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Simulating the Potential Effects of a Shelf-Tag Nutrition Information Program and Pricing on Diet Quality Associated with Ready-to-Eat Cereals[1]

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Abstract

Previous research has shown that the Guiding Stars Program^{TM} (GSP), a shelf-tag nutrition information system used in some supermarkets in the United States (US), increases consumer demand for ready-to-eat (RTE) breakfast cereals that the program considers more nutritious. Further, consumer demand for cereals is found to respond to price. Here we simulate potential changes in RTE cereal consumption predicted by estimated demand if a GSP or a 10% price manipulation were in effect nationwide in the US, and measure the impact on intakes of whole grains, added sugars, sodium, and calories. We find small effects for the GSP and somewhat larger ones for a 10% price intervention.

Keywords: breakfast cereals, Guiding Stars Program, pricing intervention, dietary outcomes

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Introduction

A comparison of actual to recommended food purchasing patterns shows that US consumers typically underspend on healthy foods like whole grains and overspend on refined grains, fats, sugars and sweets (Guthrie et al. 2013). These purchasing patterns translate into poor diets, contributing to obesity, heart disease, stroke, cancer, diabetes, osteoarthritis, and other health conditions that impose considerable economic costs through increased health care expenditures and lost productivity. Medical costs of obesity alone were estimated to be as high as $147 billion, or 10% of all medical costs, in 2008 (Finkelstein et al. 2009; O'Grady and Capretta 2012; Tsai et al. 2011).

Such high social costs make dietary improvement an important public priority. Since 1980, the US government's nutrition policy has been based on the *Dietary Guidelines for Americans* (USDA and USDHHS 2011). These guidelines, updated every five years with input from an independent expert advisory group, draw on the current nutrition science to provide basic advice on what consumers should eat to be healthy. Federal agencies support a wide range of nutrition education efforts to disseminate this information (USDA and USDHHS 2011) and encourage Americans to make healthy food choices.

These informational efforts provide industry with an incentive to develop nutritionally improved products and promote them to health-conscious shoppers (Martinez 2013; Mancino and Kuchler 2012). Over the past two decades, the US market has seen an influx of nutritionally improved products such as lower fat dairy products and whole-grain breads and cereals (Martinez 2013; Mancino and Kuchler 2012; Rahkovsky et al. 2012). Nevertheless, American diets continue to differ from dietary guidelines recommendations.

US law regulates nutrition labeling of packaged foods to promote accurate consumer knowledge of specific products (FDA 2013). The required nutrition label, known as the Nutrition Facts label, appears on most packaged foods in the US, usually on the back or side of the package. Although intended to help shoppers select healthful foods, the Nutrition Facts label is seldom or never used by many consumers and others find it hard to understand (Rahkovsky et al. 2013; Rothman et al. 2006). Some private sector groups in the US and around the world have developed simplified nutrition information guides that may help address this problem (IOM 2012). One such guide is the *Guiding Stars Program*™ (GSP) implemented by Hannaford, a regional supermarket chain in the Northeast of the US (Sutherland et al. 2010). Using metrics designed by an expert group of nutritionists, foods sold in Hannaford supermarkets are placed in one of four categories, from 0 to 3 stars, with more stars indicating higher overall nutritional quality (Fischer et al. 2011). Starred products are identified with shelf tags next to their prices in the store. While this system lacks the detail of the Nutrition Facts label, its simplicity and visibility may lead to its use by many consumers.

Utilizing supermarket scanner data in the US, Rahkovsky et al. (2013) employed an economic model that incorporates factors affecting sales of ready-to-eat (RTE) cereals to evaluate the effect of the GSP in its first 20 months. By analyzing retail purchase data before and after the implementation of the GSP and utilizing a treatment-and-control approach, the GSP was found to result in an increased market share of products that the program considers more nutritious at the cost of products that the program considers less nutritious. In addition, demand was found to be responsive to changes in cereal prices, suggesting that price manipulation might also encourage healthier cereal purchases. This is consistent with previous research finding that price manipulation influences consumption of healthier and less-healthy foods (Todd and Lin 2012; French et al. 2003).

