dietary quality of free food acquired at school and work could contribute to the overall health of families, especially those participating in SNAP.

## Introduction

Poor diet quality is a key contributor to negative health outcomes, including obesity, cardiovascular disease, and type 2 diabetes.[76-78] While diet quality has improved modestly over time, the average American diet consistently falls short of national dietary guidelines.[79-81] Low-income Americans are less likely to meet national dietary guidelines[80] and experience higher rates of diet-related chronic diseases.[82-84] Food insecurity, defined as a lack of consistent access to enough food for an active, healthy life,[85] is also associated with negative health outcomes (e.g., obesity, type 2 diabetes)[86] and is more than three times higher among Americans living in poverty compared to the general population (35.3% vs 11.1%).[87] This dual burden of poor diet quality and food insecurity makes free food—food acquired at no cost—a very important part of the nutrition safety net for low-income families.

A recent USDA report found that one fifth of all food and beverages in the American diet are acquired at no cost, with higher rates of free food acquisition by participants in the Supplemental Nutrition Assistance Program (SNAP).[12] SNAP is the largest program in the federal nutrition safety net, helping close to 40 million Americans afford food.[88] SNAP participants receive monthly funds to pay for groceries; thus, foods purchased with SNAP benefits are not technically "free." Instead, much of the free food identified in the USDA report was acquired at school or at work. Half of all food and beverage acquisitions at schools are free, largely due to the National School Lunch Program (NSLP), the second largest federal nutrition assistance program which provides free and reduced-price lunches to approximately 30.4 million children daily.[89] Children on SNAP are automatically enrolled to receive free school meals, while all children in the nation's highest-poverty school districts receive free school meals, regardless of their household income.[90] School meals provided through the NSLP are required to adhere to strict nutrition standards based on the Dietary Guidelines for Americans.[91] At work, over 70 percent of acquisitions are free, from sources such as catered lunch meetings.[12] Although there are some nutritional standards governing food offered in institutional settings (e.g., federally recommended healthy food service guidelines),[91,92] many sources of free food in the workplace have no standardized nutrition requirements.

Free food in institutional settings is of particular interest from a public health perspective, as institutional-level policies could improve the nutritional quality of free foods provided. Cost is a major barrier to consumption of healthier foods, especially among low-income households, so the provision of free food offers a unique opportunity to modify food preferences by allowing people to try new foods without any monetary risk; this may be an especially effective tactic to encourage children to learn to enjoy more nutritious foods.[13] Institutions that offer healthier free food may also could promote the development of healthy eating as normative behavior.[14-17]

Despite the available evidence that free food makes up a considerable portion of total food acquired by U.S. households, it is unknown whether acquisition and nutritional quality of free food vs. non-free food is similar across the population or if it varies by participation in SNAP. To answer these important questions, we focused on two institutional settings in which a large proportion of free food is acquired—in schools and workplaces. Specifically, this study examined the national prevalence and nutritional quality of free food acquired by children at school and employees at work, stratified by household SNAP participation.

**Methods**

Study Sample

Data were obtained from the National Household Food Acquisition and Purchase Survey (FoodAPS, 2012–2013), a nationally representative survey of 4,826 U.S. households representing 14,317 individuals released in 2015 by the United States Department of Agriculture (USDA) as a restricted-use data set.[93] FoodAPS collected data on all food acquisitions and purchases (including food at home and away from home) by all members of sampled households over one week, with oversampling of low-income and SNAP households. The primary household meal planner (primary respondent) provided demographic and diet- and health-related information about the household and its individuals through two in-person interviews and three brief telephone interviews. Each household member aged at least 11 years old was asked to track all food acquisitions (including location of acquisition, food items acquired, and cost) by using food diaries, scanning barcodes, and saving receipts from stores and restaurants. Adults used their own food diaries to record foods acquired by children under age 11.[93] Multi-part incentives were offered to encourage participation by all household members. Analysis for this study took place in 2019–2020.

Measures

The primary outcomes of this study were the prevalence and nutritional quality of free and non-free foods and beverages acquired at school and work over the week of data collection, stratified by SNAP status. Nutritional quality was measured using the 2010 USDA Healthy Eating Index (HEI-2010), which measures alignment with the *2010 Dietary Guidelines for Americans* (DGA) using a density approach (e.g., nutrients per 1000 calories), and has been widely used to assess and compare diet quality.[80,94,95] The total score is comprised of 12 components and ranges from 0 (worst ) to 100 (best). The HEI increases with consumption of 9 dietary components encouraged in the 2010 DGA (e.g., whole grains) and decreases with consumption of 3 dietary components recommended in moderation (e.g., refined grains).[94] We examined the 12 individual component density scores as a secondary outcome. HEI-2010 total and component scores were calculated based on previously described methods using the nutrient composition of acquired foods in the FoodAPS database.[96] Other secondary outcomes included the 10 most commonly acquired foods and beverages (category 2 level of USDA's "What We Eat in America" categories,[97] e.g., coffee and tea, white potatoes, sandwiches) for free at school and at work.

Outcomes at school were evaluated among school-aged individuals 5–18-years-old, and outcomes at work were evaluated among any household member 17 years or older that reported working at a job or business. Individuals were divided across three categories according to SNAP status, based on designations in FoodAPS: 1) SNAP participants, 2) lower-income SNAP-eligible non-participants (household incomes ≤185% FPL, "SNAP eligible non-participants"), and 3) higher-income participants that were SNAP ineligible (household incomes >185% FPL, "SNAP ineligible"). These household income cutoffs are consistent with prior analyses using FoodAPS published by the USDA[80] and in the peer-reviewed literature.[98] Household income was self-reported in interviews with the primary respondent. SNAP participation status in the prior 30 days was determined by both survey responses and matches to administrative records.

Statistical Analysis

Analyses were conducted using Stata 15.1 software. The first set of analyses focused on free acquisitions by SNAP status. Survey-weighted proportions were used to describe the percentage of total free food and beverages acquired by SNAP status among all households, school-aged individuals, and employed individuals. Percentages of free food for children at school and for employees at work were also included. Survey-weighted logistic regression was used to compare the proportion of free acquisitions by SNAP status. The second set of analyses focused on HEI scores. Survey-weighted means were used to describe HEI-2010 total and component scores for free and non-free food and beverage acquisitions for children at school and for employees at work by SNAP status. Scores were compared using survey-weighted linear regression with an interaction term for whether food was acquired for free and SNAP status, and adjusted for individuals' age, sex, race (white, black, other), Hispanic ethnicity, household number of children 5–18 years old, household WIC status, and household food insecurity (food secure or insecure [low or very low food security as measured by the USDA's Adult Food Security Scale]). Analyses of employed individuals at work additionally controlled for education (high school or less, some college, or college+) and marital status (married or unmarried).

We conducted two sensitivity analyses to 1) examine primary outcomes using modified income cutoffs for household SNAP status (non-participants $\leq$130% FPL and >130% FPL), and 2) restrict the nutritional quality analyses at school to children that reported receiving free school meals. We also conducted an exploratory analysis to examine the prevalence and nutritional quality of free food acquired at school and work by food insecurity status.

## Results

Demographic characteristics of school-aged and employed individuals and their households are shown by SNAP status in Table 2.1. Compared to SNAP ineligible individuals, school-aged and employed SNAP participants were significantly younger, and a higher proportion were Hispanic and black. Their households were significantly larger, and a higher proportion received WIC benefits and were food insecure. Compared to their SNAP non-participant counterparts, a significantly higher proportion of school-aged SNAP participants received free school lunch through the NSLP, and a significantly lower proportion of employed SNAP participants were married and had attended college.

**Table 2.1: Characteristics of school-aged (5-18 years old) and employed individuals (>16 years old) and their households by SNAP/income groups**

| **SCHOOL-AGED INDIVIDUAL CHARACTERISTICS** | **SNAP participants** (n=1508) | **non-SNAP ≤185% FPL** (n=788) | **non-SNAP >185% FPL** (n=1042) |
|---|---|---|---|
| Mean Age (SD) | 10.9 (6.4) | 11.7 (5.3)* | 11.4 (3.1)* |
| Male (%) | 51.7 | 47.8 | 49.2 |
| Hispanic (%) | 33.8 | 32.4 | 15.2** |
| Race (%) | | | |
| White | 52.8 | 65.4* | 76.0** |
| Black | 30.5 | 17.5* | 10.9** |
| Other | 16.7 | 17.1 | 13.1 |
| School in session during study period (%) | 58.4 | 52.9 | 58.7 |
| School Level (%) | | | |
| Kindergarten | 7.5 | 4.7* | 3.6* |
| Elementary/Primary | 36.3 | 25.5* | 28.9* |
| Middle School/Junior High | 16.0 | 17.7 | 16.3 |
| High School | 16.2 | 25.6* | 22.9* |
| Other | 1.1 | 3.1 | 1.2 |
| Cost of school lunch (%) | | | |
| Free | 93.2 | 59.4** | 17.1** |
| Reduced Price | 3.4 | 23.2** | 12.3* |
| Full Price | 3.4 | 17.4** | 70.6** |
| **CHARACTERISTICS OF HOUSEHOLDS WITH SCHOOL-AGED INDIVIDUALS** | **SNAP HH** (n=783) | **non-SNAP ≤185% FPL** (n=418) | **non-SNAP >185% FPL** (n=624) |
| Mean number of food acquisition events per week (SD) | 16.3 (16.5) | 16.7 (14.8) | 18.1 (8.5)* |
| Mean number of household members (SD) | 4.4 (2.9) | 4.4 (2.6) | 4.0 (1.0)** |
| Mean number of household children (<19 years old) (SD) | 2.4 (2.2) | 2.3 (1.8) | 1.9 (0.8)** |
| Mean number of school-aged household children (5-18 years old) (SD) | 1.9 (1.9) | 1.9 (1.5) | 1.7 (0.8)* |
| Anyone in household receiving WIC (%) | 55.1 | 43.3 | 13.1** |
| Food insecure (low or very low, 30-day, adult) (%) | 42.5 | 40.8 | 7.0** |

**Table 2.1: Characteristics of school-aged (5-18 years old) and employed individuals (>16 years old) and their households by SNAP/income groups (Continued)**

| **EMPLOYED INDIVIDUALS' CHARACTERISTICS** | **SNAP participants** (n=1347) | **non-SNAP <185% FPL** (n=1131) | **non-SNAP ≥185% FPL** (n=2904) |
|---|---|---|---|
| Mean Age (SD) | 37.1 (19.8) | 39.9 (17.7)* | 43.0 (10.2)** |
| Male (%) | 47.1 | 51.6 | 52.9* |
| Hispanic (%) | 32.4 | 30.2 | 11.6** |
| Race (%) | | | |
| White | 56.3 | 67.3** | 78.9** |
| Black | 25.5 | 14.6** | 9.0** |
| Other | 18.2 | 18.1 | 12.2* |
| Education (%) | | | |
| High school or less | 63.0 | 51.8** | 27.9** |
| Some college | 27.4 | 36.2* | 31.3 |
| College+ | 8.6 | 11.9 | 40.6** |
| Married (%) | 29.2 | 44.8** | 56.8** |
| **CHARACTERISTICS OF HOUSEHOLDS WITH EMPLOYED INDIVIDUALS** | **SNAP HH** (n=935) | **non-SNAP ≤185% FPL** (n=750) | **non-SNAP >185% FPL** (n=1680) |
| Mean number of food acquisition events per week (SD) | 14.2 (14.3) | 12.3 (11.9)* | 13.4 (6.6) |
| Mean number of household members (SD) | 3.8 (2.9) | 3.0 (2.6)** | 2.6 (1.1)** |
| Mean number of household children (<19 years old) (SD) | 1.6 (2.4) | 1.1 (1.9)** | 0.7 (0.8)** |
| Mean number of school-aged household children (5-18 years old) (SD) | 1.0 (2.0) | 0.8 (1.6)* | 0.5 (0.7)** |
| Anyone in household receiving WIC (%) | 60.6 | 40.9* | 13.5** |
| Food insecure (low or very low, 30-day, adult) (%) | 39.3 | 31.4* | 7.5** |

*significantly different from SNAP, p<0.05; **p<0.001

Note: School-aged individuals are individuals aged 5-18 years old. Employed individuals are any individuals who reported working at a job or business. Food insecurity was measured with USDA's 10-question 30-day Adult Food Security Scale (e.g., "In last 30 days, worried food would run out before we got more money", "Couldn't afford to eat balanced meals in last 30 days"). "Often" or "Sometimes" = 1; "Never" = 0. Raw score 3-5=Low food security; 6-10=very low food security. "Other School Level" includes "other school" and "home-schooled". Total school level does not add up to 100 because other children are classified as "on vacation", "not old enough", etc.

Figure 2.1 shows proportions of free and non-free food and beverage acquisitions by SNAP status. Overall, a significantly higher percentage of SNAP households' acquisitions were free (26.8%) compared to SNAP non-participant households (eligible: 23.3%, p=0.017; ineligible: 21.1%, p<0.001). SNAP-participant children obtained 82.6% of their food for free, and more than half of that free food was obtained at school (58.8% of all acquisitions). This was a significantly higher proportion of free food overall compared to SNAP non-participant children ($p<0.001$), for whom free food made up 62.1% (SNAP eligible) and 44.0% (SNAP ineligible) of all foods acquired. SNAP non-participant children also acquired much of their free food while at school (eligible: 40.1%; ineligible: 14.8%). Employed individuals acquired much less of their overall food for free (24–26%), and there were no significant differences by SNAP status. Of all their acquisitions, 8–9% were free and at work.

