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Comparing the impact of targeted subsidies and health prompts on choice process variables and food choice: The case of dietary fiber

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Keywords: Subsidy, point-of-decision prompt, fiber, consideration set, food choice, choice process variable, information use

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Abstract
Fiscal tools—taxes and/or subsidies—are increasingly used to address diet-related health problems. However, some studies have found that these tools are markedly more effective if attention is draw to the tax or subsidy, suggesting that the price change alone may go unnoticed in the complex food environments that consumers face. Interventions that prompt individuals to consider health during choice show promise for promoting healthy food choices in both simple laboratory settings and complex, real-world markets. In this pre-registered study, I examine the impact of dietary fiber health prompts and/or dietary fiber subsidies on the per-serving fiber content of foods chosen, the documented set of products considered, and (self-reported) nutrition information use by participants in an online supermarket setting. Participants were randomized to one of four conditions: 1) control, 2) subsidy, 3) fiber prompt, and 4) fiber prompt + subsidy. Results show that both the prompt and prompt + subsidy conditions significantly increase fiber content of foods chosen (with the latter having a larger effect). While all three interventions influence the probability of using nutrition information during food choice and affect the set of products that respondents consider relative to the control condition, the effects were larger for the prompt and prompt + subsidy conditions. A multiple mediation analysis illustrates that both direct and indirect (through the set of products considered and the use of fiber information during choice) pathways lead to the significant overall increase in fiber content of selected foods.

Keywords: Subsidy, point-of-decision prompt, fiber, consideration set, food choice, choice process variable, information use

1. Introduction

Increases in obesity rates and related non-communicable diseases have directed sustained attention to the development of policies to promote healthier food consumption patterns in the US and throughout the world. Though the primary policy strategy in the US has been to provide objective information about the nutritional content of foods, in recent years, fiscal tools (taxes and/or subsidies) that aim to change the relative prices of foods and beverages that vary in healthiness have been studied in experiments and have begun to be adopted in real-world settings. Taxes have been used to discourage consumption of nutrient-poor foods and beverages in certain communities in the United States and in Mexico (Falbe et al., 2016; Taillie et al., 2017; Zhong et al., 2018), while a program designed to encourage consumption of fruits and vegetables among participants in the Supplemental Nutrition Assistance Program (SNAP) subsidizes consumption of those products (Durward et al., 2019).

A potential force limiting the impact of fiscal tools on purchasing behavior is the complexity of retail food markets, resulting in incomplete consideration of products, information, and outcomes by consumers (De Los Santos et al., 2012; Gustafson, 2022; Meißner et al., 2020). While theoretical work on rational incomplete consideration has burgeoned over the past decade (Caplin et al., 2019; Caplin and Dean, 2015; Kimya, 2018; Lleras et al., 2017), empirical studies are limited. Many food and beverage product categories feature dozens to thousands of unique products (Botti and Iyengar, 2006; Fasolo et al., 2009; Gustafson et al., 2016; Zizzo et al., 2021). A recent mobile eye-tracking study found that the majority of consumers in a supermarket considered few items—frequently directly picking the product they purchased off the shelf without examining alternative products or even attributes of the selected product—when making food choices (Machín et al., 2020). Incomplete attention has important implications for the efficacy of taxes or subsidies. Incomplete attention to products or information may cause price changes to go unnoticed. Even if these shoppers do examine prices, changes in relative prices may not be detected if shoppers restrict their attention to a nutritionally homogeneous set of items. Evidence suggests that segments of the population that are highest priority for health promotion interventions, such as individuals with obesity, direct their attention to systematically different types of products than normal weight individuals (Werthmann et al., 2011). In an online shopping experiment, individuals with obesity were significantly less likely to consider healthier items while making food choices than normal weight participants (Gustafson et al., 2021).

There is evidence that inattention is an important factor in consumer response to fiscal policies. For instance, consumers have been found to overspend as a result of inattention to whether sales taxes are included in the initial price (Chetty et al., 2009). In food markets, taxes included in the posted price only affected sales for some products if the shopper's attention was

drawn to its presence by noting it on price-adjacent signage (Donnelly et al., 2021; Zizzo et al., 2021). A large-scale survey of consumers in countries with national taxes on sugar-sweetened beverages found that a significant percentage of consumers were unaware of the tax (Acton et al., 2022).

In this research, we use a complex choice environment—featuring dozens of products in each food category—that gives participants the option to direct their attention to all products or a subset of products and documents the set of products that are considered during the choice process to study the impact of a subsidy applied to high-fiber products on the per-serving fiber content of choices. Participants made choices in three product categories that feature wide variation in per-serving fiber content: breads, ready-to-eat breakfast cereals, and crackers. We compare fiber content in the subsidy condition to a control condition (no subsidy offered); we also implemented two additional conditions. One condition exposed participants to a short message prompting participants to consider the health benefits of dietary fiber, which studies suggest is infrequently considered during choice and poorly understood in the general adult population (Barrett et al., 2020; Gustafson and Rose, 2023, 2022), while in the final condition, participants both received the message about health benefits of dietary fiber and faced subsidized prices for high-fiber foods. Recent research on the impact of messages that draw shoppers' attention to health attributes of foods at the point of decision shows promise in both physical real-world retail (Gustafson et al., 2018; Papies et al., 2014) and experimental, computer-based food choice environments (Arslain et al., 2020). In a study that captured choice-process variables, exposure to health prompts importantly changed multiple elements of the choice process, including the set of products considered and use of nutrition information, both of which contributed significantly to healthier product choices (Arslain et al., 2021b).

This research offers multiple contributions to the literature on promotion of healthy food choices. First, the experimental setting combines myriad products with documentation of incomplete consideration of products and product information. Permitting and documenting incomplete product consideration by participants provides novel evidence of the impact of fiscal policies like subsidies on choice process variables—the sets of products considered and attention to product information—in complex product environments, which importantly influence ultimate product choices. Second, we compare the impact of the subsidy on choice process variables and dietary fiber content of food choices with alternative interventions that draw participants' attention to health impacts of dietary fiber, and further examine the combined effect of providing health benefits of dietary fiber and subsidizing high-fiber products, providing evidence of the comparative impact of different interventions for targeting increased consumption of an important, under-consumed nutrient. Third, we use the documentation of choice process variables to analyze the pathways through which the three interventions influence the per-serving fiber content of foods chosen. We hypothesized that both subsidy and fiber information prompt conditions would lead to 1) consideration of sets of products with higher per-serving fiber content, 2) increased use of product-specific fiber information during food choice, and 3) greater per-serving fiber content in the foods chosen relative to the control condition. Further, we hypothesized that the combined prompt + subsidy condition would yield significant increases in these three outcomes relative to the subsidy, prompt, and control conditions. In the remainder of the article, we present a literature review (section 2), detail the methods and analytical approach (section 3), present results (section 4), and provide discussion and conclusion (section 5).