Rahkovsky et al. (2013) provided evidence that the GSP helps consumers make more nutritious food choices, but they stopped short of estimating the effect on the nutritional quality of consumers' diets, which is the goal of private and public dietary interventions. Our research objective is to extend the analysis by Rahkovsky et al. (2013) by examining the potential nutritional impacts of changes in RTE cereal purchases in response to a hypothetical nationwide GSP in the US. Further, we use the RTE cereal demand elasticities generated in that study to simulate the potential dietary outcomes of a pricing intervention strategy. To accomplish our objective, we use a nationally representative food consumption survey data, namely the 2005-08 National Health and Nutrition Examination Survey (NHANES). The NHANES includes information on the foods consumed by a representative sample of Americans and the nutrients obtained from those foods. The nutritional outcomes of interest are intakes of food energy (calories), added sugars, whole grains, and sodium.

We focus on these nutritional outcomes because increasing whole grain intake and decreasing calories, added sugars and sodium are priority recommendations for improving diets and preventing obesity, a major global health problem (USDA and USDHHS 2011; WHO 2004). Intakes of calories, added sugars, and whole grains directly and indirectly affect body weight and RTE cereal choice may significantly affect an individual's overall intake of these dietary components. RTE cereals have been cited as an important source of whole grains (Bachman et al. 2008), but have also been criticized as a source of added sugars (Castetbon et al. 2012; Schwartz et al. 2008). These seemingly contradictory characteristics of RTE cereals arise from the considerable variation in the nutrient content of RTE cereals. Some are formulated to be high in whole grains with little or no added sugars and other ingredients; others are made from refined grains and are high in added sweeteners and other ingredients that may add calories or sodium. Therefore consumer choice within the product category is the key to the nutritional impacts of cereal consumption. Since RTE cereals are eaten on a daily basis by many US consumers, it is plausible that shifts to purchases of healthier cereals could improve overall diet quality.

In addition to examining the effects of the GSP, we also examine the potential effects of a separate, hypothetical price manipulation on cereal purchases and nutritional outcomes. Encouraging healthier food choices either by subsidizing healthier foods or taxing less-healthy choices has been suggested as a policy option (Todd and Lin 2012; Powell and Chaloupka2009). Examining the potential nutritional impacts of the GSP and price manipulation provides policy-relevant information to the public and private sectors. In this study, we also demonstrate that empirical results from food demand studies can be combined with food consumption and nutrition data to estimate dietary outcomes resulting from dietary intervention strategies.

Methods

We begin by briefly summarizing the empirical results on demand for RTE cereals of differing nutritional quality from Rahkovsky et al. (2013) that yield the elasticity estimates we will use in our simulation. We follow with a discussion of the NHANES, our dietary intake data source, and end with an explanation of our simulation approach.

GSP's Effect on Cereal Demand

Hannaford, a US supermarket chain, convened a scientific advisory panel to create the GSP, which evaluates the nutrient content of foods and beverages using nutrition data displayed on the US FDA-regulated Nutrition Facts label and the list of ingredients printed on product packaging (Fischer et al. 2011). An array of nutrients is evaluated, including nutrients that American consumers are encouraged to obtain more of (vitamins and minerals, fiber, and whole grains) and nutrients that American consumers are encouraged to limit (*trans* fatty acids, saturated fatty acids, cholesterol, sodium, and added sugars). For each nutrient, the minimum and maximum threshold values were established and fitted into the Guiding Stars algorithm to generate nutritional scores. A negative score is assigned when a food is rich in nutrient to limit (such as sodium), and a positive score is assigned for high value of a nutrient to encourage (such as fiber). The nutritional scores are totaled for each food, ranging from -24 to 7. The scores are then divided into four categories, from 0 to 3 stars, with more stars indicating higher overall nutritional quality. Because the star value is based on the overall composite nutritional scores, a food with higher star value does not necessarily score higher in every nutrient than a lower-starred food. A food with a star value of 1 to 3, has a tag with corresponding number of stars placed on the shelf next to its price, and a food not awarded a star value has no star in its tag.