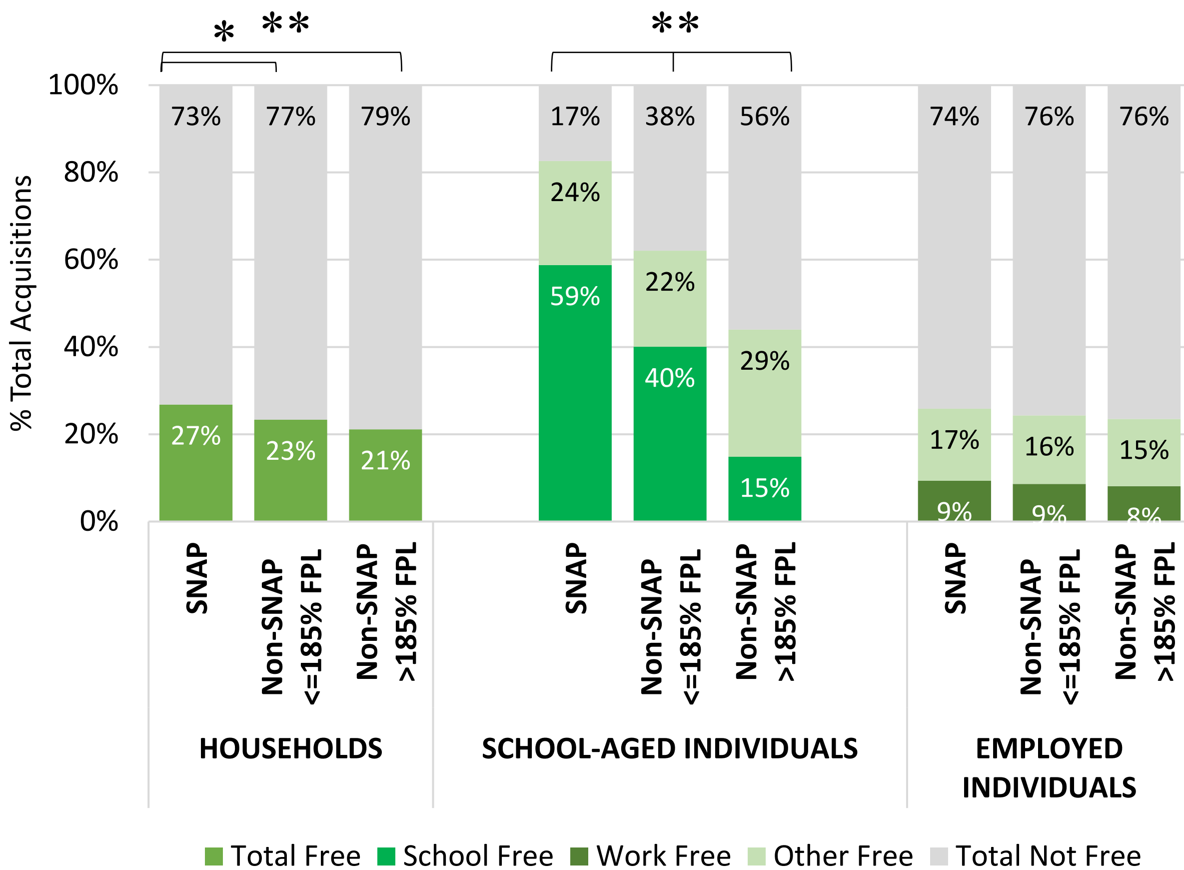



**Figure 2.1: Free and non-free acquisitions by location across SNAP status, survey-weighted proportions**
* % free significantly different between groups, $p<0.05$; ** $p<0.001$

Figure 2.2 shows the adjusted mean HEI-2010 scores of free and non-free food acquisitions by children at school. Free food acquired by SNAP-participant children at school had a higher HEI-2010 compared to the non-free food they acquired (50.3 vs. 43.8, p=0.033) and compared to the free food acquired by SNAP ineligible children (50.3 vs. 38.0, p=0.001). Free food acquired at school by SNAP ineligible children had a lower HEI-2010 compared to the non-free food they acquired at school (38.0 vs. 50.6, p=0.004). When analyses were restricted to free acquisitions among children who reported receiving free school lunch, there were no significant differences in HEI-2010 (range: 47.7–51.4) (Appendix Figure 2.1).

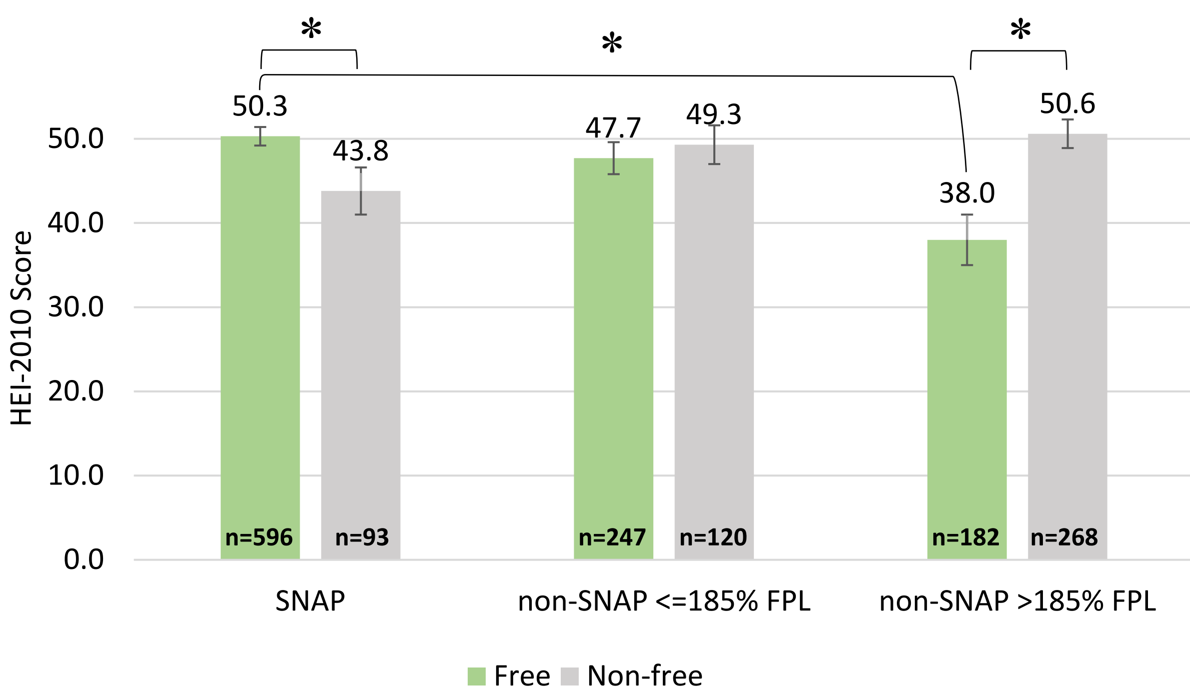



**Figure 2.2: Mean HEI-2010 scores of free vs. non-free food acquisitions by children at school, by SNAP status**
Note: Survey-weighted, adjusted for individuals' age, sex, race, Hispanic ethnicity, household number of children 5–18, household food insecurity, and household WIC status. *Sig. dif. $p<0.05$

The HEI component density score analysis of free food acquired at school (Appendix Table 2.1) showed that SNAP-participant children had significantly higher component density scores for total vegetables, greens and beans, total fruit, whole fruit, total protein foods, seafood and plant protein, and empty calories, and a significantly lower component density score for sodium compared to SNAP ineligible children. There were no significant differences between the two SNAP status categories for whole grains, dairy, fatty acids ratio, or refined grains. Appendix Table 2.2 shows the most common foods and beverages children acquired for free at school; across all children, these included fruit, plain and flavored milk, 100% juice, sandwiches, vegetables, white potatoes, and pizza. Sweet bakery products made up a higher proportion of free food for SNAP non-participants compared to SNAP participants.

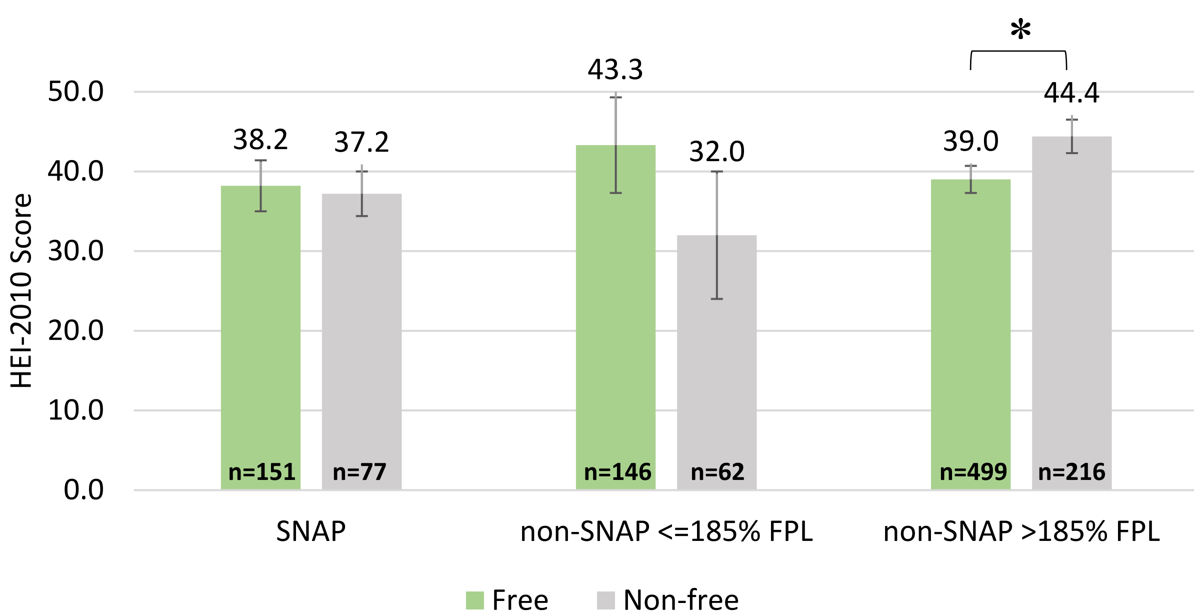



**Figure 2.3: Mean HEI-2010 scores of free vs. non-free food acquisitions by employees at work, by SNAP status**
Note: Survey-weighted, adjusted for individuals' age, sex, race, Hispanic ethnicity, education, marriage status, household number of children 5–18, household food insecurity, and household WIC status. *Sig. dif. $p<0.05$

At work, free food acquired by SNAP ineligible employees had a significantly lower HEI-2010 compared to the non-free food they acquired (39.0 vs. 44.4, p=0.025) (Figure 2.3).

There were no other significant differences within or between SNAP status, but HEI-2010 scores were consistently low for free and non-free work acquisitions (32.0–44.4).

There were no significant differences in HEI component density scores of free food employees acquired at work by SNAP status (Appendix Table 2.3). The most common free foods and beverages employees acquired at work included coffee and tea, sandwiches, sweetened beverages, vegetables, and water (Appendix Table 2.4). Sweet bakery products made up a higher proportion of free food for SNAP non-participants compared to SNAP participants.

Primary outcomes analyzed with a modified income cutoff for household SNAP status (non-participants ≤130% FPL and >130% FPL) did not differ significantly from main analyses (Appendix Figures 2.2–2.4). The prevalence of free food and its nutritional quality acquired at work by food insecurity status were also similar to main analyses (Appendix Figures 2.5, 2.7). The nutritional quality of free food at school did not differ by food security status, but non-free school food acquired by food secure children had a higher HEI-2010 compared to free school food they acquired (HEI-2010: 52.9 vs. 45.2, p=0.013) and compared to non-free school food acquired by food insecure children (52.9 vs. 46.6, p=0.012) (Appendix Figure 2.6).

**Discussion**

We analyzed a unique national sample of U.S. households to examine the prevalence and nutritional quality of free food and beverage acquisitions by household SNAP status. We found that 27% of all SNAP households' foods were acquired for free, which is significantly higher than the 21% of SNAP ineligible non-participant households' foods acquired for free. This indicates that SNAP participants may be more reliant on the provision of free food than higher-income non-participants. This is supported by our finding that children in SNAP households acquired the majority (83%) of their total food for the week for free, and more than half of their total food for the week was acquired for free at school.