2. Literature Review

In this research, we combine multiple strands of literature to compare the impacts of fiscal tools and attention-recruiting interventions on food choices. We start by surveying the literature on fiscal tools and then move on to interventions that recruit attention to aspects of the decision.

2.1. Taxes and Subsidies

Taxes, typically used to discourage purchases of unhealthy products, and subsidies, used to encourage purchases of healthy products, have increasingly been tested experimentally and been implemented to shift consumption towards healthier foods and beverages (An, 2013; Berkowitz et al., 2021; Cohen et al., 2017; Cornelsen et al., 2019; Falbe et al., 2016; Taillie et al., 2017; Zhong et al., 2018). The implementation of taxes and/or subsidies changes the relative prices of foods, which should engender healthier choices through substitution and income effects. Policies using taxes to discourage consumption of unhealthy items, such as sugar-sweetened beverages (SSBs) and junk foods, which are highly caloric but nutrient poor have been found to decrease consumption in specific municipalities in the US where they have been implemented, as well as on a larger scale in other countries, such as Mexico (Donnelly et al., 2021; Falbe et al., 2016; Hernández-F et al., 2019; Taillie et al., 2017; Zhong et al., 2018). The decreases in consumption have also been found in specific, high-risk groups, such as low-income households (Falbe et al., 2016).

Programs that aim to encourage consumption of healthy, but under-consumed foods use subsidies or discounts to incentivize the purchase of those items. An early review article of 24 studies conducted in seven countries found robust evidence that subsidizing healthy foods significantly increased purchases of the targeted foods (An, 2013). Recently, the United States Department of Agriculture (USDA) has promoted the scale-up of programs to promote fruit and

vegetable consumption through nutrition incentives grants and produce prescription grants, which are frequently targeted at low-income or high-risk households. An example of programs supported by USDA funding is Double Up Food Bucks (DUFB), an effort to promote increased consumption of fresh produce that arose out of local efforts to improve the diets of low-income households while simultaneously benefiting local farmers. This program has been adopted for implementation with low-income households who participate in the Supplementary Nutrition Assistance Program (SNAP) administered through the USDA (Steele-Adjognon and Weatherspoon, 2017). Analyses of the impact of DUFB on fruit and vegetable purchases and consumption show statistically significant but modest increases (Atoloye et al., 2021; Durward et al., 2019; Steele-Adjognon and Weatherspoon, 2017; Wielenga et al., 2020; Zimmerman et al., 2016).

Experiments, which offer researchers greater control over the choice environment and the ability to implement complementary interventions, have been widely used to study tax/subsidy policies alone and in combination with other interventions on food/beverage choices, such as advertising and nudges (Epstein et al., 2010; Forwood et al., 2015; Temple et al., 2016). Some of these studies examine comparative effectiveness of taxes and subsidies on key nutritional outcomes, such as calories purchased (Epstein et al., 2015, 2010). While Epstein et al. (2010) find that taxes, but not subsidies, reduce calories purchased, a subsequent study found that taxes and subsidies impacted the energy purchased from the taxed/subsidized items, but did not affect overall calories purchased (Epstein et al. 2015). However, the subsidy condition in this study improved the nutritional profile of the purchased foods.

Many experimental studies examine combinations of fiscal tools and other interventions. For instance, subsidies on fruits and vegetables combined with restrictions on the purchase of

items with low nutrient density were found to be more effective in promoting healthy purchasing patterns than either subsidies or restrictions alone (Harnack et al., 2016). A study integrating taxes and subsidies with nudges identified the combined implemenation of nudges and salient price changes (increases for unhealthy products and decreases for healthy products) as most effective (Hoenink et al., 2020). A secondary analysis of the data from this experiment was used to examine food group-specific changes in choices in response to the tax/subsidy and nudge intervention; results showed that consumers' choices in grain-based, which feature heavily in the products we study, and dairy categories were most responsive to the intervention (Stuber et al., 2021). Research on combinations of taxes, subsidies, and advertising similarly find that combinations of interventions are most effective at changing behavior, though some individual interventions, such as taxing unhealthy foods and advertising healthy foods also significantly decreased calories purchased (Streletskaya et al., 2014).

Systematic reviews and meta-analyses have primarily examined the impact of taxes on SSBs, though a few also examine foods. Meta-analyses on the impact of taxes on SSBs show that these taxes significantly reduce purchase and consumption of SSBs, but that there is quite a bit of heterogeneity in the relationship between the tax rate and changes in consumption across studies (Cawley et al., 2020; Teng et al., 2019). Other meta-analyses find evidence that SSB taxes decrease BMI (Cabrera Escobar et al., 2013). A meta-analysis that examined the impact of taxes and subsidies on the nutritional quality of purchases suggested that taxes and subsidies should be paired to maximize efficacy (Niebylski et al., 2015), while a more recent study found slightly larger effects from subsidies than taxes, and additionally supported the combination of fiscal tools with additional interventions (Afshin et al., 2017).

2.2. Interventions Targeting Consideration of Health during Choice

Recently, interventions targeting active consideration of the health implications of food consumption during the choice process have begun to be tested. There is a vast literature on nudges, a term that has been liberally adopted by researchers and applied to a wide-ranging set of interventions (Van Kleef and Trijp, 2018), including the provision of information to, for instance, communicate the popularity of healthy items (Stuber et al., 2022). Psychological research into cognitive processes and decision-making—especially the distinction between quick judgments using few cognitive resources versus deliberate, cognitively intense judgments—serves as one foundation of the literature on nudging (Vecchio and Cavallo, 2019). Indeed, research suggests that the impact of objective nutrition information—which is sometimes presented as an informational nudge—in food choice occurs more from prompting the consideration of health attributes than providing accurate information (Urminsky and Goswami, 2019). Increasing the salience of nutritional attributes by changing the presentation of objective information or providing dynamically updating information or labels significantly improves the nutritional quality of food choices (Gustafson and Zeballos, 2019; Urminsky and Goswami, 2019; VanEpps et al., 2021).

A literature on directly prompting consideration of health during choice with roots in neuroscience and cognitive methodologies has extended from simple, laboratory settings into real-world markets and more complex experiments in recent years. In an fMRI study, Hare, Malmaud, and Rangel (2011) find that prompting participants to consider health during food choice leads to the choice of foods that are significantly healthier than a choices made in a no-prompt control condition. However, there was no difference between choices in the control condition and in a condition that prompted participants to consider taste preferences during

choice, suggesting that taste preferences are naturally integrated into food choices while health attributes are not. Importantly, participants' neural activity differed between those exposed to the health prompt and those who were in the taste or control condition; those in the health prompt condition had neural activity patterns similar to those of dieters who successfully exerted self-control during choice (Hare et al., 2009).

In a temporally precise mouse-tracking study, (Hare et al., 2011; Sullivan et al., 2015) identified marked differences in the speed with which participants integrated taste and health attributes during food choice, potentially contributing to observed differences in self-control. Building on this research, (Lim et al., 2018) find that among an overweight sample, the provision of calorie labeling speeds up the integration of health attributes during decision-making, engendering healthier decisions overall.

