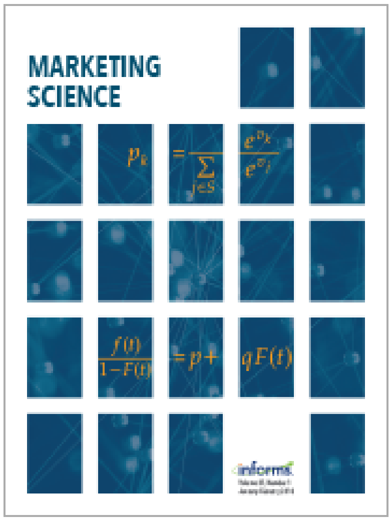

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The Impact of Voluntary Labeling

Anita Rao,[a,*] Raluca Ursu[b]

[a] McDonough School of Business, Georgetown University, Washington, District of Columbia 20057; [b] Stern School of Business, New York University, New York, New York 10012

*Corresponding author

Contact: anita.rao@georgetown.edu, https://orcid.org/0000-0001-8303-1969 (AR); rursu@stern.nyu.edu, https://orcid.org/0000-0003-2239-1498 (RU)

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Abstract. Policymakers have mandated food labeling standards, for example, through the Nutrition Labeling and Education Act. However, many claims made by firms are voluntary, such as when they label products as containing "low calories" and "no high-fructose corn syrup (HFCS)." This paper examines whether the use of voluntary labels can help consumers make more informed choices, or if labels lead consumers to ignore other relevant product characteristics, resulting in choices that can be harmful. With theory providing both types of predictions, we empirically analyze firm- and consumer-side behavior, focusing on the specific case of the "no HFCS" label and the corresponding sugar content—an increasingly policy-relevant product characteristic—of such products. We first document common firm practices in the industry across various product categories where the use of the label is prevalent. We then examine consumer search and purchase behavior through an incentive-aligned experiment. We find that products with the "no HFCS" label are less healthy, containing more sugars, than others, and that certain subsets of consumers search less and buy nutritionally worse products in the presence of voluntary labels. Our findings inform both managers and policymakers about whether and how voluntary labels should be displayed.

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1. Introduction

The U.S. Food and Drug Administration (FDA) mandates, through acts such as the Nutrition Labeling and Education Act (NLEA), that firms report the nutritional content of their products, such as the calories, fat, cholesterol, sodium, fiber, total sugars, and protein content. In addition, firms often use voluntary labels to selectively showcase certain attributes of their products to consumers, such as when they use "low calorie," "gluten-free," or "low fat" labels. When labels provide relevant information, they can help consumers make more-informed decisions; for example, a "gluten-free" label is relevant for a consumer with celiac disease. At the same time, voluntary labels can lead consumers to make less healthy choices if they obfuscate negative product attributes while highlighting favorable nutritional information. For example, a "low fat" label may conceal the fact that the product is high in calories, potentially harming consumers by obfuscating relevant nutritional product facts.[1] Obfuscating labels are especially concerning because consumers not only believe the health claims but also overgeneralize from specific claims to the overall healthiness of a product (e.g., Andrews et al. 1998).

This paper asks if and how voluntary claims impact consumer choices. Focusing on the "no high-fructose corn syrup (HFCS)" label, we evaluate whether voluntary labels impact choices in a way that benefits or harms consumers.

HFCS is a caloric sweetener that enjoyed widespread usage as a replacement for sugar because of its low cost. An influential article in 2004 (Bray et al. 2004), using correlational data, linked HFCS to the rising obesity rates in the United States, sparking controversy around this ingredient and leading firms to label their products as containing no HFCS. Subsequently, articles pointed out that had sugar (and not HFCS) continued being used in U.S. products, holding prices fixed, we would likely have seen the same increasing rate of obesity. Thus, the scientific consensus today is that both HFCS and sugar are equally harmful and singling out any one caloric sweetener can be misleading (e.g., Rippe and Angelopoulos 2013).

The "no HFCS" label and the corresponding sugar content of the product provide a clean setting to study the impact of voluntary labels on health for several reasons. HFCS directly replaces sugar and is nutritionally similar to sugars. Examining other related constructs such as calories and fat can be ambiguous because not all calories are harmful. Calories that come from sources such as whole grains or even certain types of fat can be beneficial. Thus, when examining just calories, claiming that a higher-calorie product is unequivocally worse than a lower-calorie product would be harder. Added sugars (from any source, including HFCS) have been shown to be unambiguously harmful to health, supporting our choice of focusing on sugars.[2] Sugar is also a product characteristic that policymakers are increasingly concerned about and has led to levers such as mandated sugar labels (e.g., the 2016 law of food labeling and advertising in Chile) and soda taxes (implemented in multiple U.S. cities, for example, Boulder, CO; Washington, DC; and Philadelphia, PA).

In this context, either the "no HFCS" label can serve to inform consumers that, all else equal, a product does not contain the controversial ingredient, or it may obfuscate consumers, causing them to ignore a product's overall sugar content and therefore to make a less healthy choice.

We take a two-pronged approach to answer our research question. First, to guide our study of the effect of labels on consumer choices, we document which type of firm uses the label. Using firm labeling data across various product categories where the use of this label is prevalent, we ask (1) whether all firms eligible to make the claim do so, (2) whether firms display the label to differentiate themselves from their unlabeled counterparts, or (3) whether only products that have poorer quality (higher sugar content) do so. This exercise is motivated by the theoretical literature that provides different predictions. Work on full information disclosure states that all firms eligible to make the claim will do so; otherwise, consumers will assume those firms' products do not contain that attribute and will purchase from other firms. Theories of competition posit that, all else equal, firms without the controversial ingredient will highlight this information to consumers in an attempt to differentiate themselves from otherwise similar competitors. And, finally, theories of obfuscation suggest lower-quality products will choose to obfuscate such quality by presenting other favorable information upfront. Note that although these theories motivate our descriptive exercise, we are not testing firm conduct and are agnostic as to whether firms intentionally choose such strategies or if other theories explain their behavior.

Second, we design a preregistered incentive-aligned experiment to directly study consumers' search and purchase behavior in the presence of voluntary labels. This experiment helps us understand consumers' substitution patterns in the presence of the label. Specifically, do consumers make more informed choices in the presence of the label, more easily avoiding the HFCS ingredient without impacting the sugar content of products purchased, or does the label lead to them buying products with higher sugar content?

Using data from NielsenIQ's Label Insight technology, which tracks package labels across a wide variety of products and categories, our firm-side exercise provides three relevant descriptives. First, contrary to the complete-information-disclosure literature, we do not find evidence that most firms eligible to make the claim do so. Rather, even though a majority of products do not contain HFCS (the percentage ranges from 64%–100% across 24 categories we analyze), only a small fraction of products choose to advertise the absence of HFCS on their packaging (ranging from 2%–30% across 24 categories we analyze). Second, we find evidence suggestive of differentiation efforts by firms that are otherwise nutritionally equivalent. Comparing the sugar content of "no HFCS"-labeled products to that of products containing HFCS, we find no statistically significant nutritional differences between the products with the "no HFCS" label and the products containing HFCS. This finding suggests firms with no HFCS could use the label to differentiate themselves from products with similar sugar content but that also contain HFCS. Lastly, focusing on the subset of products that contain no HFCS, we find that in 14 (out of 24) categories, products with the "no HFCS" label have more sugar than products without the label and that this effect is statistically and economically significant. The remaining 10 categories have no significant association between the label and the product's sugar content. In no category is the effect significantly negative. These findings are consistent with the obfuscation literature where lower-quality (higher-sugar) products are the ones highlighting the absence of HFCS.

Armed with the evidence from our firm-side exercise that supports both theories of differentiation (label helps consumers differentiate between similar options) and obfuscation (label can lead to a less healthy choice with respect to sugar), we turn to analyzing consumer-side behavior. To do so, we run an incentive-aligned experiment on a website we designed to mimic a typical online grocery store where consumers can search and purchase products in a given category. In designing this website, we pick a category where sufficient products use the "no HFCS" label and where the label and the sugar content of a product in our firm-side data are significantly correlated. Cereal satisfies both of these criteria (see our evidence in Section 3) and will be the focus of our paper. As of 2023, nearly all cereals had removed HFCS as an ingredient. This is especially true for the big three manufacturers, Kellogg's, General Mills, and Post, that will be used in our experiment. Nonetheless, some products display the "no HFCS" label on their packaging. As a result all products are HFCS free with variation in whether the product contains the HFCS label. Our experiment will replicate this real-world setting to measure the impact of voluntary labeling. In addition, another category we test is Condiments (with ketchup as the subcategory).

Our experiment involved three conditions: a control condition, a "no HFCS" label treatment condition, and a "no artificial colors" label treatment condition. Participants were randomized into each of these conditions with equal probability. Participants in the control group saw 10 products listed on the screen. In the "no HFCS" label treatment group, products that have the label in the real world advertised this fact in the image (through a "no HFCS" label), as well as in the text next to the brand name. Five of the 10 products displayed the label in the treatment group. In the "no artificial colors" label treatment group, the same five products displayed a "no artificial colors" label instead (products were eligible for both labels). This "no artificial colors" treatment condition serves as a decoy, allowing us to test whether our results are due to the presence of a label in general or due to the specific "no HFCS" label used. Note that in the experiment, we ensured sugar content was balanced across labeled and unlabeled products. Therefore, labeled products and sugar content are uncorrelated in the experiment (unlike in the firm-side observational data), with the average sugars per condition being similar.

We find voluntary labels do not impact the overall propensity to purchase—participants are no more likely to purchase in control than in treatment. Also, participants' search behavior or their tendency to choose sugary products is unaffected by the label. However, this average effect masks some relevant heterogeneous responses. In particular, we find that, among those consumers who have worse information (i.e., consumers who are unsure whether products carrying the "no HFCS" label are healthier), the presence of the "no HFCS" label does impact the type of product purchased: in the presence of the "no HFCS" label, participants are more likely to purchase products with more sugar than when the same products carry the "no artificial colors" label. Examining their search behavior, we find that in the presence of the "no HFCS" label, these participants also search fewer products.

In the ketchup experiment, these effects are exacerbated: although voluntary labels do not impact the overall propensity to purchase, even the average participant is more likely to purchase products with more sugar. In terms of search behavior, we find that in the presence of the "no HFCS" label, the average participant searches fewer products, spends less time searching each product, and is less likely to read about ingredient information.