Hannaford implemented the GSP in its stores starting in September 2006. Rahkovsky et al. (2013) used scanner data from 13,175 supermarkets in the US, collected between September 2005 and April 2008, to estimate a cereal demand model that assessed the effect of GSP on cereal purchases. There are 134 Hannaford stores in the data, and an equal number of non-Hannaford stores sharing similar characteristics with Hannaford are chosen to facilitate a treatment-control approach.

The approach was incorporated into a Rotterdam demand system (Barten 1964; Theil 1980) such that the effects of prices, income, marketing activities, and demographics on cereal demands were separated out of the GSP effect. The estimated Rotterdam model was used to predict the changes in market shares among the four types of cereals segmented by nutrition attributes and to derive the own- and cross-price demand elasticities among the four types of cereals.

The GSP was estimated to result in a decline of 0-star market share by 2.58 percentage points that are distributed among 1-, 2-, and 3-star cereals by 1.15, 0.89, and 0.54 percentage points, respectively[2]. Rahkovsky et al. (2013) reported four sets of demand elasticities measuring

[2] "0-star" cereals are termed as "unstarred" cereals by Rahkovsky et al. (2013), in the GSP, these cereals do not have any star tag placed on the grocery shelf. We use the term "0-star" for ease in exposition.

consumers' responsiveness to cereal prices before and after GSP at Hannaford (treatment) and control stores (Appendix Table 1). The own-price elasticities (numbers on the diagonal) range from -0.63 to -2.20, which are higher than the demand elasticities reported in the literature of US food demand (Andreyeva et al. 2010). This is expected because of highly aggregated food categories are modeled in the food demand literature, whereas cereals are separated into four categories by Rahkovsky et al. (2013). These four cereals are closer substitutes among themselves than between cereals and other food groups. The homogeneity condition in the economic theory therefore states that the own-price elasticities are larger for a cereal demand system than for a broad food system consisting of cereals and other foods.

National Health and Nutrition Examination Survey Data

Although findings from Rahkovsky et al. (2013) imply that both GSP and price manipulation have potential for improving the nutritional profiles of RTE cereals purchased, the lack of nutrient data in the store purchase data set made it impossible to directly assess the GSP effects on diet quality. To simulate the potential dietary outcomes of a hypothetical nationwide GSP or pricing intervention on cereal consumption, we use data on the food and nutrient intakes of a representative sample of Americans. We obtain these data from the 2005-08 National Health and Nutrition Examination Survey (NHANES), collected by the Centers for Disease Control and Prevention, US Department of Health and Human Services (CDC 2013). NHANES surveys a nationally representative sample of individuals of all ages, with respondents reporting all the foods they consumed over a 24 hour period and the amount of each food that they consumed. This information is used to estimate their nutrient intakes using the USDA's Food and Nutrient Database for Dietary Studies (USDA/ARS 2013).

There are more than 7,000 food items reported by NHANES respondents, including 209 unique food product codes for cereals. Each of these cereal product codes includes information on the cereal's nutrient content (including calories and sodium) and food group servings data for added sugars and whole grains (Bowman et al. 2008). Using these data, we evaluated each cereal according to the GSP's scoring algorithm and assigned star rating designation to each of the 209 cereal products. Among the 209 cereals, 72 cereals (34%) are 0-star, 72 are 1-star (34%), followed by 48 (23%) 2-star and the remaining 17 (8%) are 3-star. In terms of US consumption, 1-star cereals have the largest market share of 34%, followed by 2-star (31%), 0-star (30%), and 3-star (5%) (Table 1). On a given day, 36% of Americans consume any cereals, and 13, 15, 11 and 2% of Americans consume 0-, 1-, 2-, and 3-star cereals, respectively (Table 1).