In physical and online retail settings, multiple studies have identified impacts of prompts that explicitly draw attention to health attributes during choice or subtly prime individuals to consider health (Arslain et al., 2020; Gustafson et al., 2018; Papies et al., 2014). In physical supermarkets, both prompts and primes have been found to increase healthy choices. Papies et al. (2014) showed that overweight individuals exposed to a health prime selected significantly fewer unhealthy snacks than either overweight individuals exposed to a neutral prime or normal weight individuals exposed to any prime. Gustafson, Kent, and Prate (2018) report on a health prompt message posted prominently near the entrance to a supermarket in a rural Native American community. Although both nutrition facts panels and a community developed healthy food shelf labeling system were in place (Gustafson et al., 2018; Gustafson and Prate, 2019), a prompt message encouraging the purchase of fruits and vegetables significantly increased the number

and value of healthy foods purchased relative to a no-prompt control, with most of the increase coming from fruits and vegetables.

While this research suggests that prompts (or, in simple settings, information that acts as a prompt (Urminsky and Goswami, 2019)), increases attention to health attributes, the complexity of real-world choice settings, with dozens to hundreds of alternatives in many product categories, means that consumers in the same market may ultimately choose from markedly different sets of products through their own actions to direct attention to particular products or product information. Few empirical economic studies examine implications of incomplete attention in consumer markets, though incomplete consideration has been documented via eye-tracking in small choice sets ($n \leq 16$) in the face of a time constraint (Reutskaja et al., 2011), while other studies have estimated that most consideration sets contain from one to five items per product category (Hauser and Wernerfelt, 1990; Machín et al., 2020; Roberts and Lattin, 1991). Two recent studies used assumptions (rather than collecting choice process data) about consumers' consideration sets to examine the effect of incomplete consideration on valuation estimates. (Campbell et al., 2014) assume participants' consideration sets based on the maximum price at which a participant chose an item in a choice experiment and use the inferred consideration set to examine differences in WTP estimates under assumptions of complete versus incomplete consideration. (Gustafson et al., 2016) observed a wine choice made in a supermarket with a large selection (>1000) of American wines by shoppers, who were then invited to participate in an experiment. Participants valued alternative wines from the same price range, under the assumption that relevant alternatives would be similar in price. In both studies, the assumed consideration set significantly changed measures of WTP for attributes relative to a full consideration assumption. A third study directly documented consideration sets from online

shoppers' internet browsing data to investigate online consumer search in book shopping (De Los Santos et al., 2012). Over one-third of consumers paid more than they could have, due to incomplete search behavior. Accounting for incomplete consideration resulted in own-price demand elasticity estimates that were markedly higher than estimates made under the assumption that consumers had considered all available products (and, thus, prices).

In the realm of food choice, a few recent papers have developed an experimental framework to examine food choices conducted via computer, which documents choice process variables, including the set of products people considered and nutrition and price information used during choice. (Arslain et al., 2021b) conducted an experiment that generated data on choice process variables—such as the products actively considered during the choice process, use of information during choice, and the amount of time spent on decision-making—as well as documenting the participants' ultimate choices to build on research on prompt messages in complex choice settings. Using a health prompt focused on dietary fiber, a multiple mediation analysis of the pathways through which the prompt operated showed that exposure to the health message increased the likelihood that consumers considered a healthier set of products, increased the likelihood that they used nutrition information during choice, and additionally directly promoted healthier food choices, resulting in significantly healthier (and higher fiber) food choices. Using a similar framework, but focusing on the set of products considered during choice, (Gustafson et al., 2021) showed that individuals with high body mass index (BMI) scores were significantly more likely to only include lower nutritional quality products in their consideration sets. These consideration sets omitted higher nutritional quality foods that many policies or interventions target, suggesting that—in the absence of efforts to draw their attention to the presence of the policy or intervention—these individuals would not be exposed to the

intervention. In this work, we extend this research to examine subsidies on high-fiber foods in addition to informational prompts studied in earlier work.

3. Methods

The experiment and analysis plans were pre-registered with the Open Science Framework (https://tinyurl.com/2p9bd7rv). The experiment and survey were programmed in Qualtrics (https://www.qualtrics.com); we recruited participants from Prolific (www.prolific.co), an online platform for recruitment of survey participants. Participants received $1.85 to complete the survey, based on an intended hourly rate of just over $10, with an estimated survey completion time of 11 minutes. The average completion time was approximately nine and a half minutes, slightly lower than the estimated time. Data were collected August 20-21, 2021.

Participants completed a survey composed of two parts: i) an experiment on hypothetical food choices and ii) a survey. Prices for the food products were based on then-current prices (in August 2021) of those products at a national supermarket chain. The experiment featured four conditions. In all four conditions, we incorporated a cheap talk script encouraging participants to think about other real-world uses of their money into the instructions to reduce the impact of hypothetical bias on choices (Penn and Hu, 2018).

3.1. Experimental Conditions

The conditions in the experiment on food choices were: 1) a control condition, 2) a subsidy condition, 3) a prompt condition, and 4) a "subsidy + prompt" condition in which participants received a prompt message and faced subsidized prices. In the subsidy condition and subsidy + prompt condition, the prices of food items were reduced from observed market prices

by either 10 or 20 percent, based on the contribution of the per-serving dietary fiber content to recommended daily consumption. Items that provided 10-19 percent of recommended daily consumption of dietary fiber per serving were discounted by 10 percent; those that provided ≥20 percent of recommended daily consumption per serving were discounted by 20 percent. Products that provide those amounts of dietary fiber per-serving are classified as good and excellent sources of fiber, respectively (CFR, 2022). Participants were told how much fiber per serving was necessary for a product to qualify as a good (2.8 grams of fiber/serving) or excellent (5.6 grams of fiber/serving) source of fiber.

In the prompt and prompt + subsidy conditions, participants were exposed to a message that highlighted five of the six FDA-recognized health benefits of dietary fiber; the benefit not specifically mentioned was promoting regularity of bowel movements (U.S. Food and Drug Administration, 2021). We omitted this benefit to frame the message in a way that highlighted less well-known benefits since evidence suggests that people are widely—and in many cases exclusively—aware of this effect of consumption of dietary fiber. The prompt message read, "*How can dietary fiber help you reach your health goals? While some benefits of fiber consumption are well known, dietary fiber has a number of surprising benefits. Benefits that are not widely known include that dietary fiber: 1. Reduces energy intake (by, for example, promoting feelings of fullness), which helps with weight loss; 2. Lowers blood pressure; 3. Increases absorption of important minerals; 4. Lowers blood glucose; 5. Lowers cholesterol levels. Choosing products with higher dietary fiber can help you meet your health goals!*"

3.2. Design of Food Choice Environment and Survey Questions

In the experiment on food choice, participants made hypothetical food choices from three food categories that feature a high percentage of grain-based products and therefore have significant variation in the dietary fiber content per serving. The three categories were breads, ready-to-eat breakfast cereals, and crackers. Each food category featured 33 unique products. Reflecting real-world online food retail environments, participants had the ability to purposefully restrict their attention to a subset of the available products, or they could view all available products. Every product category featured three subsets, each of which contained one-third of the available products.