We also found that free school food acquired by SNAP-participant children was of higher nutritional quality compared to their non-free food and compared to free food acquired by SNAP ineligible non-participant children. Our finding that children who received free school lunch had higher HEI-2010 scores at school regardless of SNAP status suggests the NSLP may improve diet quality, especially among SNAP participants, as they are categorically eligible for the program. Other studies have found that the NSLP has led to better diet quality for low-income children compared to higher-income children.[99-101] NSLP nutrition standards were updated in 2012 for the first time in more than 15 years with the passage of the Healthy Hunger-Free Kids Act (HHFKA).[102] By July 1, 2012, schools were required to offer meals with more fruit, vegetables, and whole grains, while reducing the amount of calories, sodium, saturated fat, and added sugars.[102] Although FoodAPS collected data post-implementation of these new standards, FoodAPS' nutrient composition database was from 2009–2010, so our findings reflect pre-implementation nutrition standards. It is thus likely that if this data were collected today or even if the nutrient composition database was contemporaneous with the FoodAPS data collection, the free food that SNAP participants acquired at school would have an even higher HEI-2010 score due to product reformulation (e.g., whole grain, lower-sodium bread); other research has documented an increase in diet quality due to the updated nutrition standards.[103] The nutritional quality of non-free food acquired at school is also likely to have risen due to the 2014 implementation of the Smart Snacks in School regulation, which required higher nutrition standards for all foods sold at school during the school day, including in vending machines and a la carte in the cafeteria.[104] Given that the majority of U.S. public school students now qualify for free and reduced-price school meals,[105] and that low-income students are at the highest risk for obesity,[106] our findings suggest that the NSLP's updated 2012 nutritional standards should be maintained, and not weakened, as has been proposed by the current presidential administration.[107]

Other policies that govern nutrition standards for foods offered throughout the school day could be leveraged to increase the nutritional quality of free food at school for everyone. School wellness policies were first federally mandated in 2004 for schools participating in federal school meal programs,[108] and were updated by the HHFKA.[109] One of the main categories of free school food found in this study was sweet bakery products (e.g., cookies, brownies). Although these items made up a smaller proportion of SNAP participants' free school food, they were prevalent across all groups. As these foods are often served during parties, distributing non-food alternatives or limiting which foods can be distributed for celebrations and as classroom rewards could improve the nutritional quality of free food at school for all children;[110,111] preliminary evidence suggests that such wellness policies can have beneficial outcomes for obesity prevention.[112]

This study also highlighted the lower nutritional quality of foods provided for free at workplaces across income levels. Some of the most commonly acquired free foods and beverages included sandwiches, sweetened beverages, and sweet bakery products, which often have high levels of added sugar and sodium. Workplace wellness policies with strong nutrition standards could improve the nutritional quality of free foods offered at work. More than half of all U.S. states have laws related to workplace wellness programs, although few directly address diet at work.[113] Procurement policies can also be implemented to improve diet quality at work, as has been done in numerous worksites across the country at the national, state, and local level.[114]

For example, the Center for Disease Control's *Food Service Guidelines for Federal Facilities* include DGA-aligned nutrition standards recommended for use by foodservice and vending operations in federal facilities.[92]

This study had a number of limitations. Some of these include general limitations of the FoodAPS dataset and have been discussed elsewhere.[115-118] Our data solely contain acquisition, not consumption, information. However, acquisitions still provide insight into what schools and work are providing and individuals are likely to be eating. Household members may have underreported food acquisitions due to response fatigue over the course of the week or parents not reporting all acquisitions by their under-11 children. Another limitation is that HEI scores are designed to assess overall diet quality, not individual meals; in our study HEI scores should only be interpreted as a relative measure to compare nutritional quality of food acquisitions at different locations across groups. Future research should gather data on free and non-free food acquisition and consumption at school, work, and other institutions such as food pantries, to understand how the nutritional quality of free offerings may have changed since FoodAPS data was collected in 2012–2013.

Our study had a number of strengths. Although much research has been devoted to overall diet quality of lower-income populations, this is the first study to explicitly evaluate the nutritional quality of free and non-free food in a large nationally representative sample. It is also the first to examine how the nutritional quality of free and non-free food differs at work and school by SNAP status. Our results suggest that improvements in dietary quality of free food acquired at school and work could contribute to the overall health of families, especially those participating in SNAP.

## Conclusions

Free food makes up a large portion of food acquired by U.S. households and makes up a large majority of food acquired by children living in families receiving SNAP benefits. For these children, free food acquired at school had higher nutritional quality, but the overall nutritional quality of free food at school and work was relatively low. Policy efforts by governments (e.g., nutrition standards for school meals) and the private sector (e.g., institutional wellness policies) can help to both improve the health profile of free food and reduce access to less healthy foods, which can in turn improve overall dietary quality for U.S. families.

## Appendix

### Appendix Table 2.1: HEI-2010 component density scores of free food acquisitions by children at school

| | Free School Acquisitions | | |
|---|---|---|---|
| | SNAP individuals (n=596) | non-SNAP <185% FPL individuals (n=247) | non-SNAP >=185% FPL individuals (n=182) |
| **Component density scores (max score, standard for max score)** | **Mean (SE)** | **Mean (SE)** | **Mean (SE)** |
| Total vegetables (5, ≥ 1.1 cups/1000kcal) | 2.38 (0.16) | 1.75 (0.22)[a] | 0.96 (0.28)[a] |
| Greens and beans (5, ≥ 0.2 cups/1000kcal) | 0.92 (0.15) | 0.40 (0.12)[a] | 0.05 (0.12)[a] |
| Total fruit (5, ≥ 0.8 cups/1000kcal) | 3.42 (0.17) | 2.56 (0.29)[a] | 2.25 (0.39)[a] |
| Whole fruit (5, ≥ 0.4 cups/1000kcal) | 3.29 (0.18) | 2.38 (0.28)[a] | 2.26 (0.44)[a] |
| Whole grains (10, ≥ 1.5 oz/1000kcal) | 2.56 (0.11) | 2.22 (0.18) | 2.51 (0.23) |
| Dairy (10, ≥ 1.3 cups/1000kcal) | 8.75 (0.29) | 6.87 (0.65)[a] | 7.45 (0.67) |
| Total protein foods (5, ≥ 2.5 oz/1000kcal) | 3.74 (0.15) | 2.88 (0.32)[a] | 2.05 (0.40)[a] |
| Seafood and plant protein (5, ≥ 0.8 oz/1000kcal) | 1.81 (0.17) | 1.30 (0.19) | 1.06 (0.25)[a] |
| Fatty acids ratio (10, [PUFAS+MUFAS]/SFAs ≥ 2.5) | 3.56 (0.29) | 2.80 (0.36) | 2.61 (0.51) |
| Sodium (10, ≤ 1.1 grams/1000kcal) | 2.59 (0.25) | 2.44 (0.63) | 4.29 (0.76)[a] |
| Refined grains (10, ≤ 1.8 oz/1000kcal) | 3.19 (0.20) | 2.65 (0.52) | 2.90 (0.41) |
| Empty calories[b] (20, ≤ 19% of energy) | 12.94 (0.43) | 10.10 (0.95)[a] | 9.44 (1.17)[a] |

Note: Survey-weighted, adjusted for individuals' age, sex, race, Hispanic ethnicity, household number of children 5–18, household food insecurity, and household WIC status. [a] Significantly different from SNAP individuals, $p<0.05$. [b] Calories from solid fats, alcohol, and added sugars; threshold for counting alcohol is >13 grams/1000 kcal.

### Appendix Table 2.2: Most commonly acquired foods and beverages for free by children at school

| SNAP school-age individuals | % | non-SNAP <185% FPL | % | non-SNAP ≥185% FPL | % |
|---|---|---|---|---|---|
| Fruits | 10.83 | Fruits | 10.91 | Milk | 9.81 |
| Milk | 10.75 | Milk | 10.79 | Fruits | 9.17 |
| Sandwiches | 10.16 | Sandwiches | 9.12 | Sandwiches | 8.56 |
| Flavored Milk | 10.09 | Flavored Milk | 8.41 | Flavored Milk | 8.48 |
| Vegetables (exc. potatoes) | 7.93 | Vegetables (exc. potatoes) | 8.33 | 100% Juice | 6.60 |
| 100% Juice | 7.65 | 100% Juice | 8.16 | Vegetables (exc. potatoes) | 6.21 |
| Pizza | 4.66 | White Potatoes | 4.46 | Sweet Bakery Products | 5.21 |
| White Potatoes | 3.42 | Pizza | 4.08 | White Potatoes | 5.00 |
| Quick Breads/Bread Products | 3.21 | Sweet Bakery Products | 3.11 | Pizza | 4.24 |
| Ready-to-Eat Cereals | 3.01 | Quick Breads/Bread Products | 2.86 | Poultry | 3.88 |

Note: survey-weighted, % out of total foods and beverages acquired for free at school by school-aged individuals

### Appendix Table 2.3: HEI-2010 component densities of free food acquisitions by employees at work

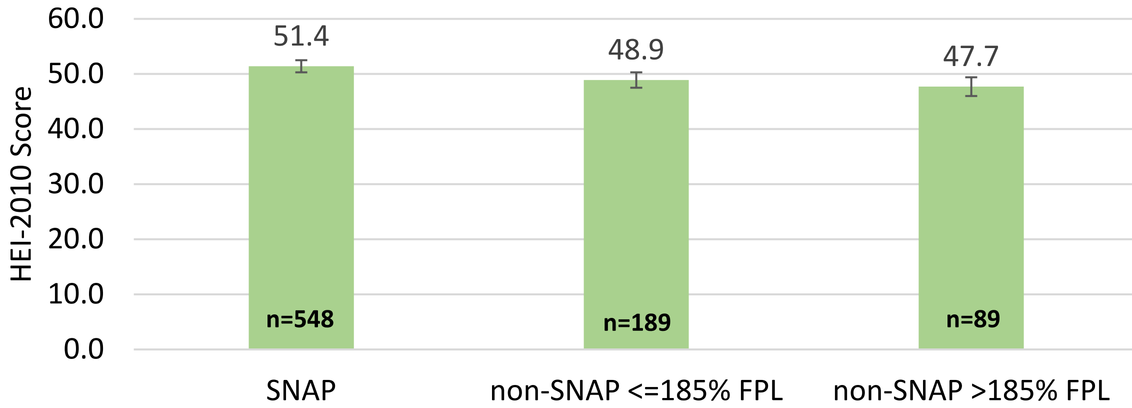
| | Free Work Acquisitions | | |
|---|---|---|---|
| | SNAP employed individuals (n=151) | non-SNAP <185% FPL (n=146) | non-SNAP >=185% FPL (n=499) |
| **Component density scores (max score, standard for max score)** | Mean (SE) | Mean (SE) | Mean (SE) |
| Total vegetables (5, ≥ 1.1 cups/1000kcal) | 1.35 (0.34) | 1.56 (0.43) | 2.24 (0.23) |
| Greens and beans (5, ≥ 0.2 cups/1000kcal) | 0.92 (0.46) | 1.05 (0.28) | 1.12 (0.27) |
| Total fruit (5, ≥ 0.8 cups/1000kcal) | 0.84 (0.36) | 1.90 (0.56) | 0.69 (0.22) |
| Whole fruit (5, ≥ 0.4 cups/1000kcal) | 0.63 (0.38) | 1.93 (0.60) | 0.71 (0.23) |
| Whole grains (10, ≥ 1.5 oz/1000kcal) | 1.21 (0.40) | 1.35 (0.49) | 1.33 (0.38) |
| Dairy (10, ≥ 1.3 cups/1000kcal) | 3.76 (0.71) | 3.32 (0.59) | 3.40 (0.46) |
| Total protein foods (5, ≥ 2.5 oz/1000kcal) | 2.24 (0.50) | 2.32 (0.33) | 2.84 (0.29) |
| Seafood and plant protein (5, ≥ 0.8 oz/1000kcal) | 1.08 (0.28) | 0.35 (0.31)[a] | 1.24 (0.34) |
| Fatty acids ratio (10, [PUFAS+MUFAS]/SFAs ≥ 2.5) | 5.27 (0.59) | 6.69 (0.57) | 4.99 (0.54) |
| Sodium (10, ≤ 1.1 grams/1000kcal) | 3.92 (0.94) | 4.47 (0.83) | 3.78 (0.46) |
| Refined grains (10, ≤ 1.8 oz/1000kcal) | 6.03 (0.96) | 6.00 (0.79) | 5.28 (0.56) |
| Empty calories[b] (20, ≤ 19% of energy) | 12.46 (1.88) | 10.40 (2.83) | 11.45 (1.28) |

Note: Survey-weighted, adjusted for individuals' age, sex, race, Hispanic ethnicity, education, marriage status, household number of children 5–18, household food insecurity, and household WIC status. [a] Significantly different from SNAP individuals, $p<0.05$. [b] Calories from solid fats, alcohol, and added sugars; threshold for counting alcohol is >13 grams/1000 kcal.