Table 1 reports descriptive statistics on cereals consumed by the US population, as reported in the 2005-08 NHANES and their nutritional quality by GSP star value. The higher rated (starred) cereals are generally more nutritious than the lower rated cereals, although the nutritional differences vary across nutrients examined. As discussed earlier, the GSP algorithm considers all nutrients identified by scientific consensus as having health benefits or risks (Fischer et al. 2011). Therefore, a food with a higher star value does not necessarily have to be superior in every nutrient to a food with a lower star value. The calorie content of cereals declines with star value, from 393 calories per 100 grams of 0-star cereals to 380 calories for 1-star, 354 calories for 2-star, and 327 calories for 3-star. Cereals of 0-star have 9.61 teaspoons (tsp) of added sugars per 100 grams, more than doubled the amount for 1-star (4.53). The added sugars content is particularly low among 3-star cereals with only 0.47 tsp per 100 grams of cereals. Consequently, the energy density of added sugars (tsp per 1,000 calories) is much lower for 3-star cereals than 0-star cereals (1.35 vs. 24.53 tsp per 1,000 calories), and we would expect a larger reduction in added sugars than calorie content by switching from lower starred cereals to higher starred cereals. All of the starred cereals are higher in whole grains than the 0-star cereals, but the 2-star cereals are actually richer in whole grains than the 3-star cereals. The 2- and 3- star cereals are lowest in sodium, with the 3-star cereals particularly low in sodium, but it is actually the 1-star cereal group that has the highest sodium level. These mixed profiles of the starred cereals may result in uneven benefits from use of the GSP across nutrients.

Table 1. Consumption and Nutritional Profile of Ready-to-Eat Breakfast Cereals by GSP Star Rating

	0-star	**1-star**	**2-star**	**3-star**
Percent of consuming population (%)	12.85	14.66	10.96	2.35
Share of the cereal consumption (%)	30.12	33.71	31.19	4.98
Nutrient density per 100 grams of cereals				
Calories (kcal/100 g)	392.59	379.51	354.01	326.51
Added sugars (tsp/100 g)	9.61	4.53	3.15	0.47
Whole grains (oz/100 g)	0.49	0.85	2.34	1.83
Sodium (mg/100 g)	564.40	651.14	472.07	124.76
Nutrient density per 1,000 calories				
Added sugars (tsp/1,000 kcal)	24.53	11.86	9.11	1.35
Whole grains (oz/1,000 kcal)	1.19	2.23	6.58	5.15
Sodium (mg/1,000 kcal)	1432.30	1719.26	1347.58	488.92

Source. 2005-8 National Health and Nutrition Examination Survey, 2 day data.

We assess the changes in consumption of added sugars, whole grains, and sodium in terms of energy density (e.g., ounces of whole grains per 1,000 calories) before and after the GSP or pricing interventions. The density approach addresses the quality of an individual's diet and is used as a key measure of how well an individual's diet adheres to US Federal dietary guidance (Guenther et al. 2007). For calories, we express the outcome as calories (kcal) per 100 grams of cereal.

NHANES also collects demographic and income data on respondents, allowing us to conduct subgroup analyses. Previous research suggests differences in RTE cereal consumption patterns between children and adults (Rahkovsky et al. 2013; Castetbon et al. 2012; Schwartz et al. 2008). In addition, Lin and Yen (2007) found adults living with children consumed fewer servings of whole grains than adults without children, suggesting that adult cereal consumption patterns may differ by presence of children. Therefore, we examine dietary outcomes for children, adults living with children 18 years of age or younger, and other adults. NHANES does not report whether or not children are present in a household. However, it is possible to identify children in NHANES by using food security data, as food security data for children under the age of 18 are answered by an adult in the household. Using data on age and food security for children, we can separate NHANES respondents into children (under the age of 20), adults living with children under the age of 18, and adults who have no children in the household.