In sum, we find evidence that the label leads certain subsets of consumers to search less and to make less healthy choices with respect to sugar—either because they infer the labeled product has other good features or because they ignore other relevant information in the presence of the label. From a health perspective, even if consumers have a preference for more sugar, consuming more sugar is unhealthy. In the absence of the "no HFCS" label, consumers search more and purchase better (lower-sugar) products. These results reveal strategic opportunities for firms to obfuscate consumers, and provide implications for policymakers to streamline the provision of information.

We contribute to the work on labeling, and more specifically, on voluntary labeling. Most prior work has studied mandated nutritional labeling (e.g., NLEA studied in Moorman 1996, Chile warning signs studied in Ale-Chilet and Moshary 2022, Araya et al. 2022, Barahona et al. 2023) or government-endorsed voluntary labeling (such as warning labels and star rating systems, which are summaries of the back-of-pack detailed nutrition panel, for example, Enax et al. 2016, Hobin et al. 2017, Newman et al. 2018, Vizcaíno and Velasco 2019, Dubois et al. 2021), and found that such labeling helps consumers make healthier choices. Also, in the context of mandatory labels and the NLEA, Balasubramanian and Cole (2002) examine search intensity (whether a participant picks up a box and reads it) and find no impact of the NLEA on search, except for a subset of highly motivated and less knowledgeable consumers.

Empirically analyzing voluntary labeling is harder, precisely because of the voluntary nature of the claims: firms choose when and what to display, making such labels an endogenous construct. Also, in contrast to mandatory labels that affect all brands equally, voluntary labels can have a different impact because only a select subset of firms might choose to display the label, even though many might be eligible to do so. Such voluntary labels that are selectively highlighted by firms have the potential to mislead (e.g., Keller et al. 1997; Andrews et al. 1998, 2000; Roe et al. 1999) and limit consumer search (Roe et al. 1999). From a consumer perspective, the question of how consumers view voluntary labels is also important. If consumers treat voluntary labels as information (i.e., in a way similar to mandatory labels, as shown in Adalja et al. 2023), then this can be a cause for concern, because in this case voluntary labels could mislead and obfuscate consumers.

Our paper contributes to and extends prior work in several ways. First, we document firm-side behavior, which has not been done in the prior literature. Second, we examine behavior in an online setting, where we expect information gathering to be easier than in a physical store; however, even here we find an effect of the presence of the label on search. Third, we design a website that consumers search as they would on a common e-retailer's website (rather than responding to side-by-side choice tasks). Therefore, our experiment design allows us to identify the impact of voluntary labeling. Fourth, our experiment examines the type of product purchased (and how people substitute between various products) and how consumers search, with most prior work looking at stated purchase intentions or healthfulness perceptions (see Ikonen et al. 2020 for a review). We also capture search at a more granular level than in prior work, looking not only at whether a product is searched, but also at search intensity: clicks into ingredient pages, as well as clicks into the nutrition facts panel.

The next section describes the relevant literature. Section 3 showcases empirical evidence for or against various effects of voluntary labels, using the firm-level labeling and nutrition data. Section 4 discusses consumer behavior in the presence of labels from our incentive-aligned experiment. Section 5 discusses the economic significance of our findings, and Section 6 concludes and discusses the implications of our findings.

2. Literature Review

This paper is broadly related to work on selective information disclosure. Hastak and Mazis (2011) document various types of truthful but misleading practices used by firms (e.g., "contains oat bran" might imply a substantial amount of oat bran; "no cholesterol" might imply competitors contain cholesterol). Moorman (1998) shows that some firms, when forced by a regulator to display their nutrient information, merely increase certain positive nutrients (e.g., vitamins) without altering any of their negative nutrients (e.g., sodium). Rao (2022b) studies firm incentives to conduct selective research and/or report only favorable outcomes of scientific studies.

Within this work, several theories can be used to derive predictions on whether firm voluntary labels will help or harm consumers, and we discuss these next. We note, however, that our goal in this paper is not to uncover or test all possible theories on the effect of voluntary claims. In our setting, we are agnostic as to whether firms are intentionally trying to benefit or harm consumers; rather, our goal is to understand whether the effect of voluntary labels on consumer choices is likely to be beneficial or harmful.

2.1. Beneficial Effects

The theoretical literature on information disclosure predicts that, in equilibrium, high-quality sellers will engage in full disclosure, because rational consumers will interpret anything short of full disclosure as a signal of low quality (Grossman 1981, Milgrom 1981, Jovanovic 1982). In our context, this theory suggests all brands with products that do not contain HFCS will highlight this information in an effort to convince consumers of their high quality. Such practices can benefit consumers by providing them with more information that aids them in making better choices. Empirical support for this theory has been found in Mathios (2000) and Jin and Leslie (2003).[3]

Similarly, consumers may be benefited if the label allows them to save on search costs. In models of search over product attributes (e.g., Branco et al. 2012, 2016; Ke et al. 2016; Gardete and Hunter 2024), consumers start with some basic product information (e.g., in our context, that available on the front of the package) and decide sequentially whether to obtain additional information on other product features (e.g., information on the back of the package). Labels can reduce search costs if they help consumers identify healthier products without having to conduct a detailed search of the back of the package. In other words, if all the label does is save consumers an additional search, with the final product purchased unchanged (or improved), it can benefit consumers.

Empirical evidence has also supported another theory on differentiation in a competitive marketplace (Jin 2005, Edelman 2011). According to the differentiation account, firms that are otherwise similar to their competitors may seek an advantage by highlighting a feature that differentiates them to demonstrate some level of superiority. In our context, if two firms sell nutritionally equivalent products, but one contains no HFCS, whereas the other does, the first firm would have an incentive to highlight this fact using a "no HFCS" label to differentiate itself from the other firm. In this case, consumers may buy nutritionally similar or better products in the presence of the label.

2.2. Harmful Effects

The theoretical work on obfuscation suggests firms with low quality have incentives to obfuscate information, thereby harming consumers. Gabaix and Laibson (2006) highlight incentives for firms to advertise virtues but hide their vices. Examples include banks, credit cards, and hotels that showcase their features but hide the fees associated with these features. Ellison and Wolitzky (2012) posit that, because of search costs, consumers will not engage in complete search over all attributes. If search over product attributes is costly, voluntary labels placed on the front of the package can lead consumers to search less and ignore relevant attributes that appear on the back of the package (Roe et al. 1999). In our setting this would translate to consumers placing more weight on the no-HFCS claims, and ignoring other relevant attributes (such as total sugars or added sugars). Firms will therefore have incentives to present favorable information about themselves to consumers in an easy-to-search manner (e.g., on the front of the package) and hide negative attributes. In the context of this paper, this theory implies brands with more sugar will wish to obfuscate this negative information by highlighting the virtuous aspects of their products, namely, the absence of HFCS. In this case, voluntary labels can lead consumers to make less healthy choices with respect to sugar.

In sum, in Table 1, we recap the theoretical predictions on how firms will use selective labeling and on whether firm voluntary labels will help or harm consumers.

3. Firm-Level Data and Evidence

3.1. Labeling and Nutrition Data

To understand which type of firm uses the label, we use package labeling, nutritional characteristics, and date of the label, across products and categories, acquired from NielsenIQ's Label Insight.

The data from Label Insight are cross-sectional, with packaging and nutritional information available *across* brands. Because packaging information might change year-to-year, the universal product code (UPC)-level information is specific to a given year and month combination, namely, corresponding to the date collected by Label Insight. To ensure claims specific to a year-month are also in stores at that time, this UPC-year-month-level data set is matched to the NielsenIQ Retail Measurement Services (RMS) data set. Using each product's unique UPC and the month the data were collected as the two identifiers, we matched the data (e.g., if a UPC had a different claim the previous year, matching by UPC alone would inaccurately reflect the claim descriptions; a UPC and month match circumvents this issue). Only matched UPCs are kept for the final analysis. UPCs that are present in the Label Insight data but not present in the RMS data (or vice versa) belong typically to store brands, or involve atypical sizes or seasonal offerings.

Categories relevant to the analysis were determined from the Label Insight data downloaded in 2020. The cutoff used is such that at least 100 products in a category have the "no HFCS" label. This cutoff allows us to rule out categories that are not sweet and thus where consumers might not expect a "no HFCS" label (our results continue to hold even when focusing only on sweet—naturally or artificially sweetened—products; see Section 3.2.2). Categories that did not make the cutoff include Gels & Pectins, Chips & Snacks, Alcohol, and Dog Food. Twenty-four categories made the cutoff and will be the focus of our analysis. These data are then matched with the RMS data, leading to a smaller subset of products and to fewer than 100 products with the label in some categories.

Table 2 lists the top categories in our data that carry the "no HFCS" label, the percentage of products with the "no HFCS" label, the median serving size, and the sugar content. The table shows that across these categories, 2%–30% of products showcase the "no HFCS" label, with Bread & Buns being the most popular category (based on magnitude alone), with 680 products showcasing the label. Figure 1 shows some examples of products in these categories and how they showcase the label.