### Appendix Table 2.4: Most commonly acquired foods and beverages for free by employees at work

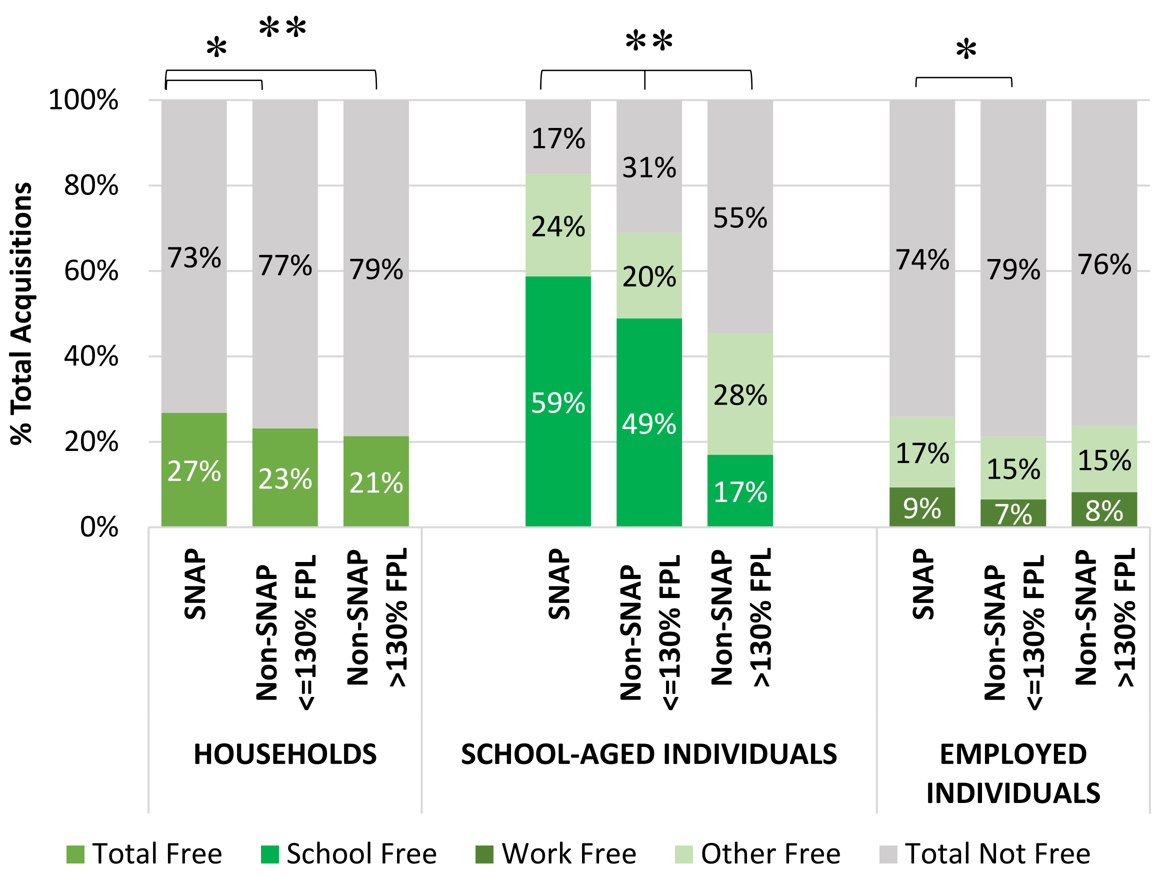
| SNAP employed individuals | % | non-SNAP <185% FPL | % | non-SNAP ≥185% FPL | % |
|---|---|---|---|---|---|
| Coffee and tea | 14.16 | Coffee and tea | 9.85 | Coffee and tea | 23.30 |
| Sandwiches | 8.42 | Sandwiches | 8.76 | Sweetened beverages | 7.68 |
| Vegetables (exc. potatoes) | 7.78 | Vegetables (exc. potatoes) | 7.94 | Vegetables (exc. potatoes) | 5.98 |
| Sweetened beverages | 7.26 | Fruits | 7.15 | Sandwiches | 5.92 |
| Plain water | 5.74 | Plain water | 7.03 | Plain water | 5.66 |
| Quick breads/bread products | 4.42 | Sweetened beverages | 5.37 | Sweet bakery products | 5.40 |
| Breads, rolls, and tortillas | 3.82 | 100% juice | 5.21 | Breads, rolls, and tortillas | 4.07 |
| White potatoes | 3.50 | Sweet bakery products | 5.18 | Fruit | 3.14 |
| Poultry | 3.30 | Breads, rolls, and tortillas | 4.52 | Fats and oils | 3.12 |
| Fruits | 3.07 | Grain-based mixed dish | 3.59 | Diet beverages | 2.41 |

Note: survey-weighted, % out of total foods and beverages acquired for free at work by employed individuals



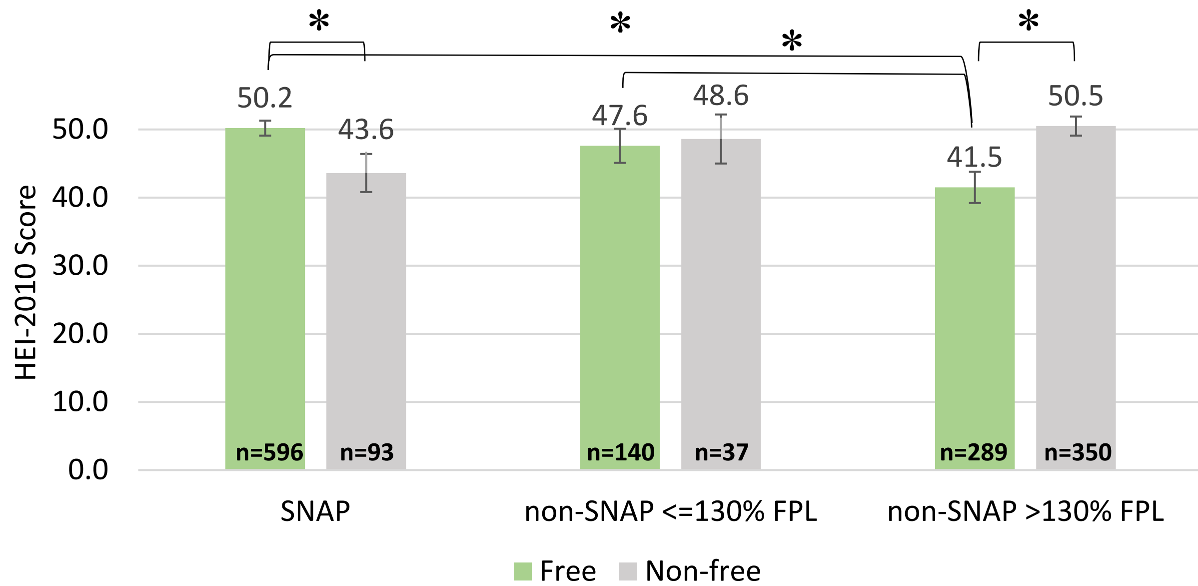

**Appendix Figure 2.1: Sensitivity Analysis: Mean HEI-2010 scores of free food acquisitions by children at school by SNAP status, restricted to children who reported receiving free school lunch**

Note: Survey-weighted, adjusted for individuals' age, sex, race, Hispanic ethnicity, household number of children 5–18, household food insecurity, and household WIC status. No significant differences.

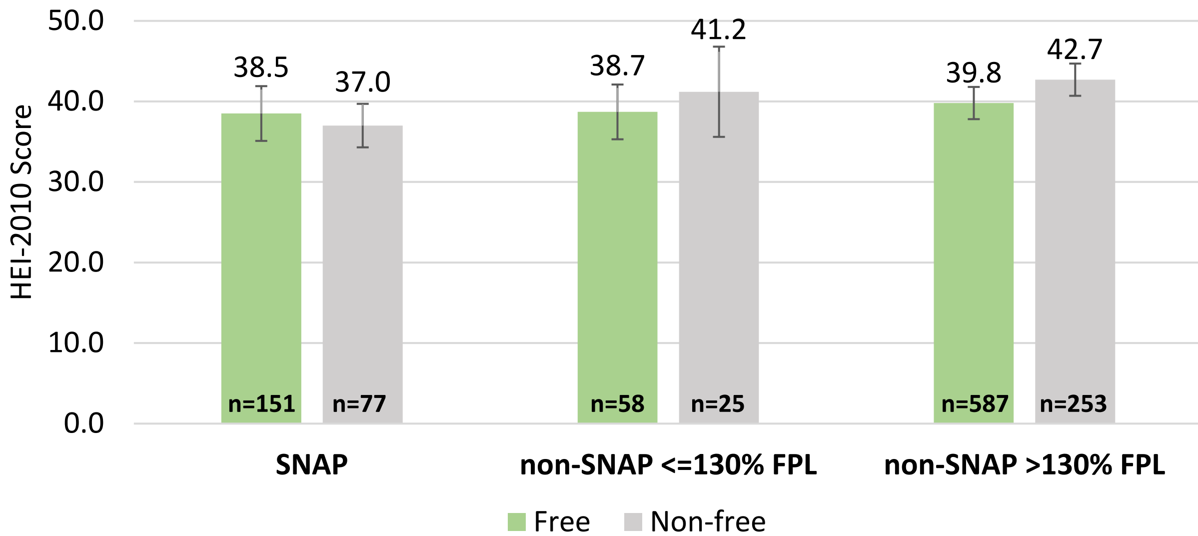



**Appendix Figure 2.2: Sensitivity Analysis: Free and non-free acquisitions by location across SNAP status (cutoff 130% FPL), survey-weighted proportions**

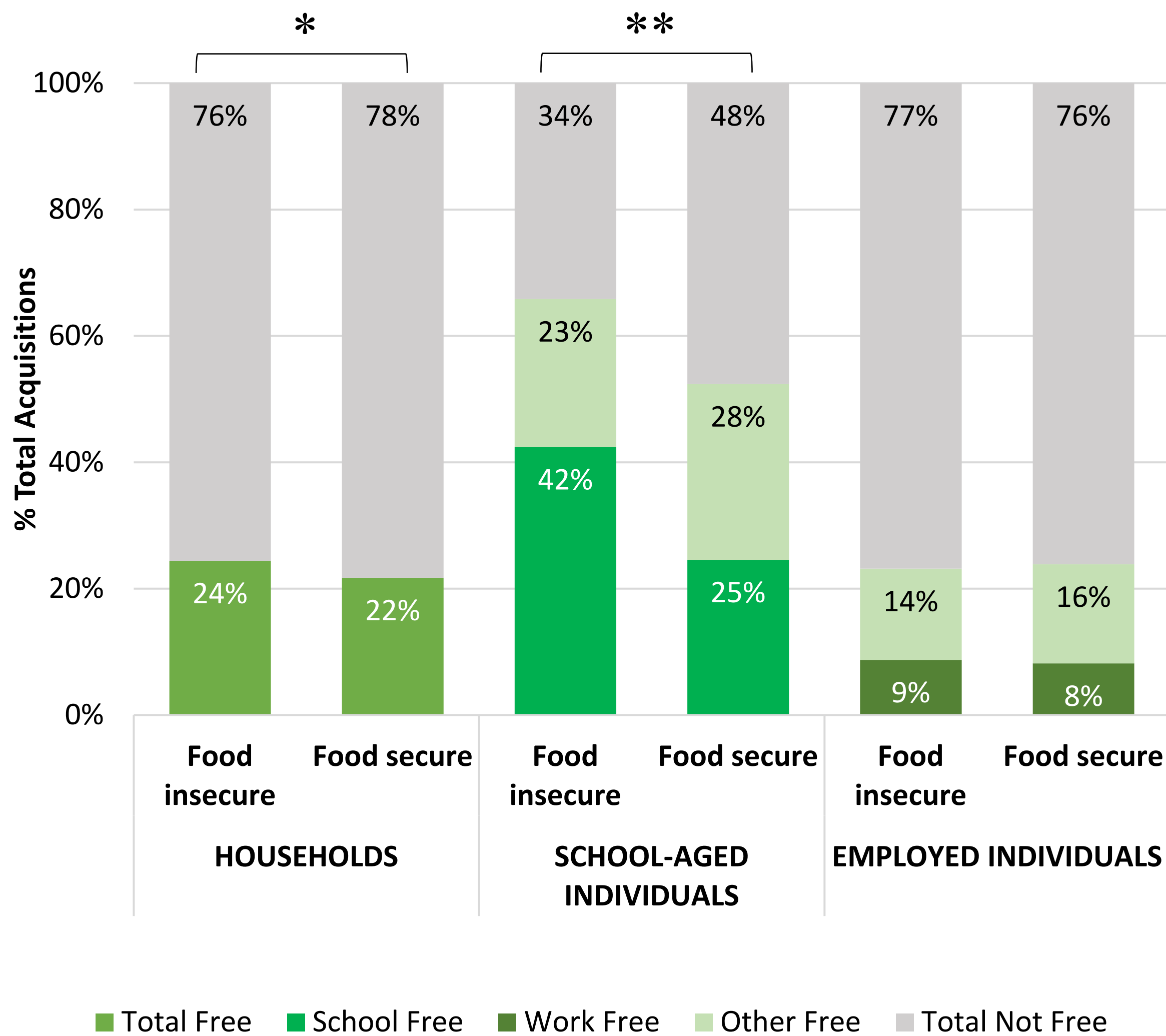
* % free significantly different between groups, $p<0.05$; ** $p\leq0.001$



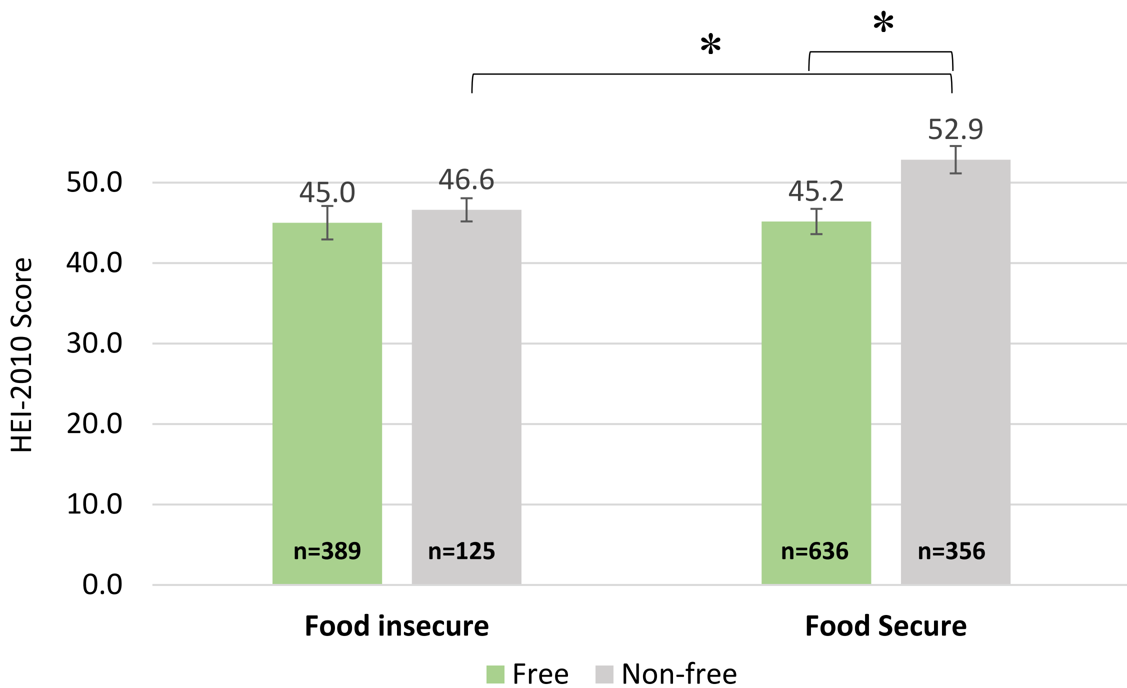

**Appendix Figure 2.3: Sensitivity Analysis: Mean HEI-2010 scores of free vs. non-free food acquisitions by children at school, by SNAP status (cutoff 130% FPL)**
Note: Survey-weighted, adjusted for individuals' age, sex, race, Hispanic ethnicity, household number of children 5–18, household food insecurity, and household WIC status. *Sig. dif. $p<0.05$