The subsets were organized based on real-world retailers' practices. For instance, the cereal category of both physical and online retail environments frequently features cereals clustered into groups such as "Kids' Cereals," "Family Favorites," and "Healthy Options." Figure 1 depicts a real-world retail website and brick-and-mortar supermarket, with pre-defined subsets. These subsets collect products that are relatively similar in terms of overall nutritional profiles. We use the same approach, but named the subsets based on examples of the products contained in each subset: "Cereals such as Frosted Flakes, Froot Loops, Reese's Puffs" rather than "Kids' Cereals." These subsets had the additional feature of separating products by a summary measure of nutrition: the Guiding Stars rating of the product (www.guidingstars.com). The Guiding Stars rating system scores nutrient levels of food products to classify them into four categories, ranging from zero (lowest nutritional quality) to three (highest nutritional quality) stars. The subsets in our experiment feature 1) zero (which will be referred to in the paper as the "least healthy set", 2) one (medium healthy), and 3) two or three stars (healthiest). The products, product nutrition and price information, and subset the product belongs to is reported in supplementary materials.

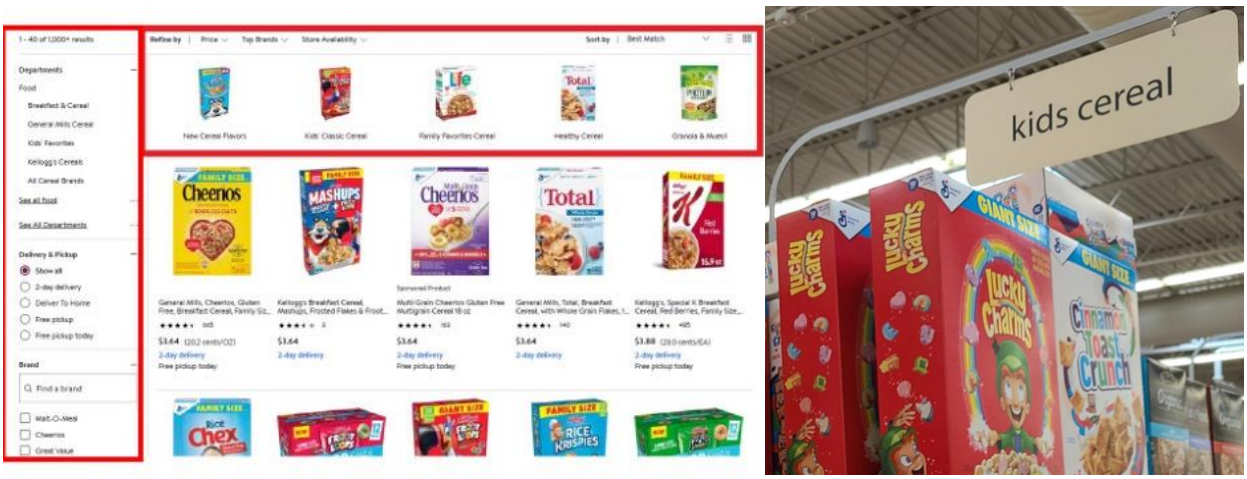

Figure 1: Cereal subsets in online and brick-and-mortar retail environments.

Participants first selected the set of products they wanted to view—all the products, or one of the three subsets—and then viewed the products in the selected set. After selecting the set of products to view, participants chose one of the products in the set of products they selected to choose from; however, they could also indicate that they would not purchase any of the available products. Information about key nutritional attributes that are featured on nutrition facts panels—such as, calories, fat, sodium, sugars, and dietary fiber—were displayed below the picture and name of all the food products in the experiment. After making all product choices, participants were retrospectively asked to indicate nutrition information they had considered during food choice for each food category. Finally, participants responded to standard demographic questions, providing information about their gender, age, education, and household income.

3.3. Data and Analyses

We created a panel dataset of participants' choice data. That is, each participant had one row for data recording their choice in the cereal category, one row for their choice in the bread category, and one row for their choice in the cracker category, resulting in three rows per

participant. The dataset additionally included all data about intermediate choice process variables—the set of products that the participant chose to see in each category, the information they used during choice—and the final product chosen in each choice category, as well as attributes of the product chosen.

We use summary statistics and regression analysis to examine the impact of the subsidy, prompt, and prompt + subsidy conditions relative to the control condition. We use linear regression to examine the impact of the conditions on fiber content per serving, relative to the control condition. The analysis was pooled across different types of products because the focus of the analysis is on the effectiveness of the policy at increasing fiber content in foods chosen rather than, say, preferences for product attributes. Examining outcomes across pooled product categories is a common practice when examining policy impacts for choices made across multiple food categories (see, e.g., (Waterlander et al., 2013)). Robustness checks that add control variables for product category and demographic variables are additionally conducted.

Next, we examine the impact of the conditions on the choice process variables. Interventions or policies may influence ultimate product choices by influencing multiple intermediate elements of the choice process, including the composition of the set of products considered and whether information is used in the choice process, among others. We analyze the choice of consideration set using multinomial logistic regression, using conditions as independent variables. The dependent variable in this analysis is the set of products, or consideration set, that the individual chose to view in each product category. The creation of the sets of products that participants could choose to view is described in section 3.2. As noted in section 3.2, the subsets were motivated by observed retailer product categorizations; in the experiment, products were separated by their Guiding Stars nutritional quality rating into three

categories. The participants' choice of the set of products to view constitutes the dependent variable in this analysis. That is, a participant may have chosen to view the least healthy set of cereals—the set of cereals with zero Guiding Stars—to make a cereal choice, the set of breads with one Guiding Star (medium healthy), and all of the available cracker products; in this case, the dependent variable for that individual would be "least healthy," "moderately healthy," and "all options" for the rows recording cereal, bread, and cracker choices, respectively. The first analysis regresses the consideration set variable on the three conditions subsidy, prompt, and prompt + subsidy (with the control condition omitted). Additional analyses add product category control variables and demographic variables to test the robustness of the results.

Second, we use ordinary logistic regression to examine the impact of conditions on consideration of fiber information during choice. In this analysis, we use the fiber information use variable collected from participants' responses to questions about the use of various pieces of information during product choice (price, as well as nutrition information). This information was collected separately for each product category. If a participant reported examining objective fiber information during their bread choice, then the binary fiber information use variable—the dependent variable—took the value of 1, and 0 if they reported not using fiber information during bread choice. The first analysis regresses the fiber use variable on the three conditions subsidy, prompt, and prompt + subsidy (with the control condition omitted). Additional analyses add product category control variables and demographic variables to test the robustness of the results.