3.2. Empirical Results

3.2.1. How Frequently Do Firms Use the "No HFCS" Label? To understand how frequently firms employ the "no HFCS" label in practice, we look at the percentage of products that do not contain HFCS in each category, as well as checking what fraction of these products use a label to highlight the lack of HFCS. Figure 2 plots the percentage of products within a category that do not contain HFCS (gray bars). This percentage ranges from 64%–100% across the 24 categories, suggesting a majority of products do not use HFCS. The same figure also shows the percentage of products within a category that choose to display a "no HFCS" label (black bars). Surprisingly, only a small fraction of products choose to advertise the absence of HFCS on their packaging—ranging from 2% in Snacks to 30% in Puddings & Custards (also seen from Table 2). This stark difference between the number of products without HFCS that are available in a category and the number highlighting the lack of HFCS per category is evidence inconsistent with predictions from the information-disclosure literature. The reason is that if brands used voluntary labels to inform consumers, we would expect all (or most) brands without the ingredient to highlight it, that is, display a "no HFCS" label, which is not what we find. In other words, the majority of firms are not choosing to provide

Table 1. Beneficial vs. Harmful Effects of Voluntary Labels

Theory	Who displays a "no HFCS" label?	Effect on consumer choices	Overall	Why?
Full information	All (or most) products without HFCS	Buy similar/better products	Beneficial	More information/save search costs
Differentiation	Products similar to those with HFCS	Buy similar/better products	Beneficial	More information/save search costs
Obfuscation	Nutritionally worse products	Buy worse products	Harmful	Ignore relevant attributes/ search less

Table 2. Categories with "No HFCS" Labels

Category	*N* products	*N* products With "no HFCS" labels	% products With "no HFCS" labels	Median sugar per 100 g	Median serving size	Serving size unit
Bars	2,263	160	7%	22.50	45	g
Bread & Buns	2,868	680	24%	4.65	45	g
Cakes & Snacks	2,078	84	4%	32.93	70	g
Candy	5,925	150	3%	58.54	34	g
Canned Fruit	420	30	7%	12.86	124	g
Cereal	1,049	233	22%	29.03	36	g
Condiments	1,579	185	12%	20.00	29	g
Cookies & Biscuits	3,355	297	9%	33.33	30	g
Crackers	915	33	4%	3.57	28	g
Deli	2,327	80	3%	2.54	30	g
Ice Cream	3,386	237	7%	21.92	79	g
Iced Tea	734	39	5%	5.29	240	ml
Jam & Jelly	873	61	7%	52.63	20	g
Juice	2,439	222	9%	9.72	240	ml
Milk	1,009	60	6%	5.08	240	ml
Nuts & Snacks	4,423	76	2%	7.14	30	g
Pastries	596	40	7%	27.06	56	g
Pasta & Pizza Sauce	1,038	41	4%	4.00	124	g
Puddings & Custards	305	91	30%	17.00	92	g
Salad Dressing	1,637	359	22%	6.67	30	g
Snacks	1,911	43	2%	3.57	28	g
Soda	1,897	76	4%	10.55	355	ml
Wholesome Snacks	1,404	73	5%	46.43	40	g
Yogurt	1,953	296	15%	10.00	150	g

Note. The table showcases descriptives for products present in both the Label Insight and NielsenIQ RMS data.

consumers information on the absence of HFCS in their products, even though such information may aid consumers.

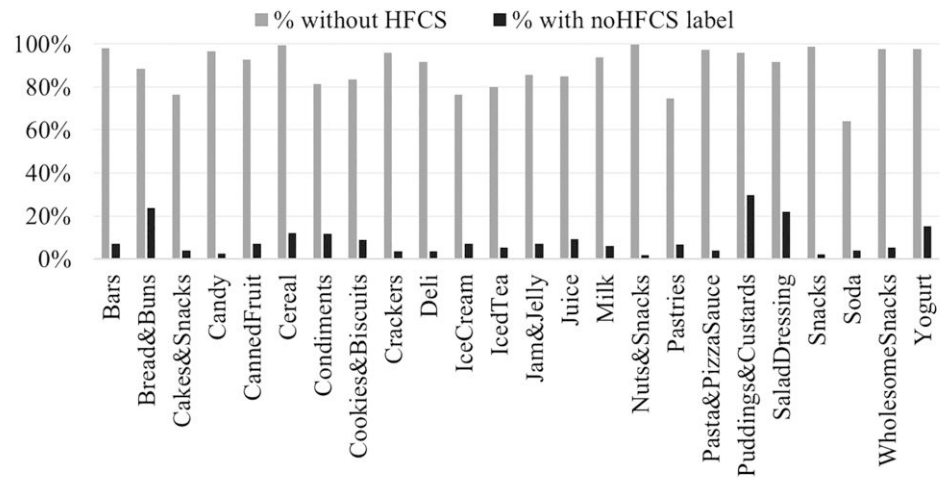
One reason why disclosure could be incomplete is high disclosure costs. However, in our context, disclosure amounts to printing an additional label on the package, which is likely to be costless. Another reason for incomplete disclosure could be that high-quality sellers might have better attributes to showcase on their packaging. Because of limited package space, they might choose to forgo printing the "no HFCS" label so that they can highlight other relevant information to the consumer.

3.2.2. Relation Between the "No HFCS" Label and a Product's Sugar Content. This section compares the sugar content of products displaying the "no HFCS" label with those that do not display such a label. Our dependent variable is the sugars noted in the nutrition facts panel, which contains the total sugars from any caloric sweetener: sugars, HFCS, honey, dextrose, etc. In other words, even if sugar does not appear in the ingredients list, caloric sweeteners (such as HFCS) translate into sugars in the nutritional facts column. Because the amount of sugars in the nutrition facts panel is the total amount of sugar coming from any source, the total sugars listed in the nutrition facts

Figure 1. (Color online) Examples of Products with the "No HFCS" Label Across Various Categories

Category: Bread & Buns Category: Puddings Category: Cereal

Figure 2. Percentage of Products Without HFCS and Percentage with the "No HFCS" Label Across Categories



panel are comparable across products. We also present evidence using added sugars (instead of total sugars) as a dependent variable in Online Appendix A and our results are robust.[4]

For this analysis, we focus on products that do not contain HFCS (because those that do contain HFCS cannot display a "no HFCS" label). In other words, we ask, among those who can legally claim "no HFCS," are certain types of products more likely to do so, and if so, what kinds of products are these?[5] Using the total amount of sugars per 100 grams of the product j, sugars per $100\text{g}_{j,ms}$, as the dependent variable, the following regression is estimated:

$$\text{sugars per } 100\text{g}_{j,ms} = \beta_0 + \beta_1 \text{noHFCS\_Label}_{j,ms} + \alpha_m + \alpha_s + \varepsilon_{j,ms}, \quad (1)$$

where s corresponds to the subcategory product j belongs to, and m is the year-month combination when the claims data were collected. $\text{noHFCS\_Label}_{j,ms}$ is an indicator variable that identifies whether the product contains the "no HFCS" label or not, and β_1 is the coefficient of interest. If β_1 is zero, the implication is that products with the label are no different than products without the label in terms of sugar content. If β_1 is negative, the implication is that such products have less sugar, and if β_1 is positive, the implication is that such products have more sugar.

The regression also controls for year-month fixed effects (FE), α_m, so that any time-specific changes are accounted for. For example, a trend toward lowering sugar content might make sugar content in later years lower than in earlier years, and comparing products across years might lead to spurious effects. For the same reason, for each year-month combination, we compare only those products that are available in stores and for which the claims data are available. In other words, a product in 2009 that is not available in 2012 or for which no claims data[6] are available will not be compared with products available in 2012. α_s is the subcategory-level fixed effect, which allows comparison of products with and without the label *within* each subcategory. The product categories themselves are fairly broad. For example, the category Bread & Buns consists of subcategories such as White Bread, Dinner Rolls, Naan, Hawaiian Rolls, etc. The subcategory fixed effect enables comparison of products with and without the label *within* each subcategory, for example, within Hawaiian Rolls.[7]

Table 3 presents estimates of the β_1 coefficient on the $\text{noHFCS\_Label}_{j,ms}$ indicator across various categories and with increasing numbers of controls. Here, we find that in a majority of categories (14 of the total 24 categories), products with the "no HFCS" label have significantly more sugar than those without the label.[8] In the remaining categories, the estimate is not significantly different from zero. In no category is the effect significantly negative.

We can illustrate this result in a different way as well. Figure 3 plots the additional sugars in products with the "no HFCS" label relative to those without the "no HFCS" label across various categories using the β_1 estimates from the full specification with the most inclusive set of fixed effects (Table 3, column 4). The categories in this figure are sorted in decreasing order of β_1. Once again, we see that across most categories, products with the "no HFCS" label contain more sugars. We notice the largest effect in categories such as "Pastries," "Deli," and "Condiments."

These findings are consistent with the obfuscation literature: in the majority of categories, the products with more sugars (lower nutritional quality) are the ones highlighting the absence of HFCS. Obfuscating labels are concerning because consumers not only believe the health claims but also overgeneralize from specific claims to the overall healthiness of a product (e.g.,

Table 3. Regression Estimates: Sugar Content and "No HFCS" Labels

	(1)		(2)		(3)		(4)		
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	*N* products
Bars	7.99***	0.96	8.82***	0.93	8.23***	0.95	3.12***	0.90	2,221
Bread & Buns	1.49***	0.27	1.56***	0.28	1.65***	0.29	1.28***	0.25	2,540
Cakes & Snacks	1.17	1.26	0.55	1.25	0.53	1.32	0.66	1.14	1,586
Candy	−4.35**	1.42	−4.22**	1.43	−4.96***	1.47	−0.47	1.25	5,720
Canned Fruit	−1.15	1.40	−0.74	1.48	2.19	1.49	2.39^{+}	1.39	390
Cereal	8.45***	0.92	9.5***	0.95	7.54***	1.01	4.2***	0.90	1,741
Condiments	9.78***	1.27	10.47***	1.29	10.89***	1.36	5.16***	1.28	1,287
Cookies & Biscuits	−1.57*	0.71	−1.23^{+}	0.73	−0.72	0.76	0.36	0.64	2,807
Crackers	4.54**	1.39	4.43**	1.38	5.43***	1.52	2.11	1.51	879
Deli	6.01***	1.16	6.02***	1.18	6.01***	1.22	5.72***	0.98	2,131
Ice Cream	−0.45	0.42	0.11	0.42	−0.42	0.42	0.83*	0.42	2,594
Iced Tea	2.45***	0.69	2.61***	0.68	2.77***	0.74	2.61***	0.75	586
Jam & Jelly	−2.23	2.22	−1.04	2.25	2.85	2.39	3.79	2.40	749
Juice	1.34***	0.26	1.4***	0.26	1.23***	0.28	0.89***	0.26	2,068
Milk	1.63	1.29	1.15	1.31	1.16	1.33	−0.74^{+}	0.41	945
Nuts & Snacks	8.16***	2.33	8.94***	2.32	8.98***	2.33	3.41*	1.58	4,408
Pastries	6.55***	1.58	7.57***	1.59	7.88***	1.65	6.1***	1.60	446
Pasta & Pizza Sauce	2.37***	0.37	2.41***	0.39	2.09***	0.42	0.94*	0.42	1,010
Puddings & Custards	0.68	3.21	1.82	3.35	8.93*	3.71	2.95	2.04	292
Salad Dressing	2.57***	0.75	2.5**	0.76	1.18	0.87	2.03*	0.82	1,502
Snacks	3.76*	1.74	4.82**	1.75	3.95*	1.84	3.8*	1.77	1,888
Soda	2.72***	0.58	2.52***	0.58	2.37***	0.58	0.97*	0.42	1,215
Wholesome Snacks	−26.34***	2.99	−25***	3.03	−18.72***	3.26	2.31	1.95	1,369
Yogurt	0.45^{+}	0.24	0.73**	0.24	1.07***	0.27	0.03	0.29	1,911
Year FE			Yes						
Year-month FE					Yes		Yes		
Subcategory FE							Yes		

Notes. The table showcases estimates of the "no HFCS" label indicator variable. The dependent variable is the sugar content per 100 g. Each row corresponds to estimates from regressions in that category. Column 1 presents estimates with no controls, column 2 incorporates year fixed effects, column 3 incorporates year-month fixed effects, and column 4 incorporates both year-month and subcategory fixed effects. Categories in bold indicate cases where the effect is positive and statistically significant in the regression in column 4 with the most inclusive list of fixed effects. Data are restricted to those products that do not contain HFCS.