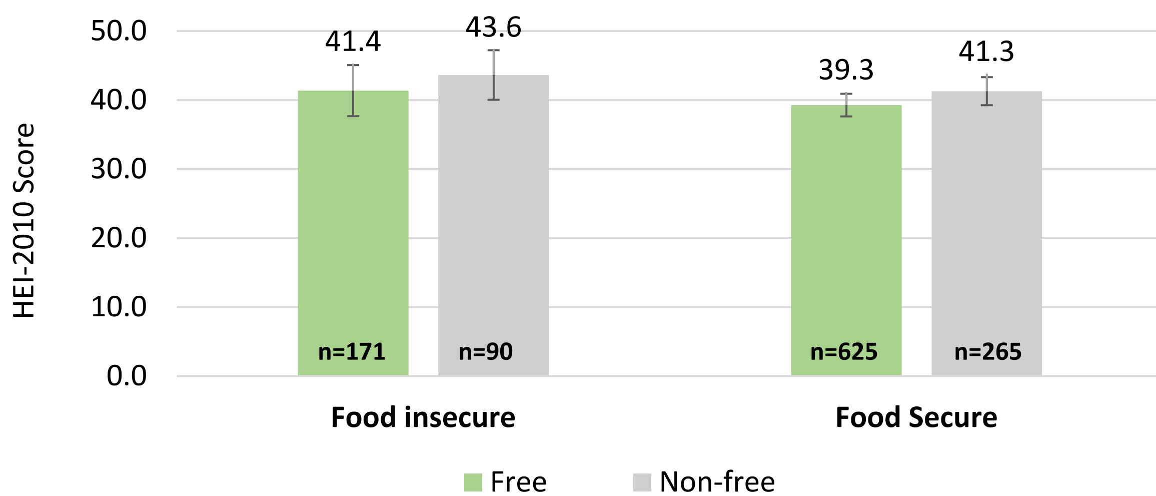

**Appendix Figure 2.4: Sensitivity Analysis: Mean HEI-2010 scores of free vs. non-free food acquisitions by employees at work, by SNAP status (cutoff 130% FPL)**
Note: Survey-weighted, adjusted for individuals' age, sex, race, Hispanic ethnicity, education, marriage status, household number of children 5–18, household food insecurity, and household WIC status. No significant differences.




**Appendix Figure 2.5: Exploratory Analysis: Free and non-free acquisitions by location across food security status, survey-weighted proportions**
* % free significantly different between groups, $p<0.05$; ** $p<0.001$




**Appendix Figure 2.6: Exploratory Analysis: Mean HEI-2010 scores of free vs. non-free food acquisitions by children at school by food security status**
Note: Survey-weighted, adjusted for individuals' age, sex, race, Hispanic ethnicity, household number of children 5–18, household SNAP/income status, and household WIC status. *Sig. dif. $p<0.05$




**Appendix Figure 2.7: Mean HEI-2010 scores of free vs. non-free food acquisitions by employees at work by food security status**
Note: Survey-weighted, adjusted for individuals' age, sex, race, Hispanic ethnicity, education, marriage status, household number of children 5–18, household SNAP/income status, and household WIC status. *Sig. dif. $p<0.05$

**CHAPTER 3:** Assessing exposure to front-of-package beverage marketing

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**Abstract**

Importance: Fruit drinks are the most widely consumed sugar-sweetened beverages by 0-5-year-olds. Parents purchase these drinks for their children in part due to misperceptions that they are healthful, which may be driven by front-of-package (FOP) claims and imagery. The FDA is considering changes to FOP marketing regulations, but there is little data on consumer exposure to FOP claims and imagery.

Objective: To assess the prevalence of FOP claims and imagery on fruit drinks, 100% juices, and non-carbonated flavored waters purchased by households with 0-5-year-olds, and differential exposure by household demographic groups.

Design: A content analysis was conducted to identify and analyze household exposure to FOP claims and imagery on fruit drinks, 100% juices, and non-carbonated flavored waters purchased by households with 0-5-year-olds.

Setting: The sample included FOP marketing data merged with 1) one week of national food acquisition data (2012–2013) and 2) one year of point-of-sale data from a Northeast U.S. supermarket (2016–2017).

Participants: Households with 0-5-year-olds included in datasets 1 (n=748) and 2 (n=300).

Exposures: Differences in exposure to FOP marketing through purchase volume were examined across household race/ethnicity, income, and SNAP and WIC participation.

Main Outcomes and Measures: The presence or absence of FOP marketing elements, including natural imagery, nutrient-content claims, and health claims, and household exposure to these elements.

Results: The sample included 515 fruit drinks, 338 100% juices, and 40 flavored waters. The most common claims included nutrient claims (fruit drinks: 72%, 100% juices: 68%, flavored

waters: 95%), which most commonly highlighted vitamin C (35–41% across beverage categories) and the absence of sugar (30–48%). The majority of beverages also contained implied-natural claims (fruit drinks: 60%, 100% juices: 64%, flavored waters: 95%) and natural imagery (fruit drinks: 97%, 100% juices: 96%, flavored waters: 73%). Households across racial/ethnic groups, levels of income, and SNAP and WIC participation were widely exposed to these marketing tactics through their purchased beverages.

Conclusions and Relevance: The majority of 100% juices, fruit drinks, and flavored waters purchased by households with 0-5-year-olds contained FOP claims and imagery implying that the products were healthy and natural. Given the potential for these marketing elements to increase health perceptions and potentially mislead parents into purchasing sugary beverages for their young children, the FDA should consider updating regulations for FOP claims and imagery.

## Introduction

Sugar-sweetened beverage (SSB) consumption is highly prevalent in early childhood and associated with adverse dental and metabolic health outcomes later in life. In the U.S., 31% of children 12-23 months and 51% of children 4-5 years of age consume SSBs daily,[119] with higher consumption among lower vs. higher income and black and Hispanic vs. Non-Hispanic white children.[119-122] Dietary patterns developed in early life form the basis for future food and beverage preferences,[123,124] and SSB consumption in early life is associated with poorer diet quality, dental caries, metabolic dysregulation, and obesity later in life.[20-26]

The most widely consumed SSBs by children 0-5-years-old are fruit drinks, which account for 9.4% of daily energy intake in this age group.[18,19] Fruit drinks are generally recognized as fruit-flavored beverages with less than 100% juice and with added sweeteners. These beverages often contain as much added sugar and calories as regular soda but may be misperceived as healthier options because of marketing, claims, and packaging that resembles 100% juice. Several studies have shown that parents, who purchase the majority of beverages consumed by young children,[125] believe fruit drinks are healthier options for their child than both regular and diet soda.[27,59,126]

Front-of-package (FOP) marketing, like health-related claims (e.g., "all natural," "contains 100% vitamin C"), and imagery (e.g., pictures of whole or cut fruit) are highly prevalent on fruit drinks.[127-129] Such marketing may influence parents' beverage selections for their young children; consumers spend less than 12 seconds on average viewing and assessing a product on any given shopping trip,[130,131] so FOP information is more quickly accessible and salient than the back-of-package Nutrition Facts panel, which almost 40% of Americans do not use.[132] More than one third of parents of 2-to-5-year-olds specifically look for claims with the words "real/natural" and "vitamin C" when choosing drinks for their children.[27] Although not technically false, such claims and imagery are often misleading; multiple studies have found that FOP health-oriented claims and images appear more frequently on packaged beverages of lower nutritional quality.[133,134] This deceptive marketing tactic may create a "health halo",[135-138] increasing parents' perceptions of healthfulness[139,140] and potentially influencing their selections. Because the majority of SSB calories consumed by children are in the home,[28] correcting parent misperceptions by mitigating or removing deceptive aspects of FOP marketing could substantially reduce consumption and diminish the impact of SSBs on childhood obesity.

The Food and Drug Administration (FDA) is currently considering changes to the way it regulates claims and other FOP labeling as a part of its Nutrition Innovation Strategy, which aims to reduce preventable death and disease related to poor nutrition, in part by empowering consumers to make decisions that are more informed.[29] Currently the FDA regulates two broad categories of claims:[141] nutrient-content claims, which describe the level of a nutrient in a product (e.g., "rich in Vitamin C"); and health claims, which characterize the relationship between a food and risk of disease (e.g., "reduces risk of heart disease"). The FDA further recognizes structure/function claims, which characterize the relationship between a nutrient and its structure or function in the human body (e.g., "calcium builds strong bones"), but does not proactively regulate those claims. The FDA has indicated particular interest in exploring evidenced-based modifications to regulations on claims related to added sugars and the use of the words "healthy" and "natural", especially on products that contain fruit.[29] "Healthy" is currently regulated as an implied nutrient content claim that characterizes a food as having predefined levels of total fat, saturated fat, cholesterol and sodium, and "natural" is not currently regulated.[141] However, the agency lacks supporting data on the current prevalence of FOP marketing.[29] Although some studies have examined the prevalence of certain types of FOP marketing claims on beverages,[129,133] there have been no comprehensive assessments of existing FOP claims and imagery on beverages purchased by parents of young children, and no studies have examined differential exposure to these claims and imagery by household demographic differences.

The goal of this study was to identify all beverages commonly consumed by young children purchased by households with 0-5-year-olds and assess the pervasiveness of beverage FOP marketing tactics by beverage category. We specifically examined the FOPs of fruit drinks, 100% juices, and non-carbonated flavored waters, as these beverages are regularly consumed by young children and contain fruit or fruit flavor with varying levels of sugar and added sweeteners. To understand the reach of these marketing tactics, we also evaluated differential exposure to FOP claims and imagery through purchase volume by household race/ethnicity, income level, and participation in the Supplemental Nutrition Assistance Program (SNAP) and Special Supplemental Nutrition Program for Women, Infants, and Children (WIC).

**Methods**

We linked beverage sales from two unique datasets with FOP marketing data to conduct a content analysis of FOP claims and imagery across purchased beverages by households with 0-5-year-olds. We then restricted our sales data to a nationally representative sample of households with sociodemographic information to assess exposure to these marketing elements by beverage category and household characteristics.

Study Sample

We first identified all beverages purchased by households with 0-5-year-olds in two datasets. The first was USDA's National Household Food Acquisition and Purchase Survey (FoodAPS), a nationally representative database of 4,826 U.S. households (748 households with children 0–5 years old) that details one week of household food and beverage acquisitions from 2012–2013.[142] To complement those data, we used a proprietary dataset that included one year (2016–2017) of loyalty card-linked sales data from 300 households with children 0-5 years old shopping in a large Northeast supermarket chain. Participating households were enrolled in a prior randomized controlled trial to assess the impact of a two-for-one incentive for fruits and vegetables on household purchases.[143] These datasets contained household product purchases (identified by Universal Product Code, UPC) and household demographic data (race/ethnicity, income, SNAP and WIC status).

These datasets were combined and merged by UPC with all beverages in the Label Insight database, which contains detailed package information (e.g., nutrition facts, ingredient list, brand name, date collected) and package images from 458,513 unique products representing over 85% of top-selling foods and beverages in the U.S.[144] We then restricted our sample to unique 100% juices, fruit drinks, and non-carbonated flavored waters that matched UPCs with the Label Insight data. Beverages categorized as 100% juice included 100% fruit juice, 100% fruit/vegetable juice blends, and coconut water with no added caloric or non-caloric sweeteners. Fruit drinks included fruit-flavored drinks (e.g., juice cocktails), frozen and liquid concentrates, and powdered mixes with less than 100% fruit juice and added caloric or non-caloric sweeteners. Non-carbonated flavored waters included fruit-flavored non-carbonated waters with or without added caloric or non-caloric sweeteners. Our final sample contained 893 beverages, with 338 100% juices, 515 fruit drinks, and 40 non-carbonated flavored waters.

## Content Analysis

Package photos of all matched 100% juices, fruit drinks, and non-carbonated flavored waters were obtained from Label Insight for coding. We adapted a codebook from a previous study of beverage FOP marketing[133] to identify the presence or absence of various FOP marketing elements, including fruit and vegetable imagery, nature imagery, child-directed imagery and text, nutrient-content claims, health claims, and structure/function claims. Two coders participated in a five-day codebook training and then independently coded a subsample of 20% of beverages drawn at random from the full sample to assess inter-rater reliability (n=178). All variables with <80% agreement were deemed superfluous and removed from the codebook (n=7). All variables with 80–90% agreement that were deemed superfluous were removed (n=4) and the rest were modified for clarity (n=9). All discrepancies between the two coders for every remaining variable were resolved through discussion, and the codebook was modified for clarity. The two coders then split the remaining 80% of the sample and coded each part separately.

## Data Analysis

We used descriptive statistics to characterize the nutritional profile (median calories and grams of sugar per serving) and the prevalence of each imagery and claim type within each beverage category. To understand whether exposure to imagery and claims differed by purchasing patterns and volume sold across households nationwide, we modified our sample to include all acquisitions of fruit drinks, 100% juices, and non-carbonated flavored waters within the FoodAPS dataset, and used survey-weighted logistic regression to examine differences in the prevalence of the most common imagery and claim types within each beverage category by household race/ethnicity (non-Hispanic (NH) White, NH Black, and Hispanic), income ("lower-income" ≤185% FPL vs. "higher-income" >185% FPL), and SNAP and WIC participation (non-participants vs. participants). Statistical tests were not conducted when there were fewer than 10 observations per category. All statistical tests were conducted with Stata 15.1 software.