Finally, we examine the contribution of the experimental conditions and the intermediate choice process variables on fiber content using a multiple mediation analysis (VanderWeele, 2016). A multiple mediation analysis (MMA) estimates the direct and indirect effects of an

exogenous variable—the experimental condition in our case—on an outcome variable (the per-serving fiber content of foods chosen in the experiment). The indirect effects that we examine are the consideration set that the individuals select from and the use of fiber information during choice. For the MMA, we rank the consideration sets based on the average nutritional quality—based on Guiding Stars ratings—of the constituent items from 1 (lowest quality) to 4 (highest quality) in order to have an ordered variable. We use the health rank of the consideration set in the analysis to facilitate interpretability of the results. The MMA is conducted by estimating separate models for the impact of the conditions (subsidy, prompt, prompt + subsidy) relative to the control condition. The MMA incorporates three analyses and uses bootstrapping to estimate standard errors for the direct and indirect effects of the conditions on the fiber content of chosen foods (VanderWeele, 2016). The first analysis is a linear regression of the ultimate dependent variable—the fiber content of foods chosen—on the variables condition, the health rank of the consideration set, and the use of fiber information during choice. The second analysis is a regression of consideration set rank on condition, while the third analysis is a regression of fiber information use on condition (these results are represented by the analyses reported in tables 3 and 4). The results from the analyses that comprise the multiple mediation analysis are reported in the supplementary materials.

We use R statistical software to conduct the analyses (R Core Team, 2021) and the Lavaan package in R to conduct the multiple mediation analysis (Rosseel, 2012). The R code used in the analyses are available as supplementary materials. The research was approved by the university's institutional review board. We consider results with p-values < 0.05 to be statistically significant.

4. Results

The demographic characteristics of participants in the different conditions of the experiment are displayed in table 1. Participants in the research were predominantly female (72% pooled across conditions) and just over 30 years old on average. Participants had received an average of slightly over 14 years of education and had an average household income of approximately $67,000. None of the differences between conditions in the demographic variables are statistically significant.

Table 1: Demographic data of participants by condition

	Control Mean	Prompt Mean	Subsidy Mean	Prompt + subsidy Mean
Female (1=Yes)	0.74	0.73	0.72	0.70
Age (Yrs.)	29.9	30.9	29.8	30.5
Education (Yrs.)	14.3	14.5	14.3	14.3
Income ($10K)	65.6	69.9	66.6	66.5

Source: Data from the experiment.
Notes: N=1005; for the calculation of summary statistics, the number of data points were lower for the variables education and income because some individuals indicated that they preferred not to respond to these two questions were not included in the calculation. There were six respondents who declined to respond to the education question and 49 who chose not to respond to the question about household income.

All participants made three choices. However, as in most experiments on consumer choice, participants could indicate that they would not purchase any of the products. A small number of choices—252 out of 3015 choices (or 8.3% of the choices)—made by participants were for "none of these." The average completion time for the survey was just under nine and a half minutes. Participants received $1.85, which had been calculated to provide a per-hour compensation rate of just over $10/hour and an estimated completion time of 11 minutes. There were 35 surveys that were initiated but not completed (which are not included in the total number

of completed surveys reported above); this includes would-be respondents who did not meet the criteria that respondents be ≥19 years of age due to age of majority rules in the researcher's state and were required to "return" the survey. Only 10 would-be respondents who qualified for the study began the survey but did not complete it. The majority of product sets that participants chose to view were subsets of the full set of products: over 70 percent of the product sets viewed across all three product categories were subsets.

4.1 The impact of condition on fiber content of products chosen

Next, we examine the impact of the conditions on the per-serving fiber content of foods selected in the experiment using a multivariate linear regression. We report the results of regression analyses in table 2 (column 1) with controls for product categories (column 2). Raw results and results that include demographic control variables are available in supplementary material table 2.

Table 2: Linear regression of the impact of prompt, subsidy, and prompt + subsidy conditions on the fiber content (g/serving) of products chosen in the choice task

	Estimate (Std. Dev.)	Estimate (Std. Dev.)
Intercept	2.049*** (0.076)	2.007*** (0.089)
Subsidy	0.151 (0.108)	0.150 (0.103)
Prompt	0.357*** (0.108)	0.354*** (0.103)
Prompt + subsidy	0.607*** (0.108)	0.603*** (0.103)
Cereal		0.810*** (0.090)
Crackers		-0.676*** (0.089)

Adj. R2	0.011	0.098

Data: From experiment
Notes: *** = p-value < 0.001; ** = p-value < 0.01.

We find that only conditions that feature a fiber prompt message yield statistically significant increases in per-serving fiber content in foods chosen. The prompt condition results in choices with 0.35 additional grams per serving relative to the control condition (which constitutes a 17.6 percent increase in grams of fiber per serving). The prompt + subsidy condition leads to a 0.60 gram per-serving increase in dietary fiber (a 30 percent increase in grams of fiber per serving). The subsidy condition does not result in a significant increase in per-serving fiber content of foods chosen. Both the prompt ($p<0.05$) and prompt + subsidy ($p<0.001$) conditions significantly increase fiber content relative to the subsidy condition.

4.2 The impact of condition on choice process variables: consideration sets and information use

Next, we examine the impact of condition on choice process variables. First, we examine participants' selection of the set of products to consider, using multinomial logistic regression. We report odds ratios and 95 percent confidence intervals from the analysis in table 3. The model estimates the impact of the intervention conditions (relative to the control condition) on the selection of the medium healthy, healthiest, and all options consideration sets (relative to the least healthy consideration set). The results show that every condition significantly impacts consideration set formation. Participants in the subsidy condition were approximately 1.4 times more likely to view the medium healthy consideration set instead of the least healthy consideration set than those in the control condition. The prompt condition leads participants to be around 1.5 times more likely to view the healthiest set of products than participants in the

control condition and nearly 1.4 times more likely to the view all available options. Participants in the prompt + subsidy condition were more likely to view all consideration sets relative to the least healthy condition. Specifically, they were 1.9 times more likely to choose to view the medium healthy set, 1.8 times more likely to view the healthiest set, and over 1.6 times more likely to choose the all-options set. Participants in the prompt and prompt + subsidy conditions were significantly more likely to view the healthiest set rather than the least healthy set relative to the subsidy condition, while participants in the prompt + subsidy condition were significantly more likely to view the medium healthy set (vs. the least healthy set) relative to participants in the prompt only condition.