$^{+}p < 0.1$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

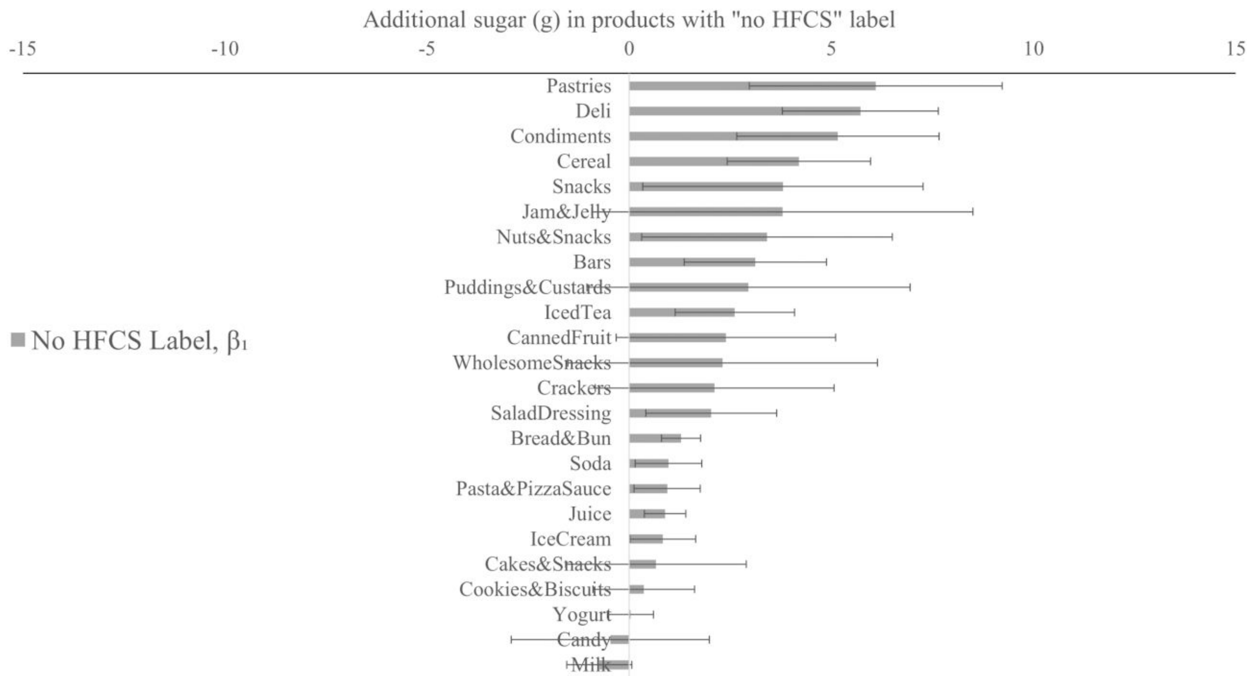
Andrews et al. 1998). Thus, such a practice may harm consumers by misleading them into choosing products with a label that are nutritionally worse. In addition, for the same amount of sugar, the HFCS-containing products might be healthier than the "no HFCS"-labeled sugar-containing counterparts. This is because most categories in our data likely use HFCS 42[9] and HFCS 42 has lower fructose than sugar.[10]

We perform several robustness checks. First, we control for the fact that categories differ in the number and the type of other labels that are displayed on products. For example, in the Cereal category, these labels are "whole grains," "fiber content," "natural," and "sweetened." Online Appendix C lists these top labels per category. To account for the additional labels on products, we estimate a version of the regression in Equation (1), but where we additionally control for the top four labels in each category (see Equation (3) in Online Appendix C). Our main results from this section on the relation between the "no HFCS" label and the sugar content of a product continue to hold (see Online Appendix C).

Second, we focus on the subset of products that have natural and artificial sweeteners to rule out the possibility that in some categories, consumers might not expect a "no HFCS" label, because products in the category are not sweet or sweetened. Inclusion of naturally unsweet products, which might be unlabeled because the absence of sweetener is irrelevant to the product, might overstate the effect. To create this subset, we search from the ingredient list per product for (1) sugars as classified by the USDA, WebMD, and Yale New Haven Health, and (2) artificial sweeteners as classified by the FDA. The results provided in Online Appendix D are robust to this subset of products.

Third, other unobservables could be correlated with the sugar content; for example, certain brands might be more sugary than others, affecting our results. We acknowledge that other characteristics that could be correlated with the presence of the label could impact our estimates. To control for such unobservables to the extent possible, we add brand fixed effects. Specifically, we control for the top brands[11] per category, grouping the rest into the Other brand, and estimate the

Figure 3. Additional Sugars (Grams) in Products with the "No HFCS" Label



Notes. The figure plots the estimated additional sugars in products with the "no HFCS" label, β_1, across various categories. These estimates are obtained from the regression analysis specified in Equation (1), which controls for store availability, month, and product subcategory fixed effects. Only products that do not contain HFCS are included in the analysis.

regression with these additional fixed effects. Our results, provided in Online Appendix B, continue to be robust.

3.2.3. Are "No HFCS"-Labeled Products Nutritionally Equivalent to Products Containing HFCS?

Our findings so far show that among all products that do not contain HFCS, products with the label are nutritionally worse than products without the label. However, whether—among all products in our data—the labeled products are better, worse, or nutritionally equivalent to their HFCS-containing counterparts is unclear. The regression specified in Equation (2) below helps answer this question:

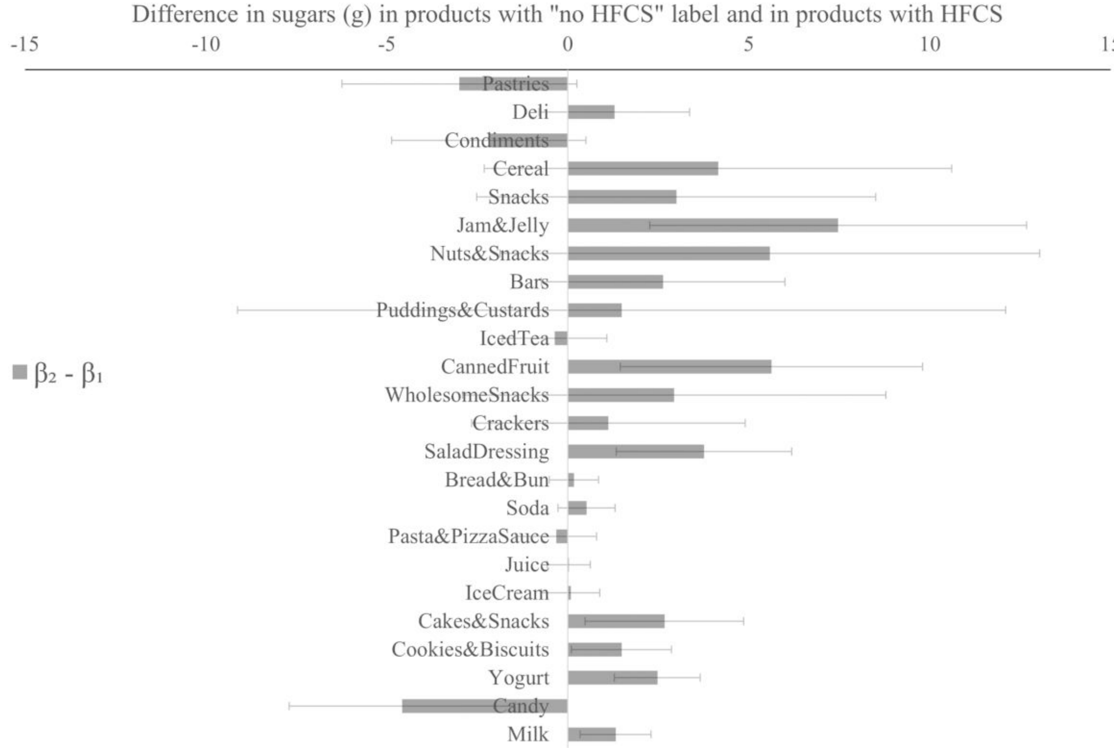
$$\text{sugars per } 100\text{g}_{j,ms} = \beta_0 + \beta_1 \text{noHFCS\_Label}_{j,ms} + \beta_2 \text{hasHFCS}_{j,ms} + \alpha_m + \alpha_s + \varepsilon_{j,ms}. \quad (2)$$

Here, β_1 corresponds to the additional sugars in products with the "no HFCS" label, and β_2 corresponds to the additional sugars in products that contain HFCS. If $\beta_2 > \beta_1$, the implication is that products containing the ingredient are nutritionally worse than products without the ingredient (and with the label); if $\beta_2 = \beta_1$, the implication is that the two are nutritionally equivalent.

Figure 4 plots the difference between the two coefficients for each category controlling for year-month, α_m, and subcategory, α_s, fixed effects. In most categories, the confidence intervals overlap with zero, suggesting the two kinds of products are nutritionally equivalent, that is, show no statistically significant difference in their sugar content. This overlap is especially true for the 14 categories where a positive and significant association between the label and the product's sugar content was found earlier in this section (e.g., "Pastries," "Deli," or "Condiments"). In other words, there is no evidence that the "no HFCS"-labeled products are nutritionally better than the products that contain HFCS. This finding suggests firms selling products with high sugar content and no HFCS could use the label to differentiate themselves from products with similar sugar content but that also contain HFCS. Such a practice could aid consumers by providing them with relevant product information.