## Results

Our main sample contained 515 unique fruit drinks, 338 unique 100% juices, and 40 unique non-carbonated flavored waters. 100% juices had the highest median calories and grams of sugar per serving (110 kcal, 25 g), followed by fruit drinks (70 kcal, 16 g) and flavored waters (0 kcal, 0 g). All three categories had a wide range of calories and grams of sugar (100% juice: 30–320 kcal, 5–57 g; fruit drinks: 0–300 kcal, 0–65 g; flavored waters: 0–120 kcal, 0–32 g).

### Prevalence of Imagery and Claims

The prevalence of all imagery and claims across beverage categories are detailed in Appendix Table 3.1. Results with subsets of imagery and claims in four broad categories are presented below.

#### *Healthy/Nutrient Claims*

The majority of beverages in our sample contained macro or micronutrient claims (fruit drinks: 72%; 100% juice: 68%; flavored waters: 95%) (Table 3.1). Nearly half of fruit drinks (48%) and 100% juices (45%) and the majority of flavored waters (80%) contained macronutrient claims, the most common of which were sugar absent claims (e.g., "lower sugar"), which appeared on 35% of fruit drinks, 39% of 100% juices, and 48% of flavored waters. Micronutrient claims were present on roughly half of beverages across all three categories. Vitamin C claims (e.g., "excellent source of Vitamin C") were the most common micronutrient claims on fruit drinks (41%), 100% juices (39%), and flavored waters (35%). The word "healthy" was not present on any fruit drinks or flavored waters, and only present on 1% of 100% juices. Implied healthy claims (e.g., "good for you") were more common, and present on 4% of fruit drinks, 19% of 100% juices, and 33% of flavored waters. Very few beverages (1–2%) contained structure/function or health claims.

**Table 3.1: Prevalence of Healthy/Nutrient Claims by Beverage Type**

| | Fruit drinks (n=515) | | 100% juice (n=338) | | Flavored waters (n=40) | |
|---|---|---|---|---|---|---|
| | **n** | **%** | **n** | **%** | **n** | **%** |
| **NUTRIENT CLAIMS** | **373** | **72%** | **229** | **68%** | **38** | **95%** |
| **Macronutrient claims** | 248 | 48% | 152 | 45% | 32 | 80% |
| Calorie-related claims | 108 | 21% | 22 | 7% | 18 | 45% |
| Sugar claims | 182 | 35% | 131 | 39% | 19 | 48% |
| Sugar absent claims | 157 | 30% | 131 | 39% | 19 | 48% |
| Sugar present claims | 6 | 1% | 0 | 0% | 0 | 0% |
| Non-caloric sweetener claims | 46 | 9% | 9 | 3% | 3 | 8% |
| No artificial sweeteners | 42 | 8% | 9 | 3% | 2 | 5% |
| Non-caloric sweetener present | 6 | 1% | 0 | 0% | 1 | 3% |
| Fat, protein, and other macronutrient claims | 9 | 2% | 4 | 1% | 0 | 0% |
| **Micronutrient claims** | 241 | 47% | 173 | 51% | 19 | 48% |
| Vitamin C claims | 210 | 41% | 131 | 39% | 14 | 35% |
| Antioxidant claims | 33 | 6% | 10 | 3% | 2 | 5% |
| Vitamin B claims | 21 | 4% | 5 | 1% | 17 | 43% |
| Vitamin A claims | 13 | 3% | 18 | 5% | 4 | 10% |
| Vitamin D claims | 6 | 1% | 21 | 6% | 0 | 0% |
| Other micronutrient claims | 29 | 6% | 55 | 16% | 4 | 10% |
| **FACTS UP FRONT LABEL** | **307** | **60%** | **153** | **45%** | **30** | **75%** |
| **HEALTHY CLAIMS** | **22** | **4%** | **68** | **20%** | **13** | **33%** |
| "Healthy" claim | 0 | 0% | 4 | 1% | 0 | 0% |
| Implied healthy (e.g., "good for you") | 22 | 4% | 64 | 19% | 13 | 33% |
| **STRUCTURE/FUNCTION CLAIMS** | **5** | **1%** | **3** | **1%** | **0** | **0%** |
| **HEALTH CLAIMS** | **0** | **0%** | **7** | **2%** | **0** | **0%** |

*Natural Claims and Imagery*

Natural claims (e.g., "all natural") were not widely observed on fruit drinks (6%), 100% juices (4%), or flavored waters (10%) (Table 3.2). Implied natural claims, however, were present on the majority of fruit drinks (60%), 100% juices (64%), and flavored waters (95%), and the most common of these claims indicated that the product contained natural flavors or ingredients. The vast majority of beverages contained natural imagery. Fruit and vegetable imagery was highly prevalent on fruit drinks (93%), 100% juices (96%), and flavored waters (65%). Nature imagery (e.g., orchards, bodies of water) was also present on the majority of beverages, either in the brand logo or on the package as artwork (fruit drinks: 64%; 100% juices: 66%; and flavored waters: 55%).

**Table 3.2: Prevalence of Natural Claims and Imagery by Beverage Type**

| | | | Fruit drinks (n=515) | | 100% juice (n=338) | | Flavored waters (n=40) | |
|---|---|---|---|---|---|---|---|---|
| | | | n | % | n | % | n | % |
| **NATURAL CLAIMS** | | | **317** | **62%** | **219** | **65%** | **39** | **98%** |
| | Natural/All Natural | | 29 | 6% | 12 | 4% | 4 | 10% |
| | Implied natural | | 310 | 60% | 218 | 64% | 38 | 95% |
| | | Natural flavors/ingredients | 256 | 50% | 72 | 21% | 38 | 95% |
| | | Natural synonyms (e.g., pure, fresh) | 58 | 11% | 88 | 26% | 2 | 5% |
| | | No artificial colors or flavors | 46 | 9% | 13 | 4% | 7 | 18% |
| | | No preservatives | 36 | 7% | 24 | 7% | 7 | 18% |
| | | Non-GMO | 35 | 7% | 81 | 24% | 2 | 5% |
| | | Organic | 28 | 5% | 25 | 7% | 2 | 5% |
| | | Not/never from concentrate | 18 | 3% | 67 | 20% | 0 | 0% |
| **NATURAL IMAGERY** | | | **498** | **97%** | **324** | **96%** | **29** | **73%** |
| | Fruit/Vegetable Imagery | | 480 | 93% | 323 | 96% | 26 | 65% |
| | Nature imagery | | 330 | 64% | 222 | 66% | 22 | 55% |
| | | Package artwork | 210 | 41% | 89 | 26% | 7 | 18% |
| | | Brand logo | 199 | 39% | 185 | 55% | 15 | 38% |

*Other Claims and Imagery*

Fruit and juice claims (e.g., “contains juice”, “made with real fruit,” “contains 2 servings of fruit,” “15% juice”) were present on nearly all 100% juices (98%), half of fruit drinks (47%), and very few flavored waters (5%) (Table 3.3). Child-directed imagery and text was present on nearly half of all fruit drinks (44%) and flavored waters (45%), and 16% of 100% juices.

**Table 3.3: Prevalence of Other Claims and Imagery by Beverage Type**

| | Fruit drinks (n=515) | | 100% juice (n=338) | | Flavored waters (n=40) | |
|---|---|---|---|---|---|---|
| | **n** | **%** | **n** | **%** | **n** | **%** |
| **FRUIT & JUICE CLAIMS** | **240** | **47%** | **330** | **98%** | **2** | **5%** |
| Contains juice | 213 | 41% | 215 | 64% | 2 | 5% |
| Made with whole fruit | 23 | 4% | 30 | 9% | 0 | 0% |
| Servings of fruit/veg | 11 | 2% | 56 | 17% | 0 | 0% |
| Percent juice declaration | 55 | 11% | 281 | 83% | 0 | 0% |
| Smaller than net weight statement | 16 | 3% | 18 | 5% | 0 | 0% |
| **CHILD-DIRECTED IMAGERY & TEXT** | **228** | **44%** | **55** | **16%** | **18** | **45%** |
| Child-directed imagery (anthropomorphized ingredients, animals, youth, adult celebrities, sports, fantasy) | 114 | 22% | 25 | 7% | 6 | 15% |
| Child-directed text (unconventional or exaggerated fonts; extreme taste/experience; enjoyment, pleasure, or fun unrelated to health; words explicitly referencing children) | 190 | 37% | 46 | 14% | 18 | 45% |

*Potentially Deceptive Claims and Imagery: Misalignment of Fruit and Vegetable Imagery and Ingredients*

Among fruit drinks and flavored waters with FOP images of fruits or vegetables (93% of fruit drinks and 65% of flavored waters), the majority (72% and 92% respectively) did not contain a fruit or vegetable or juice/concentrate as a first or second ingredient (Table 3.4). Forty percent of fruit drinks and 88% of flavored waters depicted a fruit or vegetable on the FOP that was not included as a product ingredient at all. Additionally, 4–13% of beverages with fruit and vegetable imagery did not depict the main fruit/vegetable ingredient on the FOP (e.g., vegetable juice displaying vegetable imagery but containing apple juice as its first ingredient).

**Table 3.4: Prevalence of Potentially Deceptive Claims and Imagery by Beverage Type**

| | | Fruit drinks | | 100% juice | | Flavored waters | |
|---|---|---|---|---|---|---|---|
| | | n | % | n | % | n | % |
| **Restricted to BEVERAGES WITH FRUIT/VEGETABLE FOP IMAGERY** | | **480 of 515** | **93%** | **323 of 338** | **96%** | **26 of 40** | **65%** |
| | Fruit/vegetables are not a first or second ingredient | 345 | 72% | 0 | 0% | 24 | 92% |
| | Fruit/vegetable image on FOP not included as ingredient | 194 | 40% | 1 | 0% | 23 | 88% |
| | Image of first fruit/vegetable ingredient not on FOP | 17 | 4% | 42 | 13% | 2 | 8% |
| **Restricted to BEVERAGES WITH NON-CALORIC SWEETENERS (NCS)** | | **241 of 515** | **47%** | **0** | **0%** | **32 of 40** | **80%** |
| | Disclose containing any NCS | 6 | 2% | N/A | N/A | 1 | 3% |
| | "No artificial sweeteners" claim | 24 | 10% | N/A | N/A | 2 | 6% |
| | Contain Acesulfame K | 100 | 41% | N/A | N/A | 5 | 16% |
| | Contain Stevia | 53 | 22% | N/A | N/A | 22 | 69% |
| | Contain Aspartame | 49 | 20% | N/A | N/A | 0 | 0% |
| | Contain Sugar alcohols | 31 | 13% | N/A | N/A | 11 | 34% |

*Potentially Deceptive Claims and Imagery: Non-Caloric Sweetener Disclosure*

Non-caloric sweeteners (NCS) were present in nearly half of all fruit drinks (47%) and the majority of flavored waters (80%), and but only 2–3% of these beverages disclosed the presence of NCS on the FOP. Furthermore, a "no artificial sweeteners" FOP claim was present on 10% of fruit drinks and 6% of flavored waters that contained NCS. The most common NCS in in fruit drinks was acesulfame K (41%) and in flavored waters was stevia (69%).

<u>Differences in Exposure to Imagery and Claims across Household Demographics</u>

Within the FoodAPS nationally representative sample of households, fruit drinks were purchased 844 times (286 unique UPCs), 100% juices were purchased 356 times (168 unique

UPCs), and flavored waters were purchased 16 times (12 unique UPCs). Due to small sample sizes, we only evaluated the most common claims and imagery on fruit drinks and 100% juices across household demographic categories (Appendix Tables 3.2–3.5).

*Differences by Household Race/Ethnicity*

Hispanic households purchased a significantly larger relative share of fruit drinks with natural or implied natural claims (65% of fruit drinks purchased by Hispanic households) compared to NH white households (42% of fruit drinks purchased by NH white households, p=0.037) (Appendix Table 3.2). NH black households purchased a significantly larger share of 100% juices with sugar-related claims (67%) compared to NH white (37%, p=0.029) and Hispanic households (28%, p=0.017) (Appendix Table 3.3). NH black households also more commonly purchased 100% juices with Vitamin C claims (66%) compared to NH white households (36%, p=0.047), and 100% juices with implied natural claims (75%) compared to Hispanic households (40%, p=0.020). There were no other significant differences in the prevalence of common imagery and claims on fruit drinks or 100% juices purchased across non-Hispanic white, non-Hispanic black, and Hispanic households.

*Differences by Income, SNAP, and WIC participation*

Lower-income households (≤185% FPL) less commonly purchased fruit drinks with any type of natural claim (44%) compared to higher-income households (>185% FPL) (60%, p=0.048) (Appendix Table 3.4). There were no other significant differences between income groups and none between SNAP or WIC participants and non-participants (Appendix Table 3.5).

**Discussion**

We conducted a content analysis of claims and imagery on fruit-flavored water-based beverages purchased by families with 0-5-year-olds and evaluated differences in exposure to claims based on purchasing patterns across different household demographic groups. We found that the majority of 100% juices, fruit drinks, and flavored waters contained FOP claims and imagery implying that the products were healthy and natural, but few had explicit "healthy" or "natural" claims. The most common claims indicating healthfulness included macro and micronutrient claims (found on 72% of fruit drinks, 68% of 100% juices, and 95% of non-carbonated flavored waters), which most commonly highlighted vitamin C (35–41% across beverage categories) and the absence of sugar (30–48%). The majority of these beverages also contained implied-natural claims (e.g., "pure", "natural flavors"), fruit and vegetable imagery, and nature imagery. Our survey-weighted nationally representative analysis suggested that although there were some differences in purchasing patterns between household groups, households across racial/ethnic groups, levels of income, and SNAP and WIC participation were widely exposed to these marketing tactics through their purchasing of 100% juices and fruit drinks.