Table 3: Multinomial logistic regression of the impact of prompt, subsidy, and prompt + subsidy conditions on selection of consideration set relative to control condition and least healthy consideration set

	1			2		
	Medium Healthy	Healthiest Set	All Options	Medium Healthy	Healthiest Set	All Options
Subsidy	1.39 (1.05, 1.84)	1.12 (0.84, 1.48)	1.29 (0.99, 1.66)	1.40 (1.05, 1.85)	1.12 (0.84, 1.49)	1.29 (0.99, 1.66)
Prompt	1.31 (0.99, 1.75)	1.49 (1.13, 1.97)	1.39 (1.07, 1.79)	1.33 (0.99, 1.77)	1.53 (1.16, 2.03)	1.40 (1.08, 1.82)
Prompt + subsidy	1.91 (1.54, 2.54)	1.82 (1.37, 2.41)	1.64 (1.26, 2.13)	1.93 (1.45, 2.58)	1.87 (1.40, 2.48)	1.65 (1.27, 2.16)
Cereal				0.91 (0.70, 1.17)	0.69 (0.54, 0.88)	0.74 (0.59, 0.94)
Crackers				0.58 (0.45, 0.75)	0.30 (0.23, 0.39)	0.60 (0.48, 0.75)
Intercept	0.53 (0.43, 0.64)	0.57 (0.47, 0.69)	0.75 (0.63, 0.90)	0.66 (0.51, 0.85)	0.93 (0.73, 1.18)	1.00 (0.79, 1.25)

Notes: We report odd ratios and (95 percent confidence intervals) for each condition.

Next, we examine the impact of the conditions on the use of fiber information during food choice using ordinary logistic regression (table 4). We report two versions of the model: one that only includes the conditions and a second that adds the product category.

Table 4: Ordinary logistic regression of the impact of prompt, subsidy, and prompt + subsidy conditions on the use of fiber information during food choice.

	OR (95% CI)	OR (95% CI)
Subsidy	1.778 (1.402, 2.261)	1.785 (1.406, 2.272)
Prompt	2.089 (1.653, 2.649)	2.119 (1.675, 2.689)
Prompt + subsidy	2.318 (1.836, 2.934)	2.345 (1.855, 2.971)
Cereal		0.864 (0.717, 1.041)
Crackers		0.573 (0.470, 0.700)
Intercept	0.219 (0.182, 0.262)	0.272 (0.220, 0.333)
AIC	3681.7	3652.8

All three conditions significantly increase the odds that participants use fiber information during food choice relative to the control condition. Participants in the subsidy condition are nearly 1.8 times more likely to use fiber information than participants in the control condition. Participants in the prompt condition are around 2.1 times more likely to use fiber information, while participants in the prompt + subsidy condition are over 2.3 times more likely to use fiber information during food choice. Participants in the prompt + subsidy condition are additionally significantly more likely to use fiber information than those in the subsidy only condition.

Participants are significantly less likely to use fiber information during cracker choice than during bread choice.

Finally, we conducted a multiple mediation analysis of the impact of each condition relative to the control condition. For the subsidy condition, there is no significant cumulative effect of the intervention (relative to the control condition). While consideration of higher health-ranked consideration sets lead to significantly higher fiber content in the foods chosen by participants, the subsidy did not significantly influence participants to consider higher ranked sets of products. However, there is a significant but relatively small indirect effect of the intervention on the use of fiber information during choice, which promotes choice of higher fiber foods. This pathway leads to 0.06 additional grams of fiber per product ($p<0.01$). Figure 2 presents these results.

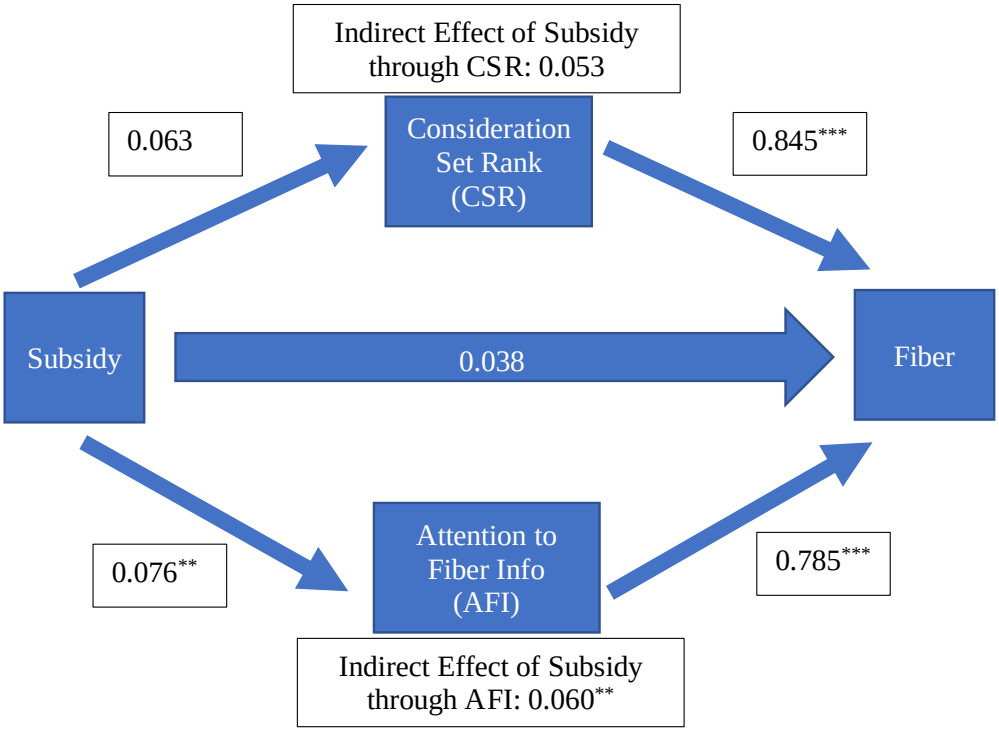

Figure 2: Multiple mediation analysis of the direct effect and indirect effects of the subsidy on fiber content of food choices. Indirect effects were the health rank of the consideration set and use of fiber information during choice (AFI); ***p < 0.001, **p < 0.01.

The other two conditions—prompt and the interactive prompt + subsidy—have significant impacts on increased fiber content through multiple pathways. As shown in table 2, the prompt condition has a cumulative effect of increasing per-serving fiber content by 0.35 grams per product ($p<0.001$). The MMA identifies that approximately 0.26 grams—or about 75 percent of the increase in fiber—comes from changes in the consideration set and increased use of fiber information during choice. Participants in the prompt condition consider a healthier set of products than those in the control condition, which leads to the choice of higher fiber products (0.159 grams of fiber/serving, $p<0.01$) and use fiber information more frequently during food choice (0.09 grams of fiber/serving, $p<0.001$). Figure 3 presents these results.