In sum, our evidence using firm-level data supports the possibility that voluntary labels both aid (through differentiation) and harm (through obfuscation) consumers. If consumers purchase worse (higher-sugar) products in the presence of the label even when better (lower-sugar) options that are otherwise identical (e.g., HFCS free) exist, then this behavior is consistent with the obfuscation story; if consumers buy nutritionally identical products, but now with the label, then this behavior supports the differentiation account. To directly study the effect of voluntary labels on consumer choices, in the next section, we design a preregistered incentive-aligned

Figure 4. Difference, $\beta_2 - \beta_1$, in Sugars (Grams) Between Products with HFCS as an Ingredient and Those That Use the "No HFCS" Label



Notes. The figure plots the difference between β_2, the estimated additional sugars in products containing HFCS, and β_1, the estimated additional sugars in products with the "no HFCS" label, across various categories. These estimates are obtained from the regression analysis specified in Equation (2) that controls for store availability, month, and product subcategory fixed effects. All products are included in the analysis.

experiment and measure consumers' responses to firm voluntary labels.

4. Consumer Behavior in the Presence of Voluntary Labels

In this section, we study how labels affect consumer behavior. Using observational data to study consumer demand in response to labels is challenging because exogenous variation in when a firm introduced a label is rare. Firms might introduce a label in anticipation of demand, and a before-after analysis suffers from the usual endogeneity concerns. We therefore develop an experiment designed to mimic a typical online grocery store. We now describe the details of the experimental design and our results, preceded by an explanation of the category we chose to feature in the experiment.

4.1. Choice of Product Category

Of the 24 product categories studied in the previous section, we wish to pick a category where a considerable percentage of products display the "no HFCS" label and where a significant correlation between the label and the product's sugar content was found.

Categories with more than 10% of products with the label include Bread & Buns, Cereal, Condiments, Puddings & Custards, Salad Dressing, and Yogurt (see Table 2). Of these categories, as can be seen in Figure 3, Condiments, Cereal, Salad Dressing, and Bread & Buns (in decreasing order of the magnitude of correlation) have a significant correlation with the label and sugar content. We therefore focus our experiment on cereal, as well as the Condiments category (focusing on ketchup as a subcategory).

We chose cereal as our main category because it satisfies many of the criteria required to run an effective incentive-compatible experiment. First, cereal is a frequently consumed and high-sugar-content product category, making our welfare implications consequential. Second, cereal is nonperishable and easy to deliver to participants via a large online retailer to fulfill the incentive-compatible portion of the experiment (see below for more details). Also, as of 2023, nearly all cereal products are HFCS free, so the only variation between treatment and control we will use is in the presence of the voluntary label. We note that because cereal is a frequently consumed product and many consumers might view it as a highly processed product, we do not expect our main manipulation (adding a "no HFCS" label) to have a large effect or any effect on the average consumer, either because the manipulation will not provide useful information or because consumers expect products to be less healthy overall.

Nevertheless, we expect certain groups of consumers (e.g., those who are less well informed) to show an effect.

Another category we test is ketchup. As of 2023, in the ketchup category variation exists in whether products contain the ingredient and in whether products without HFCS display the "no HFCS" label. Ketchup is less frequently consumed than cereal and is a category where sugars are hidden. In other words, consumers do not view ketchup as a sweet product or an indulgence (unlike ice cream or puddings, for which consumers expect a high-sugar product). For these reasons, we expect to see larger effects of our manipulation in the ketchup category. Ketchup also contains a lot of sugar per serving, a requirement that enables us to study health consequences in terms of sugar content purchased.[12] Finally, ketchup is also nonperishable and easy to deliver to participants. We elaborate more on this experiment, its design, and our results in Online Appendix E.

4.2. Experimental Design

In the experiment, participants were told they were shopping for cereal on our online grocery store and could purchase at most one product among a list of 10 available options. Also, participants had the option not to purchase any of the cereal products.

We designed the experiment to be incentive aligned: all participants were entered into a lottery at the end of the study, with a 1-in-15 chance of receiving an award worth $10. More precisely, if a participant won the lottery, she received the product she chose in the experiment at the listed price and the remaining balance as a cash bonus. If the participant did not pick a product in the experiment (i.e., she chose the outside option of not buying any cereal), she received the entire award as a cash bonus. All the instructions we provided participants are also illustrated in Online Appendix F.

The cereal products included in the experiment were chosen based on whether they were sold on a large online retailer and were available for delivery. This decision helped ensure we could ship the products to participants if they won the lottery (to fulfill the incentive-compatible portion of the experiment), and also helped create a product sample that is more representative of what is available in the marketplace. Additional criteria for choosing the cereals for our study are as follows: (1) Focus on one multigrain to make the choice set comparable. We chose corn cereal because it had the most firms displaying the label in the marketplace. (2) Ignore nut variants (e.g., honey nut, peanut butter) to avoid allergy-related choices to the extent possible. (3) Ignore chocolate variants to avoid snack associations. (4) We then searched for corn cereal on two large online retailers and listed all products that came up in the first two pages. This process gave us a list of around 20 unique cereals, five of which display the label either on front-of-package or on their website description. We match to the closest possible degree another cereal of similar sugar content. The resulting set of products we use is displayed below in Table 4. Sugars in cereal almost entirely come from added sugars (with the exception of Honeycomb, where 1 g out of 13 g comes from naturally occurring sugars). Therefore, our results are nearly identical using Total or Added sugars as dependent variables.

We ensured sugar content in our experiment was balanced. In other words, unlike the firm-side observational data, which have a positive correlation between labeled products and sugar content, we intentionally balanced this feature in the experiment, with the average sugars per condition being similar. Having a range of sugar levels across labeled and unlabeled products helps us study if consumers switch between products of similar sugar levels, or if they switch away from products with lower sugar levels in the presence of the label. The exact set of products, their sugar content, and whether they contain the ingredient are displayed in Table 4.

The products that were chosen to contain the label in treatment were chosen to mimic reality; that is, only those products that display the label in reality exhibit the label in the treatment condition. Note that all cereal products in the experiment are eligible for the label, that is, do not contain HFCS as of 2023 in the real world, as in our experiment.

Table 4. Cereal Experiment: Products and Sugar Content

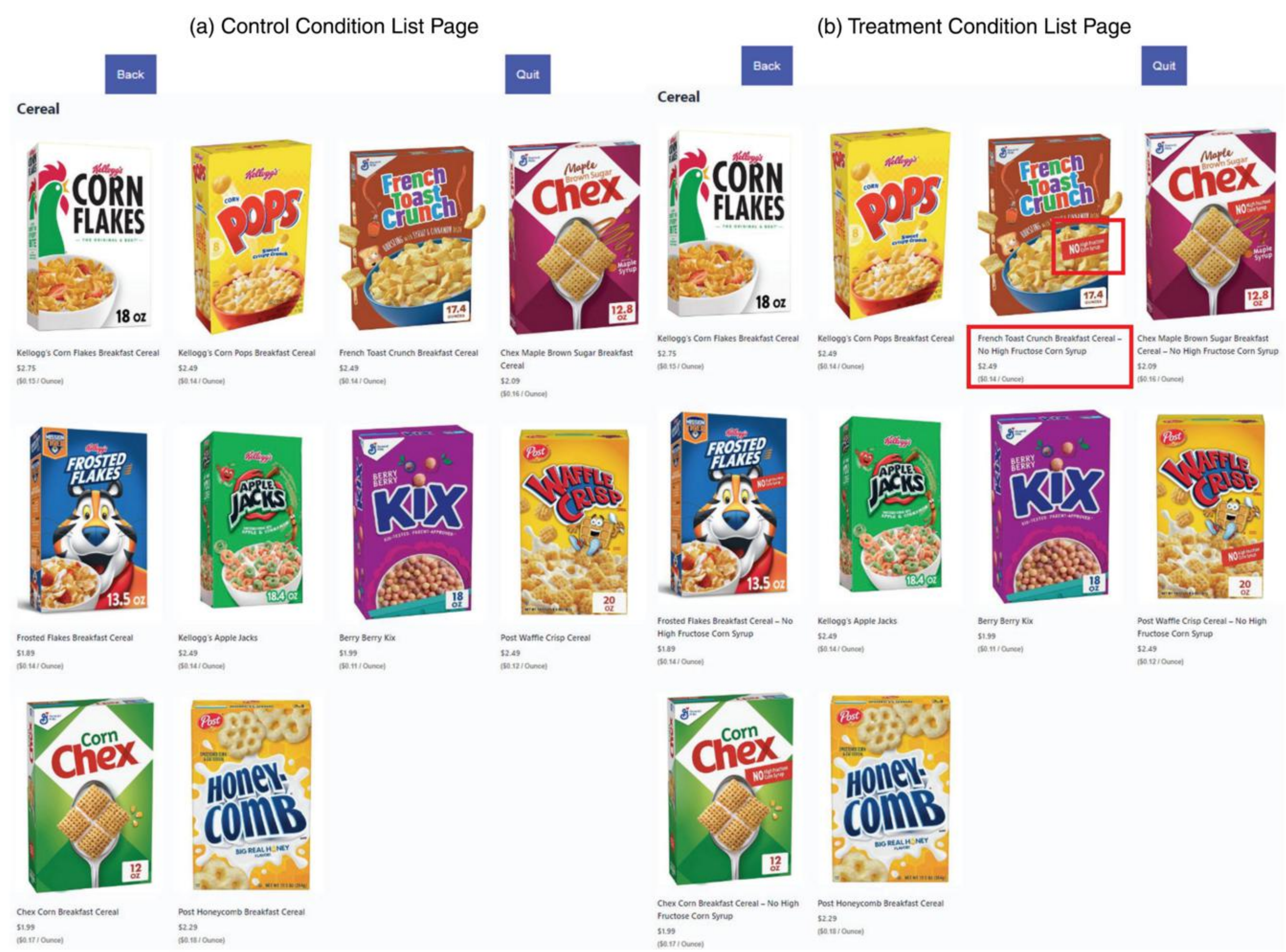
With label in experiment			Without label in experiment	
Product	Sugars (g) per 100 g	Carries label in reality?	Product	Sugars (g) per 100 g
GM Corn Chex	10.26	Y	Kel Corn Flakes	9.52
GM Maple Brown Sugar Chex	20.93	Y	GM Berry Berry Kix	20.00
Kel Frosted Flakes	32.43	Y	Post Honeycomb	32.50
GM French Toast Crunch	32.43	Y	Kel Apple Jacks	33.33
Post Waffle Crisp	37.50	Y	Kel Corn Pops	37.50
Average sugars	26.71			26.57

Note. GM, General Mills; Kel, Kellogg's.