Research has shown that nutrient and natural-related claims and imagery can increase consumer perceptions of healthfulness and may influence their selections,[27,135,137,138,145-147] which could in turn lead to increased consumption of 100% juices, fruit drinks, and non-carbonated flavored waters among young children. These patterns are not concordant with guidelines that call for limiting sugar-sweetened beverages, including fruit drinks and some flavored waters, and consuming 100% juice in small amounts because it contains high levels of sugar and low levels of fiber, and excess consumption is associated with increased obesity risk.[148]

Nutrient-content claims are regulated by the FDA, but natural imagery and most natural and implied-natural claims (e.g., natural, natural flavors/ingredients, synonyms for natural like "pure", non-GMO) are not regulated. The FDA has indicated interest in defining and regulating the word "natural" and updating their definition of "healthy,"[29] but these claims were relatively uncommon on beverages examined in this study. To prevent consumer confusion, the FDA could consider extending their regulation of "natural" to "natural flavor/ingredient" claims, which was the most common implied-natural claim in our sample and found on nearly all non-carbonated flavored waters, half of fruit drinks, and one-fifth of 100% juices.[149] Given the high prevalence of other implied natural and health claims and imagery, it is unlikely that the added regulation of "natural" and "healthy" will significantly impact consumer perceptions or purchases. To reduce health halos on sugary products, the FDA could consider restricting nutrient-content claims to products that meet specific nutrient thresholds. They could also mandate FOP health warning labels, which may reduce product health perceptions even in the presence of nutrient-content claims,[146] or FOP disclosures for nutrients of concern, as have been implemented in Chile.[150]

This study highlighted two other potentially deceptive FOP marketing tactics that could be addressed through regulation. First, among the vast majority of beverages in our sample that contained images of fruit or vegetables, the majority of fruit drinks (72%) and non-carbonated flavored waters (92%) did not contain fruits or vegetables as a main ingredient. Further, 40% of fruit drinks and 88% of non-carbonated flavored waters depicted a fruit or vegetable on the FOP that was not included anywhere in the product ingredient list. Although the FDA does not proactively regulate fruit and vegetable imagery on packages (largely due to freedom of speech protections), lawsuits have encouraged the food industry to modify potentially misleading FOP imagery.[151] Second, non-caloric sweeteners (NCS) were present in the majority of non-carbonated flavored waters and nearly half of all fruit drinks, but only 2–3% of these beverages disclosed the presence of NCS on the FOP. Furthermore, 6–10% contained "no artificial sweetener" claims, which may be accurate—companies may consider some NCS such as stevia to be "natural"—but could be confusing to consumers. There is limited research on the long-term health effects of NCS,[152] but consumption is not recommended for children.[153] To help parents identify products they may want to avoid, the FDA could consider requiring FOP disclosure of the type and quantity of non-caloric sweeteners present, as has been recommended by the American Academy of Pediatrics.[152]

This study had a number of limitations. Label Insight regularly updates package images and does not provide access to historical images, so package photos for the beverages in this study ranged in collection date from 2012–2019. Our purchasing data were from 2012–2013 (FoodAPS) and 2016–2017 (supermarket chain), so a small percentage of the beverage packages in our sample may have been redesigned since they were purchased. To identify potential changes, we reviewed all articles from 2012–present on Packaging Digest,[154] a news website that reports on changes in food and beverage packaging. The only two major beverage rebranding efforts were related to Pepsi sodas and Nestle Waters' sparkling waters, neither of which were included in this study. Another limitation was our relatively small sample of non-carbonated flavored waters, which was likely due to the older data used; these beverages have been increasing in popularity in recent years. Finally, although we speculated about potentially deceptive marketing tactics, we did not test whether these claims were actually deceptive to consumers. Future research should examine claims and imagery with more recent purchasing data and larger sample sizes and should also explore how claims and imagery directly impact consumers' perceptions and purchasing habits.

This study had several strengths. To our knowledge, it provides the first detailed catalogue of FOP claims and imagery on beverages purchased by U.S. households with children 0-5 years old. It also provides the first evaluation of differences in exposure to claims and imagery in a nationally representative sample by race/ethnicity, income, and SNAP and WIC participation.

**Conclusions**

This study found that the majority of 100% juices, fruit drinks, and non-carbonated flavored waters purchased by households with 0-5-year-olds contained FOP claims and imagery implying that the products were healthy and natural, including nutrient-content claims, implied-natural claims, and fruit, vegetable, and nature imagery. Given the potential for these marketing elements to increase health perceptions and potentially mislead parents into purchasing beverages with high levels of sugar and non-caloric sweeteners for their young children, the FDA should consider updating regulations for FOP claims and imagery.

## Appendix

**Appendix Table 3.1: Prevalence of All Claims and Imagery by Beverage Type**

| | Fruit drinks (n=515) | | 100% juice (n=338) | | Flavored waters (n=40) | |
|---|---|---|---|---|---|---|
| | **n** | **%** | **n** | **%** | **n** | **%** |
| **NUTRIENT CLAIMS** | **373** | **72%** | **229** | **68%** | **38** | **95%** |
| **Macronutrient claims** | 248 | 48% | 152 | 45% | 32 | 80% |
| Calorie-related claims | 108 | 21% | 22 | 7% | 18 | 45% |
| Diet/light | 43 | 8% | 0 | 0% | 0 | 0% |
| Low calorie | 28 | 5% | 0 | 0% | 0 | 0% |
| Reduced/lower calories | 37 | 7% | 0 | 0% | 1 | 3% |
| No calories | 5 | 1% | 0 | 0% | 10 | 25% |
| Other calorie | 58 | 11% | 22 | 7% | 7 | 18% |
| Sugar claims | 182 | 35% | 131 | 39% | 19 | 48% |
| Sugar absent claims | 157 | 30% | 131 | 39% | 19 | 48% |
| Low sugar | 0 | 0% | 0 | 0% | 0 | 0% |
| Implied low sugar | 2 | 0% | 0 | 0% | 0 | 0% |
| Less sugar than other product | 65 | 13% | 8 | 2% | 5 | 13% |
| No sugar | 28 | 5% | 2 | 1% | 5 | 13% |
| No added sugar | 19 | 4% | 116 | 34% | 2 | 5% |
| Unsweetened | 22 | 4% | 14 | 4% | 5 | 13% |
| No high fructose corn syrup | 40 | 8% | 0 | 0% | 7 | 18% |
| Sugar present claims | 6 | 1% | 0 | 0% | 0 | 0% |
| Contains natural sugar | 6 | 1% | 0 | 0% | 0 | 0% |
| Other sugar claim | 23 | 4% | 2 | 1% | 0 | 0% |
| Non-caloric sweetener | 46 | 9% | 9 | 3% | 3 | 8% |
| No artificial sweeteners | 42 | 8% | 9 | 3% | 2 | 5% |
| NCS present | 6 | 1% | 0 | 0% | 1 | 3% |
| Stevia or Truvia | 2 | 0% | 0 | 0% | 0 | 0% |
| Splenda | 1 | 0% | 0 | 0% | 1 | 3% |
| Aspartame | 0 | 0% | 0 | 0% | 0 | 0% |
| Sucralose | 0 | 0% | 0 | 0% | 0 | 0% |
| Other NCS | 3 | 1% | 0 | 0% | 0 | 0% |
| Fat claims | 4 | 1% | 1 | 0% | 0 | 0% |
| Low fat/saturated fat/cholesterol | 2 | 0% | 0 | 0% | 0 | 0% |
| Reduced fat/saturated fat/cholesterol | 0 | 0% | 0 | 0% | 0 | 0% |
| No fat/saturated fat/cholesterol | 1 | 0% | 0 | 0% | 0 | 0% |
| Other fat claim | 3 | 1% | 1 | 0% | 0 | 0% |
| Protein claims | 1 | 0% | 0 | 0% | 0 | 0% |
| Excellent source/good source of/rich in | 0 | 0% | 0 | 0% | 0 | 0% |
| Other protein claim | 1 | 0% | 0 | 0% | 0 | 0% |
| Other macronutrients | 5 | 1% | 3 | 1% | 0 | 0% |
| **Micronutrient claims** | 241 | 47% | 173 | 51% | 19 | 48% |
| Vitamin C claims | 210 | 41% | 131 | 39% | 14 | 35% |
| Excellent/good source of/high in | 59 | 11% | 19 | 6% | 11 | 28% |

**Appendix Table 3.1: Prevalence of All Claims and Imagery by Beverage Type (Continued)**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 100%+ DV | 111 | 22% | 90 | 27% | 8 | 20% |
| | | Full day's supply | 2 | 0% | 0 | 0% | 0 | 0% |
| | | Contains Vitamin C | 40 | 8% | 40 | 12% | 6 | 15% |
| | Calcium | | 8 | 2% | 31 | 9% | 0 | 0% |
| | | Excellent/good source of/high in | 2 | 0% | 12 | 4% | 0 | 0% |
| | | Contains calcium | 6 | 1% | 31 | 9% | 0 | 0% |
| | Vitamin D | | 6 | 1% | 21 | 6% | 0 | 0% |
| | | Excellent/good source of/high in | 0 | 0% | 6 | 2% | 0 | 0% |
| | | Contains Vitamin D | 6 | 1% | 21 | 6% | 0 | 0% |
| | Iron | | 0 | 0% | 0 | 0% | 0 | 0% |
| | | Excellent/good source of/high in | 0 | 0% | 0 | 0% | 0 | 0% |
| | | Contains iron | 0 | 0% | 0 | 0% | 0 | 0% |
| | Vitamin A | | 13 | 3% | 18 | 5% | 4 | 10% |
| | Vitamin B | | 21 | 4% | 5 | 1% | 17 | 43% |
| | Vitamin E | | 9 | 2% | 10 | 3% | 2 | 5% |
| | Probiotics | | 5 | 1% | 2 | 1% | 0 | 0% |
| | Antioxidants | | 33 | 6% | 10 | 3% | 2 | 5% |
| | Other micronutrients | | 8 | 2% | 15 | 4% | 2 | 5% |
| **NATURAL CLAIMS** | | | **317** | **62%** | **219** | **65%** | **39** | **98%** |
| | Natural/All Natural | | 29 | 6% | 12 | 4% | 4 | 10% |
| | Implied natural | | 310 | 60% | 218 | 64% | 38 | 95% |
| | | Natural flavors/ingredients | 256 | 50% | 72 | 21% | 38 | 95% |
| | | Natural synonyms (e.g., pure, fresh) | 58 | 11% | 88 | 26% | 2 | 5% |
| | | No artificial colors or flavors | 46 | 9% | 13 | 4% | 7 | 18% |
| | | No preservatives | 36 | 7% | 24 | 7% | 7 | 18% |
| | | Non-GMO | 35 | 7% | 81 | 24% | 2 | 5% |
| | | Organic | 28 | 5% | 25 | 7% | 2 | 5% |
| | | Not/never from concentrate | 18 | 3% | 67 | 20% | 0 | 0% |
| **HEALTH CLAIMS** | | | **0** | **0%** | **7** | **2%** | **0** | **0%** |
| **STRUCTURE/FUNCTION CLAIMS** | | | **5** | **1%** | **3** | **1%** | **0** | **0%** |
| **HEALTHY CLAIMS** | | | **22** | **4%** | **68** | **20%** | **13** | **33%** |
| | Healthy | | 0 | 0% | 4 | 1% | 0 | 0% |
| | Implied healthy | | 22 | 4% | 64 | 19% | 13 | 33% |
| | | Product is nutritious (e.g., "Vitamin Water") | 9 | 2% | 57 | 17% | 11 | 28% |
| | | Product provides health benefits (e.g., "good for you") | 13 | 3% | 15 | 4% | 7 | 18% |
| **FRUIT & JUICE CLAIMS** | | | **240** | **47%** | **330** | **98%** | **2** | **5%** |
| | Contains juice | | 213 | 41% | 215 | 64% | 2 | 5% |
| | Made with whole fruit | | 23 | 4% | 30 | 9% | 0 | 0% |
| | Servings of fruit/veg | | 11 | 2% | 56 | 17% | 0 | 0% |
| | Percent juice declaration | | 55 | 11% | 281 | 83% | 0 | 0% |
| | | Smaller than net weight statement | 16 | 3% | 18 | 5% | 0 | 0% |
| **OTHER INGREDIENT CLAIMS** | | | | | | | | |
| | Contains/Does Not Contain Energy | | 43 | 8% | 2 | 1% | 4 | 10% |
| | | Energy | 9 | 2% | 2 | 1% | 1 | 3% |