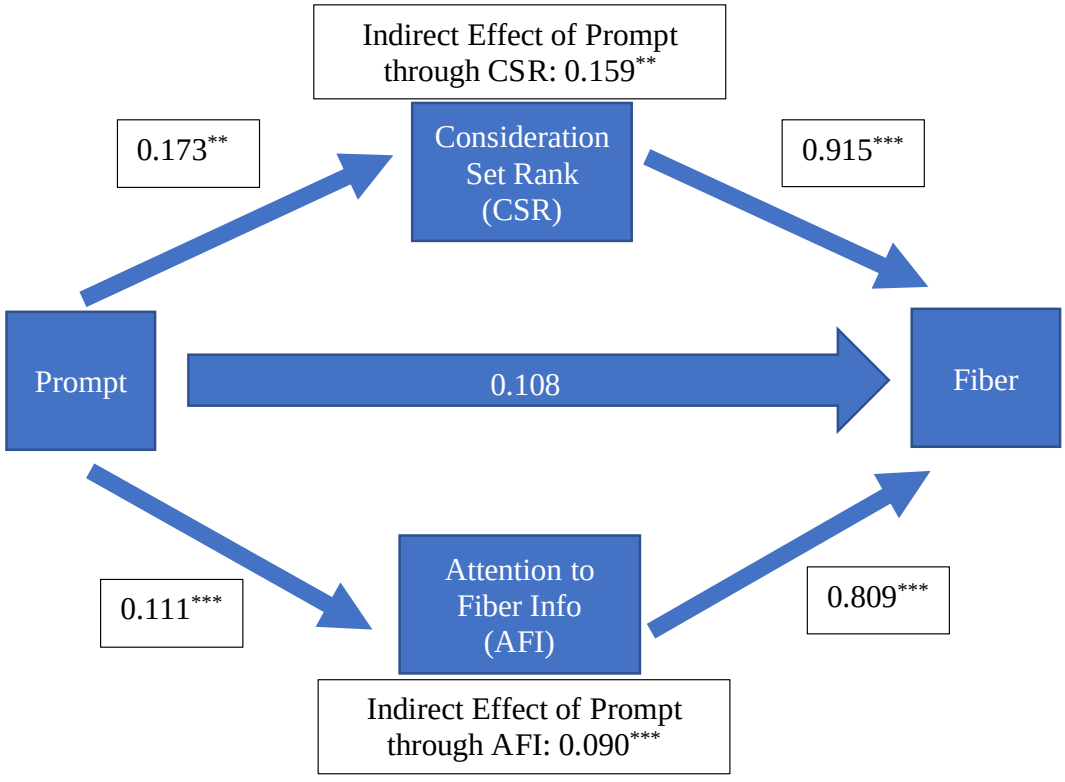

Figure 3: Multiple mediation analysis of the direct effect and indirect effects of the prompt on fiber content of food choices. Indirect effects were the health rank of the consideration set and use of fiber information during choice (AFI); ***p < 0.001, **p < 0.01.

The prompt + subsidy condition has a significant cumulative impact on per-serving fiber content of 0.6 grams per product ($p<0.001$; see table 2). The MMA identifies a significant direct effect of 0.24 grams/serving ($p<0.01$) as well as indirect effects operating through consideration set and use of fiber information. Consideration of a healthier set of products in the prompt + subsidy condition leads to an increase of 0.215 grams per serving ($p<0.001$) relative to the control condition, while increased use of fiber information leads to an additional 0.15 grams per serving ($p<0.001$). Figure 4 presents these results.

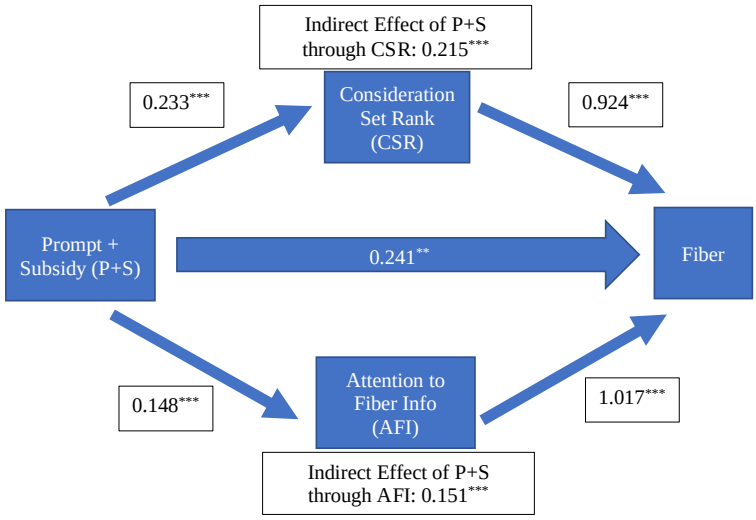

Figure 4: Multiple mediation analysis of the direct effect and indirect effects of the prompt + subsidy (P+S) condition on fiber content of food choices. Indirect effects were the health rank of the consideration set and use of fiber information during choice (AFI); ***p < 0.001, **p < 0.01.

5. Discussion

We find strong evidence that a relatively new approach to healthy food promotion—brief health messages delivered early in the choice process before shoppers have narrowed their attention to a subset of products—may be significantly more effective than widely used approaches, such as provision of objective nutrition information (which was present in all four conditions tested) or

the use of subsidies to decrease the relative price of healthier products. However, our research suggests that interventions combining health messages to motivate choice of healthier foods with traditional policy tools like subsidies provide a larger impact than prompts alone, corroborating results from previous work (Hoenink et al., 2020).

A novel contribution of this research in the evaluation of fiscal policies is the documentation of actions that consumers take that shape their choice environment, such as consideration of a subset of products or using nutrition information during choice. Documenting consideration sets shows that fewer people responded to the announcement of a subsidy on high fiber foods by considering a higher fiber set of products than when specific health benefits of dietary fiber are communicated, likely due in part to low levels of knowledge about the linkages between fiber and health (Barrett et al., 2020; Gustafson and Rose, 2022), though the resulting food choices in the subsidy condition did not contain significantly higher amounts of dietary fiber per serving than in the control. Examining choice process variables also identified that conditions containing the health prompt message made participants much more likely to consider sets of products that contained the healthiest items. All three conditions resulted in consumers being more likely to report using fiber information during choice, but, again, the subsidy condition had the lowest impact of the three.

Dietary fiber has important health implications and research indicates that nutrient-specific tax/subsidy policies are a more efficient means of achieving consumption aims (Harding and Lovenheim, 2017). Consuming foods high in dietary fiber can lower blood cholesterol levels, reduce energy intake by promoting feelings of satiety, help control blood sugar levels, facilitate mineral absorption, promote regularity of bowel movements, and lower blood pressure (U.S. Food and Drug Administration, 2021). A recent cross-over study of highly processed

versus minimally processed foods with matched nutrient profiles—except for the amount of dietary fiber in the foods (which was taken as a supplement in the highly processed diet)—showed that individuals eating ad libitum lost weight on the minimally processed diet and gained weight in the highly processed diet because they consumed about 500 more calories per day in the highly processed condition (Hall et al., 2019).

The Dietary Guidelines for Americans 2020-2025, a document produced by the United States Department of Agriculture and Department of Health and Human Services, lists dietary fiber as a dietary component of public health concern because it is under-consumed by the majority of Americans (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2020). Estimates based on the 2015-2018 National Health Assessment and Examination Survey (NHANES) suggest that only 3 percent of adult men and 6 percent of adult women consume recommended levels of dietary fiber in the US (USDA Agricultural Research Service, 2021).