After reading the instructions for the experiment and before navigating to our website to shop for cereal, participants were randomized into one of three conditions: control condition, a treatment condition with the "no HFCS" label, and a treatment condition with the "no artificial colors" label. In each treatment condition, five of the 10 listed products displayed an additional label. We designed the label and added it to the product images and titles. The difference between the two treatment conditions relative to the control condition is the presence of the label. The only difference between the two treatment conditions is which label was used—"no HFCS" or "no artificial colors"—that is, the products these labels were showcased on were identical across the two conditions (and were verified to be eligible for either label). The treatment condition with the "no artificial colors" label served as a decoy, to test whether our results are due to the presence of a label in general or due to the specific "no HFCS" label used. Figure 5, (a) and (b), illustrates the list of available options for the control and the "no HFCS" treatment conditions. By design, the order of products in the list remains constant across conditions.

Each cereal product was identified on the list page by an image, a title (containing the brand name), and a price in dollars. From this list, participants could search a product by clicking on it, in which case, they would navigate to a product page reserved for that cereal, where they could obtain additional information about the product. On such a product page, consumers can see an enlarged image of the product, accompanied by the product's name and price, as well as clickable links to the ingredients and nutrition facts of the product. Examples of product pages are shown in Figure 6, (a) and (b), in the control and treatment conditions, respectively. Product images are taken directly from manufacturers' websites with no alterations (except in the treatment conditions, where we added the label images) to ensure a realistic shopping experience.[13] Prices are taken from the online retailer (as of October 2023) and discounted by 50% so that participants had incentives to purchase the products and not just click

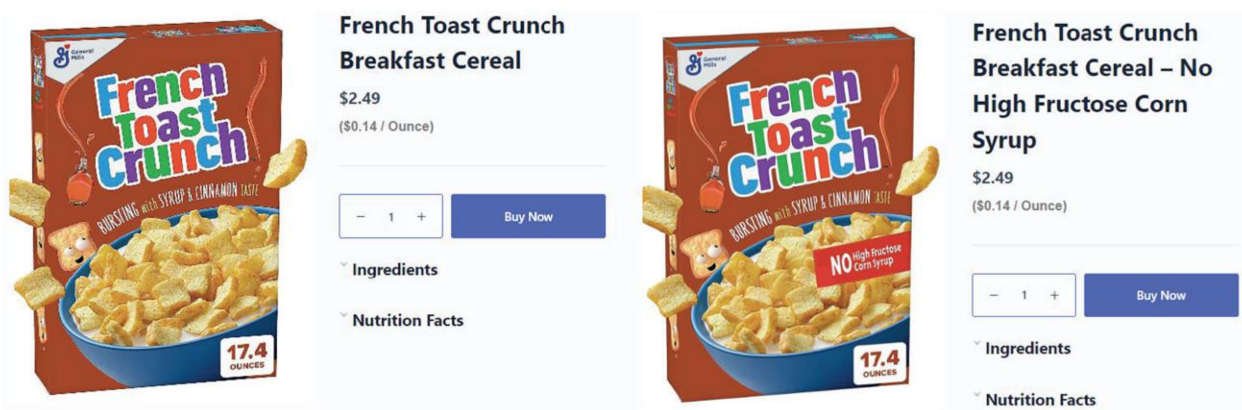
Figure 5. (Color online) List Page



Notes. In Figure 5b, five products contain the label both in the image and in the product title below the image. See highlighted product French Toast Crunch for an example.

Figure 6. (Color online) Product Page

(a) Control Condition (b) Treatment Condition



out of the study. We note that although this discount might have led to more people purchasing the product in the experiment, to the extent this effect would impact both the control and treatment groups equally, the relative effect of the treatment would still hold. After searching a cereal, participants could either return to the list page (by clicking the "Back" button) to search other products (including ones they had clicked on before), or indicate they would like to terminate the search process and choose that cereal for purchase (by clicking the "Buy Now" button). They could also, at any point, choose to not purchase anything (by clicking the "Quit" button). Once again, participants were made aware of these instructions before entering the website. Also, our design of the website mimics the standard navigation pattern present on most online retailer websites.

After finishing the shopping part of the study, participants filled out a Qualtrics questionnaire that asked questions about their cereal consumption characteristics (frequency of consumption, favorite brand), importance of reading labels, as well as ingredients list when they shop and their knowledge about HFCS. For the two treatment conditions, we asked additional questions: (1) Do you think the label was relevant to your purchase decision? and (2) Do you believe that a product with the label is healthier compared with a product without the label? We recorded basic demographic information on all participants (age, gender, and race), as well as asking them to estimate the amount of sugars per serving for a typical cereal product. If a respondent chose not to purchase but they typically buy cereal, we asked them to estimate the amount of sugars per serving of the cereal they typically buy. For details on all the questions we asked participants (in the order in which they were asked), see Online Appendix F.[14] We also included a manipulation check at the end of the experiment to test whether participants noticed and recalled the presence/absence of each voluntary label in their respective conditions (for the wording used in this manipulation check, see questions 11 and 12 displayed in Figure F.4 in Online Appendix F). Online Appendix G confirms participants were more likely to notice the correct label when it was present.

4.3. Outcomes of Interest

The experiment was designed to capture two outcomes of interest: consumer purchase and search decisions.

4.3.1. Purchase Behavior. The key purchase outcomes we consider are whether participants buy a product, whether they buy a labeled product, and the average sugar content of the products purchased. Note we focus on the total sugars contained in a product, reported in the nutrition facts panel, which contains sugars from all kinds of caloric sweeteners (including sugar and HFCS), enabling comparison of an identical construct across products. We note that added sugars are considered harmful, but not sugars that might naturally be present in foods. For both cereal and ketchup, added and total sugars exhibit a strong correlation, with most sugars coming entirely from added sugars. Our results hold when using added sugars as a dependent variable (Online Appendix H). We also wish to recall that sugar content is balanced across conditions in our experiment, so the choice to buy a labeled product may not imply a choice of a more sugary option (see Table 4).

By examining whether participants are more likely to purchase labeled products in the treatment condition than in the control condition, we can measure whether the "no HFCS" label has a positive impact on demand. By examining the average sugar content of the product purchased across conditions, we can measure whether consumers substitute from low-sugar, from equivalent, or from high-sugar options. This substitution pattern is informative and helps address whether labels can have a positive or a negative effect on consumer choices. If consumers substitute away from low-sugar options, this can lead to worse health outcomes. If they substitute away from equivalent sugar options to a labeled product, the label may help consumers make more informed choices, helping them avoid products that contain HFCS. Finally, if they substitute away from high-sugar options, the label may further help consumers choose healthier products.

4.3.2. Search Behavior. We capture the extent of search in response to the presence of voluntary labels, using the total number of products clicked (clicks into a product page), the amount of information obtained on each product (through inspection of the ingredients and nutritional facts panels), the time spent searching a product, and the time spent on the list page before clicking any products. By examining if the number of clicks (either into the product page or the ingredients and the nutrition facts drop-down menus) decreases when products with the label are present (treatment), we can measure if the "no HFCS" label affects search behavior.

4.4. Results

The cereal study was preregistered at AsPredicted (#150420) and was launched on the Prolific platform on January 9, 2024. The sample size was predetermined to be 1,000 per condition.[15] Data collection was completed in one day, with a total of 2,938 participants recruited. Participants spent approximately 5–7 minutes to complete the experiment and follow-up questions and were each compensated $1.40. In addition, all participants were entered into a lottery for the award worth $10. Online Appendix G performs a randomization check and confirms participants randomized into each condition were similar across demographic and behavioral variables we gathered in our study.

4.4.1. Purchase Behavior. As expected, we find voluntary labels in the cereal category have no effect on the average participants' purchases. Table 5 presents the overall purchase propensity (column 1), propensity to buy the labeled products (column 2), and the average sugar content[16] of the purchased products (column 3). This null average effect might arise because, as highlighted in Section 4.1, cereal is frequently consumed or consumers are not expecting the product to be healthy overall, and therefore our manipulation might not provide useful information. This is further confirmed in our manipulation check (Online Appendix G) where participants in the cereal experiment are less attentive to the label (failed the manipulation check frequently): only 46% (40%) of participants correctly indicate seeing the "no HFCS" ("no artificial colors") label in that treatment, compared with 64% (69%) for ketchup.

However, this average masks some relevant heterogeneous responses. We investigate these effects using the following question we asked in the two treatment conditions: Do you believe that a product with the label is healthier compared with a product without the label?[17] Given that all products are HFCS free, the label should not provide any informative value to consumers. Therefore, although cereal is a frequently consumed product and most consumers may be well informed, those who are unsure about the healthiness of cereal with a label may be among those consumers who have worse information. This is the group of consumers we expect will be more affected by the presence of the label. Because this question was asked of consumers only in the two treatment conditions, we compare consumer behavior across these two conditions.

We find that consumers who are unsure whether products carrying the "no HFCS" label are healthier purchase more products overall, although they do not favor products with the "no HFCS" label over those with the "no artificial colors" label. More importantly, we find that these same consumers make worse choices, buying products with more sugar when the "no HFCS" label is displayed compared with when the "no artificial colors" label is present. Table 6 shows the sugar level

Table 5. Estimates of Consumer Purchase Behavior in the Presence of a Voluntary Label

	(1) Purchased a product	(2) Purchased a "no HFCS" product	(3) Purchased sugars
No HFCS	−0.016	0.023	−0.006
	(0.019)	(0.022)	(0.006)
No art. colors	−0.018	0.018	−0.006
	(0.019)	(0.023)	(0.006)
Constant	0.784***	0.447***	0.206***
	(0.013)	(0.016)	(0.004)
Number of observations	2,938	2,938	2,938

Notes. This table presents the estimates for the three purchase-specific dependent variables. Purchased sugars in column 3 are per 100 g of product serving. When a respondent picks the outside option, they are assigned a sugar of 0 g for the regression in column 3; however, results are robust to using their specified typical cereal's sugar content. art., artificial.

$^{+}p < 0.1$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

Table 6. Purchase Differences Across Treatment Conditions: Do You Think a Labeled Product Is Healthier?