**Appendix Table 3.1: Prevalence of All Claims and Imagery by Beverage Type (Continued)**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Caffeine | 12 | 2% | 0 | 0% | 4 | 10% |
| | | No Caffeine | 30 | 6% | 0 | 0% | 0 | 0% |
| | Facts up Front label | | 307 | 60% | 153 | 45% | 30 | 75% |
| | | Calories only | 297 | 58% | 131 | 39% | 29 | 73% |
| | | Calories, Fat, Sugar, Sodium only | 8 | 2% | 9 | 3% | 1 | 3% |
| | | Plus added nutrients | 1 | 0% | 13 | 4% | 0 | 0% |
| | Gluten-Free | | 4 | 1% | 14 | 4% | 0 | 0% |
| | Fair Trade | | 0 | 0% | 0 | 0% | 0 | 0% |
| | Hydration | | 15 | 3% | 8 | 2% | 17 | 43% |
| **IMAGERY** | | | | | | | | |
| | Fruit/Vegetable Imagery | | 480 | 93% | 323 | 96% | 26 | 65% |
| | | 50% or more of package | 28 | 5% | 37 | 11% | 2 | 5% |
| | Product Imagery (e.g., glass of orange juice) | | 216 | 42% | 46 | 14% | 14 | 35% |
| | Nature imagery | | 330 | 64% | 222 | 66% | 22 | 55% |
| | | Package artwork | 210 | 41% | 89 | 26% | 7 | 18% |
| | | Brand logo | 199 | 39% | 185 | 55% | 15 | 38% |
| **CHILD-DIRECTED TEXT AND IMAGERY** | | | 228 | 44% | 55 | 16% | 18 | 45% |
| | Child-directed imagery | | 114 | 22% | 25 | 7% | 6 | 15% |
| | | Image of child | 6 | 1% | 11 | 3% | 0 | 0% |
| | | Image of adult (celebrity, athlete, character) | 11 | 2% | 1 | 0% | 0 | 0% |
| | | Image of animal/anthropomorphized animal | 11 | 2% | 1 | 0% | 2 | 5% |
| | | Image of anthropomorphized ingredient/object | 59 | 11% | 2 | 1% | 0 | 0% |
| | | Sports imagery | 24 | 5% | 7 | 2% | 4 | 10% |
| | | Fantasy imagery | 8 | 2% | 3 | 1% | 0 | 0% |
| | Child-directed text | | 190 | 37% | 46 | 14% | 18 | 45% |
| | | Use of unconventional or exaggerated fonts intended to appeal to children | 155 | 30% | 26 | 8% | 16 | 40% |
| | | Indication of an extreme experience/taste (e.g., "berry blast") | 65 | 13% | 12 | 4% | 9 | 23% |
| | | Claim related to enjoyment, pleasure, or fun unrelated to health | 29 | 6% | 11 | 3% | 1 | 3% |
| | | Words that explicitly reference children (e.g., "kids") | 20 | 4% | 15 | 4% | 4 | 10% |
| **MARKETING CLAIMS** | | | | | | | | |
| | Affordability claim | | 41 | 8% | 14 | 4% | 0 | 0% |
| | Corporate responsibility claim | | 41 | 8% | 33 | 10% | 0 | 0% |
| | Product ingredient source claim | | 9 | 2% | 30 | 9% | 1 | 3% |
| | Contest or games | | 4 | 1% | 4 | 1% | 0 | 0% |

**Appendix Table 3.2: Prevalence of Fruit Drink Claims and Imagery by Household Race/Ethnicity: Survey-Weighted Proportions by Sales Volume**

| | Non-Hispanic White (n=350) | Non-Hispanic Black (n=189) | Hispanic (n=274) |
|---|---|---|---|
| **NUTRIENT CLAIMS** | **81.0%** | **75.4%** | **78.4%** |
| **Macronutrient claims** | **56.1%** | **53.8%** | **44.1%** |
| Calorie-related claims | 12.3% | 7.2% | 6.3% |
| Sugar claims | 50.9% | 51.2% | 30.4% |
| **Micronutrient claims** | **64.8%** | **58.8%** | **60.6%** |
| Vitamin C claims | 59.9% | 58.8% | 52.3% |
| **HEALTHY CLAIMS** | **0.6%** | **0.4%** | **0.0%** |
| "Healthy" claim | 0.0% | 0.0% | 0.0% |
| Implied healthy (e.g., "good for you") | 0.6% | 0.4% | 0.0% |
| **HEALTH OR STRUCTURE/FUNCTION CLAIMS** | **0.2%** | **0.0%** | **0.0%** |
| **NATURAL CLAIMS** | **42.4%** | **48.9%** | **64.8%**[a] |
| Natural/All Natural | 8.4% | 8.8% | 8.4% |
| Implied natural | 41.8% | 48.9% | 56.6% |
| **NATURAL IMAGERY** | **99.1%** | **98.9%** | **100.0%** |
| Fruit/Vegetable Imagery | 98.2% | 98.4% | 99.2% |
| Nature imagery | 46.1% | 52.5% | 57.3% |

[a] Significantly different from Non-Hispanic White, $p<0.05$ ($p=0.037$)

**Appendix Table 3.3: Prevalence of 100% Juice Claims and Imagery by Household Race/Ethnicity: Survey-Weighted Proportions by Sales Volume**

| | Non-Hispanic White (n=206) | Non-Hispanic Black (n=40) | Hispanic (n=83) |
|---|---|---|---|
| **NUTRIENT CLAIMS** | **71.6%** | **75.0%** | **68.9%** |
| **Macronutrient claims** | **36.9%** | **67.1%**[ab] | **29.5%** |
| Calorie-related claims | 0.2% | 0.0% | 1.3% |
| Sugar claims | 36.9% | 67.1%[ab] | 28.2% |
| **Micronutrient claims** | **55.8%** | **70.4%** | **59.7%** |
| Vitamin C claims | 35.7% | 65.5%[a] | 58.9% |
| **HEALTHY CLAIMS** | **8.2%** | **27.9%** | **13.7%** |
| "Healthy" claim | 2.4% | 1.3% | 1.3% |
| Implied healthy (e.g., "good for you") | 5.8% | 26.5% | 12.4% |
| **HEALTH OR STRUCTURE/FUNCTION CLAIMS** | **3.5%** | **0.0%** | **4.0%** |
| **NATURAL CLAIMS** | **57.4%** | **75.2%**[b] | **39.6%** |
| Natural/All Natural | 2.7% | 0.0% | 0.0% |
| Implied natural | 57.4% | 75.2%[b] | 39.6% |
| **NATURAL IMAGERY** | **96.8%** | **97.8%** | **99.2%** |
| Fruit/Vegetable Imagery | 95.8% | 97.1% | 99.2% |
| Nature imagery | 72.0% | 88.0% | 75.6% |

[a] Significantly different from Non-Hispanic White, $p<0.05$, [b] Significantly different from Hispanic, $p<0.05$

**Appendix Table 3.4: Prevalence of Fruit Drink Claims and Imagery by Household Income/SNAP/WIC: Survey-Weighted Proportions by Sales Volume**

| | Higher income (>185% FPL) (n=210) | Lower income (≤185% FPL) (n=634) | Non-SNAP (n=292) | SNAP (n=552) | Non-WIC (n=388) | WIC (n=327) |
|---|---|---|---|---|---|---|
| **NUTRIENT CLAIMS** | **72.9%** | **80.1%** | **75.7%** | **78.6%** | **78.3%** | **76.1%** |
| **Macronutrient claims** | **50.1%** | **49.6%** | **47.2%** | **53.3%** | **51.0%** | **46.6%** |
| Calorie-related claims | 10.2% | 7.4% | 11.2% | 5.1% | 10.1% | 6.3% |
| Sugar claims | 37.9% | 46.6% | 37.1% | 50.4% | 44.9% | 36.2% |
| **Micronutrient claims** | **49.9%** | **68.0%** | **56.5%** | **64.7%** | **60.0%** | **59.3%** |
| Vitamin C claims | 43.5% | 64.6% | 50.0% | 62.5% | 57.9% | 49.6% |
| **HEALTHY CLAIMS** | **0.3%** | **0.6%** | **0.2%** | **0.8%** | **0.2%** | **0.9%** |
| "Healthy" claim | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Implied healthy (e.g., "good for you") | 0.3% | 0.6% | 0.2% | 0.8% | 0.2% | 0.9% |
| **HEALTH OR STRUCTURE/ FUNCTION CLAIMS** | **0.1%** | **0.1%** | **0.0%** | **0.1%** | **0.0%** | **0.2%** |
| **NATURAL CLAIMS** | **60.1%** | **43.9%**[a] | **56.5%** | **43.6%** | **48.8%** | **55.1%** |
| Natural/All Natural | 13.3% | 4.1% | 10.2% | 5.3% | 6.8% | 9.0% |
| Implied natural | 54.7% | 43.0% | 52.2% | 42.8% | 48.4% | 46.8% |
| **NATURAL IMAGERY** | **99.6%** | **99.2%** | **99.6%** | **99.2%** | **99.2%** | **99.8%** |
| Fruit/Vegetable Imagery | 99.4% | 98.1% | 99.4% | 97.7% | 98.6% | 98.7% |
| Nature imagery | 60.2% | 46.7% | 55.0% | 49.4% | 52.3% | 55.7% |

[a] Significantly different from higher income, p<0.05

**Appendix Table 3.5: Prevalence of 100% Juice Claims and Imagery by Household Income/SNAP/WIC: Survey-Weighted Proportions by Sales Volume**

| | Higher income (>185% FPL) (n=130) | Lower income (≤185% FPL) (n=226) | Non-SNAP (n=171) | SNAP (n=185) | Non-WIC (n=150) | WIC (n=174) |
|---|---|---|---|---|---|---|
| **NUTRIENT CLAIMS** | **68.9%** | **67.6%** | **69.8%** | **64.2%** | **64.7%** | **80.4%** |
| **Macronutrient claims** | **32.9%** | **42.6%** | **33.2%** | **45.1%** | **34.6%** | **50.1%** |
| Calorie-related claims | 0.0% | 1.0% | 0.2% | 0.9% | 0.4% | 0.0% |
| Sugar claims | 32.9% | 41.9% | 33.2% | 44.2% | 34.3% | 50.1% |
| **Micronutrient claims** | **59.5%** | **51.7%** | **59.0%** | **50.5%** | **53.6%** | **64.3%** |
| Vitamin C claims | 39.6% | 44.8% | 41.5% | 40.4% | 38.7% | 61.7% |
| **HEALTHY CLAIMS** | **10.8%** | **11.8%** | **11.6%** | **9.5%** | **14.4%** | **6.4%** |
| "Healthy" claim | 2.2% | 1.0% | 2.0% | 1.1% | 2.4% | 0.3% |
| Implied healthy (e.g., "good for you") | 8.7% | 10.7% | 9.6% | 8.4% | 11.9% | 6.1% |
| **HEALTH OR STRUCTURE/ FUNCTION CLAIMS** | **4.7%** | **2.1%** | **4.0%** | **3.4%** | **4.9%** | **3.0%** |
| **NATURAL CLAIMS** | **56.7%** | **56.5%** | **55.2%** | **61.2%** | **65.0%** | **47.7%** |
| Natural/All Natural | 5.7% | 1.0% | 5.1% | 1.3% | 5.5% | 0.2% |
| Implied natural | 56.7% | 56.5% | 55.2% | 61.2% | 65.0% | 47.7% |
| **NATURAL IMAGERY** | **95.8%** | **98.5%** | **96.3%** | **97.9%** | **95.0%** | **99.3%** |
| Fruit/Vegetable Imagery | 95.6% | 97.0% | 95.6% | 97.5% | 94.7% | 97.5% |
| Nature imagery | 70.3% | 67.0% | 69.8% | 67.4% | 61.7% | 80.0% |

CONCLUSIONS

The goal of this dissertation was to use strategic science to build quantitative evidence for policies that could make it easier for consumers to make healthy choices in restaurants, schools, workplaces, and supermarkets. Through collaboration with policymakers and advocates, the findings of these analyses are now being used to inform policy changes in a variety of settings.

In Chapter 1, we found that sodium warning labels on restaurant menus reduced sodium ordered, and that "sodium warning" text could make labels more effective. After communicating our findings with the city of Philadelphia, they modified their sodium warning label legislation to include "sodium warning" text. That bill was passed into law and went into effect in September 2019, so now all chain restaurants across the city are required to display sodium warning labels based on the evidence created by this dissertation. A city-wide evaluation of the policy will continue to build evidence on the real-world effects of sodium warning labels on consumer behavior and restaurant reformulation. Given that one quarter of sodium in the American diet is consumed in restaurants,[34] such labels could reduce sodium consumption and subsequently reduce rates of hypertension and cardiovascular disease nationwide.

In Chapter 2, we found that U.S. households acquired over one-fifth of their food for free. The nutritional quality of free food at school and work was relatively low, but free school food acquired by children participating in SNAP was of higher nutritional quality. Policies improving the dietary quality of free food, such as the National School Lunch Program and school and workplace wellness policies, could contribute to the overall health of families, especially those participating in SNAP. Results of this dissertation were used to spur changes to wellness policies across Harvard University. After communicating our findings with the Harvard Nutrition Department, Office for Student Affairs, Office for Sustainability, and Dining Services, we worked together to create healthy, sustainable meeting guidelines for use across all 12 Harvard graduate and undergraduate schools when planning meetings, events, and conferences.[155] We are now working with other universities across the country to adapt these guidelines for their individual institutions and plan evaluations to understand their effects on the nutritional quality of free food provided. Given the substantial role of free food in the American diet, such policies could improve overall diet quality and subsequently prevent chronic disease.

In Chapter 3, we found that most sugary drinks contained front-of-package claims and imagery implying that they were healthy and natural. This may mislead parents into purchasing them for their young children but could be addressed through FDA regulation. Results of this dissertation were used to inform a follow-up study we are conducting in collaboration with change agents at the Center for Science in the Public Interest and the FDA, which we designed to inform FDA front-of-package regulatory changes. We will use a randomized controlled trial to evaluate the effects of individual and combined front-of-package claims, imagery, sugar disclosures, and warning labels on consumer beverage choices. We hope that results can be used by the FDA to correct potentially misleading marketing on sugary drinks. This may subsequently reduce purchasing and consumption, especially among young children, which could ultimately prevent future cases of obesity, type 2 diabetes, and other chronic diseases.

In conclusion, interventions across a variety of settings can be used to improve dietary quality, with the ultimate goal of reducing chronic disease. Strategically designed research in collaboration with change agents can directly inform policy change to make it easier for all Americans to make healthier choices.

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