A recent study focused on dietary fiber consumption that used a large-scale consumer scanner panel dataset estimated that a 20 percent subsidy on fruits and vegetables would lead to a 9.4 percent increase in fiber consumption (Senia et al., 2019). Our results—based on choices in three grain-based food categories—suggest that a 20 percent subsidy on foods that are a great source of dietary fiber (foods that provide 20 percent of the daily recommended amount of dietary fiber per serving) and a 10 percent subsidy on foods that are a good source of dietary fiber (providing 10 percent of the daily recommended amount of dietary fiber per serving) leads to an approximately seven percent increase in fiber content, which is quite close to the effect estimated by (Senia et al., 2019). The prompt, on the other hand, yields a nearly 18 percent increase in per-serving fiber content of the foods selected in the experiment, while the prompt +

subsidy condition increases per-serving fiber content by 30 percent. These results suggest that brief, low-cost interventions that remind or inform people about health, resulting in more consideration of health implications, during food choice may be an important element for promoting healthier food purchases. Recent research has documented the value of reminders in gym attendance (Calzolari and Nardotto, 2017; Habla and Muller, 2021) and in food choice (Gustafson et al., 2018) in real-world settings, potentially by drawing people's attention to otherwise overlooked opportunity costs of choices (Gustafson, 2022; Read et al., 2017; Tuyizere and Gustafson, 2022). The complexity of food retail environments means that health reminders may affect multiple elements of the decision process (Arslain et al., 2021b). We document that subsidies targeting healthy food consumption also affect multiple elements of the decision process, though they are more effective when paired with the health prompt.

Our results shed light on complementary interventions that may enhance the effectiveness of policies targeting the improvement of the nutritional quality of food choices, such as providing objective information about nutrients and the use of fiscal tools to change relative prices. For instance, multiple studies find that a tax on SSBs is only effective if labeling clearly highlights the presence of the tax versus simply incorporating the amount of the tax into the overall price (Donnelly et al., 2021; Zizzo et al., 2021), which may be an example of an intervention reminding people to think about health (Urminsky and Goswami, 2019). In our research, we find that all conditions—including the subsidy only condition—increase use of fiber information during food choice, but exposure to a short message about health benefits of dietary fiber boosts the use of fiber information during choice, particularly when combined with a fiber subsidy, suggesting that the reminder about the health benefits accruing from fiber consumption may have motivated people to seek out fiber more than the message noting that high fiber

products were subsidized due to health benefits of fiber consumption. Additionally, participants who viewed the health benefit message shifted their attention away from the lowest fiber products to sets of products that included the most fiber, particularly when those individuals also could access subsidized high fiber products—resulting in participants in the prompt and prompt + subsidy conditions selecting from sets of products with more fiber on average than participants in the subsidy or control conditions.

In the real world, policies that provide objective information—such as nutrition facts panels—or use fiscal tools to change relative prices of healthy and unhealthy products may fail to motivate people to care about changing their purchasing patterns. A study on changes in electricity use in response to information about the impact of behavior changes on cost savings versus information about health impacts of emissions generated during electricity production found that health information led to significant decreases in energy usage while price information did not (Asensio and Delmas, 2015), while a paper on groundwater valuation found larger impacts resulting from information on impacts on human health than on the environment (Alhassan et al., 2022). Further, if shoppers forget or are unaware of the presence of a tax or subsidy, they may not know relative prices have changed if their consideration set is composed of nutritionally similar food products. Recent in-store research that used mobile eye-tracking to document the number of items individuals considered while shopping showed that many shoppers examined few items—and some cases only one—during choice (Machín et al., 2020), which obviates the comparison of prices or nutrient information among items. While shoppers may have collected product information on previous shopping trips or formed beliefs about relative healthfulness of the products that shaped what they choose to look at, there is significant evidence that people hold inaccurate beliefs about food products, including relative prices and

nutrition/health attributes (Arslain et al., 2021a; Haws et al., 2017), and that those beliefs impact the products considered (Gitungwa and Gustafson, 2022). However, information that corrects inaccurate beliefs changes individuals' willingness to pay for specific food items (Jo et al., 2016), the foods that people choose (Gustafson and Zeballos, 2019), and attention to products (Arslain et al., 2021b).

There are some limitations to this study. For instance, the study featured hypothetical choices. We implemented a cheap talk script to diminish hypothetical bias in people's choices (Penn and Hu, 2018). Nonetheless, it is possible that people may have responded more to the intervention conditions (versus the control condition) than they would in the real world due to experimenter demand effects or social desirability biases (Hebert et al., 1995; Nichols and Maner, 2008). In all three intervention conditions, the instructions signaled a focus on fiber as an outcome of interest via text about subsidization of high-fiber products and/or text about the health benefits of fiber. However, given that all intervention conditions featured text drawing participants' attention to fiber, it is more likely that the relative differences in impact among the three intervention conditions may be driven by the interventions themselves. Further, non-hypothetical research on prompts delivered via an unattended poster at the entrance to a real-world supermarket found that the prompt had a significant impact on purchases (Gustafson et al., 2018), which shows that prompts can have a significant impact on choices even when shoppers are unaware that they are part of a study.

A second potential limitation has to do with timing of the prompt delivery. The (Gustafson et al., 2018) study tested two prompt messages. One prompt focused only on fruits and vegetables, which was the first department in the store that shoppers encountered after entering the store and viewing the prompt poster. A second prompt tested encouraged the choice

of any healthy items, which included produce but also multiple other healthy foods offered in the store. The prompts were identical apart from their focus on fruits and vegetables vs. any healthy foods. These foods—as noted on the prompt poster—were identified by a shelf label that had been developed locally (Gustafson and Prate, 2019). The broader prompt message did not yield a significant increase in healthy purchases, despite fruits and vegetables being a subset of all healthy foods. It may be that the cognitive demands of shopping diminished the efficacy of the broader message. The design and delivery of health information and messaging is a key component of nutrition interventions that require further study to tease out the implications of attention and memory during choice processes in complex environments. We intend to address this further in future research.

6. Conclusions

Overall, we find additional evidence that prompts that communicate information relevant to the broader implications of food choices—such as impacts on health—are important for encouraging healthier choices. Our results suggest that they are more impactful than a subsidy alone, perhaps because people do not truly understand why they should make these healthier choices (Barrett et al., 2020), which limits their motivation to act. However, combining the health prompt with a subsidy has a markedly larger effect than either condition alone and in fact leads to greater increases in per-serving dietary fiber than the additive effect of the subsidy only and prompt only conditions. Combining traditional policy approaches to nutrition promotion—such as nutrient information and tax/subsidy policies—with novel approaches that target attention to the broader health implications of food choices may provide a low-cost way to improve the nutritional quality of choices.

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