	(1) Purchased a product	(2) Purchased a "no HFCS" product	(3) Purchased sugars
No HFCS	−0.055	−0.019	-2.24^{+}
	(0.037)	(0.044)	(1.23)
Constant	0.778***	0.469***	20.85***
	(0.025)	(0.029)	(0.82)
I am not sure	−0.049	0.01	−1.99
	(0.037)	(0.044)	(1.23)
Yes	0.00049	−0.012	−0.66
	(0.032)	(0.038)	(1.05)
No HFCS × I am not sure	**0.116***	**0.005**	**3.97***
	(0.054)	(0.064)	(1.79)
No HFCS × Yes	0.056	0.043	2.4
	(0.046)	(0.055)	(1.52)
Number of observations	1,956	1,956	1,956

Notes. This table presents the estimates for the three purchase-specific dependent variables, interacted with the "no HFCS" label treatment and whether a consumer thinks products with the label are healthier: Yes, No, I am not sure. Estimates for those who indicate "I am not sure" to the question in the "no HFCS" treatment condition are indicated in bold. Only respondents in either treatment condition, "no HFCS" or "no artificial colors," are included in this estimation. Purchased sugars in column 3 are per 100 g of product serving. When a respondent picks the outside option, they are assigned a sugar of 0 g for the regression in column 3; however, results are robust to using their specified typical cereal's sugar content.
$^{+}p < 0.1$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

this group purchases increases by 3.97 g per 100 g of product. This finding indicates the presence of the "no HFCS" label influences purchase behavior over and above the "no artificial colors" label, with participants buying more-sugary products. In other words, our results suggest possible health repercussions if participants are aiming for low-sugar products, because they switch to purchasing nutritionally worse products when the "no HFCS" label is showcased. To a lesser extent, those who think a labeled product is healthier also make worse choices.

These results are only exacerbated in the ketchup category. There we find that the presence of either voluntary label has a significant impact on the type of product purchased: in the presence of the label, even the average participant is more likely to purchase products with more sugar. More details can be found in Online Appendix E.

4.4.2. Search Behavior. Table 7 presents our results on how voluntary labels affect participants' search behavior. Paralleling the null average effects in purchase behavior, we find the label has no significant effect on the average participant's search behavior across various metrics of search considered.

However, once again, we find that the average effect masks a heterogeneous one. More precisely, we see a (significant at the 90% level) reduction in products searched by participants who are unsure as to whether labeled products are healthier than unlabeled ones (Table 8, column 1). To a lesser extent, those who think it is healthier also search less.

Table 7. Estimates of Consumer Search Behavior in the Presence of a Voluntary Label

	(1)	(2)	(3)	(4)	(5)
	Information seeking—clicked into			Time spent searching (seconds)	
	A product page	Ingredient list	Nutrition facts	On the list page	On a product page
No HFCS	−0.03	0.02	−0.024	−3.296	1.156
	(0.073)	(0.023)	(0.023)	(6.44)	(1.149)
No art. colors	0.005	0.031	0.017	−3.274	0.451
	(0.073)	(0.023)	(0.023)	(6.463)	(1.153)
Constant	1.859***	0.471***	0.506***	28.261***	12.549***
	(0.052)	(0.016)	(0.016)	(4.557)	(0.813)
Number of observations	2,938	2,938	2,938	2,938	2,938

Notes. This table presents the estimates for the five search-specific dependent variables. art., artificial.
$^{+}p < 0.1$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

Table 8. Search Differences Across Treatment Conditions: Do You Think a Labeled Product Is Healthier?

	(1)	(2)	(3)	(4)	(5)
	Information seeking—clicked into			Time spent searching (seconds)	
	A product page	Ingredient list	Nutrition facts	On the list page	On a product page
No HFCS	0.162	0.012	0.007	1.393	2.788
	(0.14)	(0.044)	(0.044)	(5.111)	(2.461)
Constant	1.816***	0.486***	0.521***	20.521***	10.494***
	(0.093)	(0.029)	(0.029)	(3.41)	(1.642)
I am not sure	0.102	0.027	0.022	1.583	2.755
	(0.139)	(0.044)	(0.044)	(5.105)	(2.458)
Yes	0.051	0.022	−0.006	8.801*	3.976$^+$
	(0.119)	(0.038)	(0.038)	(4.365)	(2.101)
No HFCS × I am not sure	**−0.383**$^+$	**−0.073**	**−0.103**	**−0.233**	**−3.333**
	(0.203)	(0.064)	(0.064)	(7.432)	(3.578)
No HFCS × Yes	−0.206	−0.014	−0.045	−3.672	−2.934
	(0.172)	(0.055)	(0.055)	(6.317)	(3.041)
Number of observations	1,956	1,956	1,956	1,956	1,956

Notes. This table presents the estimates for the five search-specific dependent variables, interacted with the "no HFCS" label treatment and whether a consumer thinks products with the label are healthier: Yes, No, I am not sure. Estimates for those who indicate "I am not sure" to the question in the "no HFCS" treatment condition are indicated in bold. Only respondents in either treatment condition, "no HFCS" or "no artificial colors," are included in this estimation.

$^+p < 0.1$; $^*p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

In the ketchup category, even stronger patterns emerge. More precisely, we find significant effects of the "no HFCS" label: in the presence of the "no HFCS" label, participants search fewer products, spend less time searching each product, and are less likely to read about ingredient information. More details appear in Online Appendix E.

The results presented in this section are robust to further controlling for participant demographics, favorite-brand indicators, and frequency of consumption (results available upon request).

In sum, as expected, we find voluntary labels have no effect on the average consumer purchase or search behavior. However, we find that among those consumers who have worse information, we see that the label has an effect, and specifically that the effect supports the obfuscation mechanism: consumers with worse information may search less and purchase more-sugary products in the presence of the "no HFCS" label compared with the "no artificial colors" label. These effects are supported by our results in the ketchup experiment as well.

Finally, we would like to note that although certain subsets of consumers choose higher-sugar-content products, in equilibrium, the presence of such voluntary labels may help keep the level of sugars in competing products low, thereby benefiting consumers. Search costs may also now be lower, as consumers get access to relevant information upfront. Our analysis is restricted to sugar content and the potential harms emanating from consuming more sugar and assumes product formulation will not change in the absence of the labels.

5. Economic Significance

Based on our findings from the previous section, labels affect consumer search and purchase decisions and thus can mislead certain subsets of consumers into buying higher-sugar products. To quantify the economic impact of such an effect and to understand the significance of these estimates, in this section, we translate the additional sugars, estimated from both the firm-side data and consumer-side experiment, into calories and into the amount of time gaining an additional pound of body weight would take.

5.1. From Firm-Side Data

Using the estimates from Equation (1) and presented in Table 3, we calculate the number of years gaining an additional pound of weight would take if (1) a consumer were to consume one serving of each category and (2) a consumer were to consume a typical mix of products across categories (i.e., according to the typical food consumption described by the USDA[18]).

We perform our calculations as follows. Taking the "Bars" category as an example, products with the "no HFCS" label have 3.12 g additional sugars per 100 g of the product (column 4, Table 3). For a median serving size of 45 g (column 5, Table 2), this amount translates into 1.41 g additional sugars or 5.62 additional calories from sugar per serving.[19] In the medical community, one pound of body weight is equivalent to 3,500 calories.[20] Therefore, these additional 5.62 calories from sugar per day would accrue to 3,500 calories in 1.71 years. In sum, ignoring consumption of other products and other health repercussions of consuming excess sweeteners, one serving per day of a "Bars" product with the "no HFCS" label (relative to a product without the label, holding all else equal[21]) alone could contribute to an additional pound of body weight in 1.71 years.

Figure 7 plots this estimate across all categories in which a positive significant association between the "no HFCS" label and a product's sugar content was found. In 8 of the 14 categories, gaining an additional pound of weight would take less than two years, by consuming just one serving of any one product per day. At the extreme, these numbers for soda and iced tea are 8 months and 4.5 months, respectively. The estimated number of years to gain an additional pound would further decrease if consumers consume more than one product across these categories per day (e.g., one product in the Bread & Buns category and one product in the iced tea category) or consume more than one serving of a product per day. Overall, this exercise shows the estimates reported in Table 3 are sizable.

Next, we provide an estimate using data provided by the USDA on the amount of pounds per week consumed by a consumer across various food types. Table J.2 in Online Appendix J provides the details of this calculation for a typical male consumer. The total additional sugars consumed per week based on this estimation are 52 grams. This figure implies gaining an additional pound of weight would take just around four months.[22] Note we use only the 14 categories in which the estimates are significant for this calculation, and the USDA does not provide a figure for soda, juice, and ice cream, making our estimate a conservative one (i.e., gaining an additional pound if those categories are included would take fewer months).

5.2. From Consumer-Side Data

Using the estimates from the cereal experiment, for the subgroup of consumers who state they are unsure about a labeled product's healthiness, we find 3.97 g additional sugars per 100 g of product would be consumed in the presence of the "no HFCS" label relative to the "no artificial colors" label (Table 6 and Online Appendix E). Consuming one serving of cereal per day, with a median serving size of 29 g, would amount to an additional pound gained in just under two years.

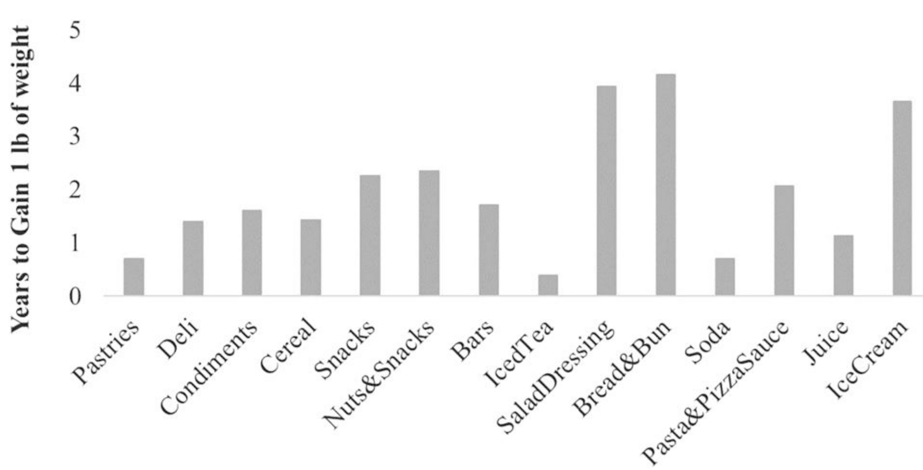
Second, using the results from the ketchup experiment, we estimate that a consumer would consume 0.145 g additional sugars in the presence of the label. Consuming one tablespoon of ketchup a day (one serving) every day for one year translates into an additional 213 calories from sugar consumed per year (0.145 g × 365 days × 4 cal). This consumption rate is a valid estimate given the Statista statistic that ketchup consumption is about 5.08 kg per capita per year or a little under a tablespoon each day.[23] These additional calories would amount to one pound of weight gain in 16 years.

We note that our estimates from the consumer-side experiments are based on a restricted sample of products, that is, not based on choices among all available products in the marketplace. Nevertheless, taken together, the firm- and consumer-side computations give us a range for the potential severity of misleading consumers into consuming more-sugary products in the presence of the label, even when nonsugary options exist (and which are chosen in the absence of a label). The cereal estimate is large and consequential. The ketchup estimate is perhaps at the lowest end of the range (with weight gain taking 16 years), but given that consumers might consume products from multiple categories or may consume multiple servings per day, weight gain of one pound may occur faster than predicted solely using this estimate.

5.3. Implications

If consumers demand products with no HFCS, the "no HFCS" label provides relevant information to the consumer. However, in our experiment, we do not find

Figure 7. Products with "No HFCS" Label and Years to Gain One Pound of Weight per Category



Note. The figure displays, for categories where a positive significant association between the label and sugar content was found in Table 3, the number of years it would take to gain an additional pound of weight if one serving of a product with the "no HFCS" label was consumed per day (relative to consuming a product without the label).

evidence for such a demand effect (purchases of products with and without the label are not significantly different).[24] Even in the absence of demand for the label, showcasing the label is not harmful by itself.

Moreover, if demand exists for sugary products, the fact that the labeled products are sweeter is not necessarily problematic. However, the experiment shows that in the absence of the label, certain subsets of participants purchase lower-sugar options, indicating that, at least in the categories we use, even though no strong preference exists for sweet products, consumers might substitute to higher-sugar options in the presence of the label. And, from a health perspective, even if consumers had a preference for more sugar, consuming more sugar is unhealthy.

Together, based on the firm-side analysis, which shows labeled products are typically nutritionally worse, combined with the demand-side analysis, which shows labels influence the quality of products purchased, our results provide evidence that voluntary labeling can lead consumers to make less healthy choices with respect to sugar.

6. Discussion

High-fructose corn syrup is a controversial ingredient that has sparked consumer interest and scientific debate. Many firms use a "no HFCS" label to highlight the fact that their products do not contain HFCS. However, if products that display the "no HFCS" label are nutritionally worse than products without the label, such claims can mislead consumers into thinking they are purchasing a healthier product. If the products with the "no HFCS" label are nutritionally equivalent or feature a better nutritional profile, the presence of the label can help consumers make more informed choices. Therefore, knowing the nutritional profile of such products and the impact of voluntary labels on consumer choices is relevant.

This paper finds products that highlight the "no HFCS" label on their packages are often nutritionally worse, containing more sugars than products not making such a claim. Also, using an incentive-aligned experiment, we show voluntary labels can negatively affect consumers' search and purchase decisions: certain subsets of consumers search less and buy nutritionally worse products in the presence of voluntary labels.

Our findings can help managers decide whether and how voluntary labels should be displayed. In particular, we show both voluntary labels we tested have no effect on overall demand for products in the category, but can shift the types of products purchased, affecting consumer substitution patterns away from low- to high-sugar products. In other words, voluntary labels can affect consumer choices, and therefore, firms should exercise caution when using such labels. Also, voluntary labels affect consumer search behavior and the amount of information consumers gather about products. Therefore, voluntary labels can lead consumers to acquire less information about relevant product characteristics, which can be managerially beneficial or harmful, depending on the importance of those additional characteristics for competition. Thus, our findings reveal strategic opportunities available to firms in the use of voluntary labels.

Our findings also have implications for the debate surrounding whether voluntary labeling by manufacturers should be allowed (O'Neil 2014, CSPI 2023). A potential solution is to standardize voluntary labels so that all products that do not have HFCS always contain the label, minimizing the potential for consumer obfuscation. Such standardization and mandatory labeling practices have been found to be effective in enhancing consumer outcomes in other settings (Ippolito and Mathios 1995, Bollinger et al. 2011, Hobin et al. 2017). At the same time, mandatory labeling can have unintended consequences. Moorman (1998) shows some firms, when forced to display their nutrient information via a regulator, merely increase certain positive nutrients (e.g., vitamins) while not altering any of their negative nutrients (e.g., sodium). Moorman et al. (2012) show nutritional quality was reduced after the enactment of the Nutrition Labeling and Education Act. Researchers have also shown mandatory disclosure can be harmful if consumers wrongly infer the policymaker's motivation behind mandating disclosure (Liaukonyte et al. 2015, Zhang 2016). For example, Zhang (2016) shows a mandated genetically modified organism (GMO) labeling policy can lead consumers to infer GMOs are much more harmful than they actually are. A related policy implication is whether firms are charging higher prices for labeled products that are high in sugar, and we leave this question for future research.

A middle ground to resolve the problems that emanate from voluntary labeling, suggested in Ippolito and Mathios (1990), could be achieved by third-party certification of labels. Precisely because health attributes have multiple dimensions, an agency should evaluate all attributes while certifying a label. As this paper shows, the "no HFCS" label and a product's sugar content are positively correlated and could both be evaluated by a certifying agency to present to consumers a more complete picture of the product's healthiness.

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The researcher(s)' own analyses are calculated (or derived) based in part on data from Nielsen Consumer LLC and marketing databases provided through the NielsenIQ Datasets at the Kilts Center for Marketing Data Center at The University of Chicago Booth School of Business. The conclusions drawn from the NielsenIQ data are those of the researcher(s) and do not reflect the views of NielsenIQ. NielsenIQ is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein. The experimental study was approved by the Institutional Review Board at Georgetown University (IRB ID: STUDY00005874).

Endnotes

[1] In the context of this paper, these claims are not false.

[2] In our analysis, we use both added sugars and total sugars and find robust effects.

[3] More recently, empirical work has shown consumers respond to misleading information as well (Rao and Wang 2017, Chiou and Tucker 2018, Kong and Rao 2021, Rao 2022a, Fong et al. 2023).

[4] Firms were required to report added sugars on nutrition labels only after January 2020 (for manufacturers with over $10m in annual sales) and January 2021 (for manufacturers with under $10m in annual sales). As a result, this variable does not exist for a majority of our data (which end in 2020).

[5] To account for the fact that consumers might consider all products and not just HFCS-free products, we (1) also examine the sugar content of labeled versus all products, and find our results to be robust (see Online Appendix B) and (2) design a consumer-side experiment which can clearly inform whether consumers are more likely to consider/search all products, or search/buy a subset of products in the presence/absence of the label (see Section 4).

[6] Claims can change year over year for the same UPC. Using the precise date when Label Insight recorded the packaging claim ensures accuracy in case such changes occurred in other years.

[7] If consumers consider only a subset of products within a particular subcategory or consider products across various subcategories, the subcategory FE is not sufficient. Our demand-side analysis therefore considers a specific subcategory and directly measures consumer substitution patterns, allowing us to control for such consideration-set differences.

[8] To account for multiple-hypothesis testing, using the Benjamini and Hochberg (1995) correction, which controls for the false discovery rate, we find that out of the original 14 categories, 10 pass the test at the 95% level and the remaining 4 pass the test at the 90% level.

[9] According to the FDA (see FDA 2018), the most commonly used HFCSs are HFCS 42 (used in processed foods, cereals, baked goods, and some beverages) and HFCS 55 (used in soft drinks). The different types of HFCSs are named depending on the concentration of fructose in the product. HFCS 55 contains 55% fructose, and HFCS 42 contains 42% fructose (whereas table sugar contains 50%).

[10] See Softic et al. (2017), where fructose has more harmful metabolic effects than glucose.

[11] Top brands are defined as those that earn a significantly higher portion of revenue (as defined by the 2019 revenue earnings compiled using the RMS data) than the rest of the brands. For example, in the Cereal category, General Mills, Kellogg's, Post, and Quaker account for 30%, 28%, 15%, and 14%, respectively, of revenues earned with the next brand, Nature's Path, earning 2% in the category. The top brands are therefore defined to be General Mills, Kellogg's, Post, and Quaker in the Cereal category. All remaining brands are classified under Other.

[12] Four grams out of 17 g of ketchup is sugar; that is, nearly one-fourth of the ketchup bottle is sugar.

[13] Fabricated products not only would be unrealistic, but also would not allow us to satisfy the incentive-aligned component of the experiment, because we would not be able to ship such products to participants.

[14] Note that we randomized across participants the order in which answer options were displayed.

[15] We determined this number based on a pilot and being able to detect a 1-g difference in purchased sugars. With a standard deviation of 6.74 g across all chosen options, a power calculation with 80% power requires an N of 714. We decided to be on the conservative side and increased the sample size to 1,000.

[16] Note that for this analysis, we assume consumers who do not make a purchase in our experiment will purchase elsewhere a cereal with 0 g of sugar. We also used respondents' average estimated sugar content of the typical product they buy if they chose not to purchase in our experiment. Our results are robust to using the average number they provide, the average sugars in the typical cereal, as well as 0 g.

[17] We also asked participants in the two treatment conditions "Do you think the label was relevant to your purchase?" In Online Appendix I we find an overall demand effect of the "no HFCS" label, where people who state the label was relevant to their purchase buy more of the labeled products only in the "no HFCS" condition (Online Appendix Table I.1, column 1). Examining search behavior, we find a drop in search in the "no HFCS" treatment condition (Online Appendix Table I.2): clicks into nutrition facts drop by 0.058. For the subgroup who state the label was relevant, we see time spent searching declines by 5.37 seconds, but they do investigate more products, perhaps because the label enables them to conduct a more streamlined search.

[18] See https://www.ers.usda.gov/media/8612/priceindexdata.pdf, accessed November 15, 2023.

[19] One gram of sugar = four calories.

[20] See https://www.today.com/health/how-many-calories-in-a-pound-rcna131344, accessed February 15, 2024.

[21] We focus on products without the ingredient HFCS, because these are the products that are legally eligible to make the claim of "no HFCS."

[22] With 1 g sugar equivalent to 4 calories, this estimate amounts to 208 calories per week. With 1 pound of weight equal to 3,500 calories, gaining an additional pound of weight would take 16 weeks or around 4 months.

[23] The source is https://www.statista.com/forecasts/1291201/average-ketchup-consumption-per-capita-in-the-united-states, accessed October 15, 2023.

[24] For the select subset of participants entering the "no HFCS" treatment condition, we do find a demand for products with the label.

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