We also assess outcomes for individuals living in higher and lower income households. Households are separated into higher and lower income groups using a household income cut-off of 185% of the US government's poverty threshold (the income cutoff for the US Special Supplemental Nutrition Program for Women, Infants, and Children).

Simulation Analysis

For the simulation analysis, we use a population approach.[3] For each of the four star categories of RTE cereals, US cereal consumption is totaled using individual intake data and sample weight. The weighted total consumption is used as the base for simulation of both a nationwide GSP program and a pricing intervention. We conduct the simulations for the population as a whole and for each of the subgroups previously identified. These groups include individuals who may or may not consume cereals. Cereal is consumed by 36% of Americans on a given day. As shown in Table 1, the proportions of the population that consume 0- to 3-star cereals sum to 41%, indicating that only 5% of Americans consume multiple groups of cereals on a given day. In the case of price manipulation, cross-price elasticities are used to estimate the substitution or complementary effects, which cannot be estimated in the case of zero consumption because it remains zero when multiplied by cross-price elasticities. Therefore, simulations cannot be conducted on an individual basis. Instead, our results show the average dietary improvement for the broad population and subgroup-level effects of GSP or pricing interventions.

As shown in AppendixTable 1, there are four sets of demand elasticities that we employ in the simulation. The diagonal numbers are uncompensated own-price elasticities and off-diagonal numbers are cross-price elasticities. We use these elasticities to simulate the effect of a price intervention scenario, in which the price of 0-star cereals is increased by 10% and prices of 2- and 3-star cereals are decreased by 10% while leaving the price of 1-star cereals unchanged. Other price intervention scenarios, such as changing the price of 1-star or different price changes, can also be simulated but are not carried out in this study. We simulate pricing effects for all four sets of demand elasticities and then take a simple average to represent the pricing effect.

When simulating the GSP effects, changes in market shares reported by Rahkovsky et al. (2013) are used to predict shifts in consumption among cereals by star value under the nationwide GSP simulation. The total consumption amount is fixed, meaning that the GSP simulation does not

[3] This population approach differs from the individual-based simulation (Lin et al. 2011). In an individual approach, changes resulting from intervention are estimated for each individual. This individual approach facilitates the detection of a change in status for an individual, for example a change from obese to healthy weight, and then estimates a change in national prevalence of a status, such as reduction in the national obesity rate. As explained later, this approach is inappropriate for this study because consumers usually consume only one type of cereals.

change total cereal consumption, rather it reallocates total consumption among the four cereal categories. In simulating pricing effects, the simulated total consumption amount from the four cereal categories may differ from the observed (before pricing intervention) total consumption amount. Because we use density measures as our nutrient outcome variables, this approach will not affect our assessment of quality changes. It is important to note that the demand elasticities were estimated by a system consisting of four cereal groups; substitutes and complements of cereals were not included due to data limitations. Therefore, cross-price effects between cereals and their related food groups are not captured in the simulation.

As discussed earlier, we use the population approach to simulate dietary improvement. The delta method (Oehlert 1992) can be applied to the variance-covariance of the own- and cross-price demand elasticities to calculate the variances of predicted cereal consumption under each intervention. However, our outcome variables are expressed in terms of density, making it problematic to calculate the variances associated with the observed and predicted densities. We overcome this difficulty by bootstrapping, in which we use unrestricted random sampling method to draw 1,000 sample replicates from the NHANES data. The bootstrapping procedure is implemented by using Proc Surveyselect in SAS (SAS Institute 2009). For each sample, we calculate nutrient density before and after intervention and then from the 1,000 replicates we calculate the means, standard errors, and 99-percent confidence intervals of the means for each nutrient density. The confidence intervals allow us to test whether the nutritional quality of cereal consumption differs by demographics and whether the dietary improvements from interventions are significant.

Results

Appendix Table 2 shows the predicted changes in dietary intakes under a hypothetical nationwide GSP or 10% pricing intervention. The lack of overlap between the confidence intervals for baseline and predicted estimates indicates that both the GSP and the pricing interventions have statistically significant effects, at the 1% probability level, on dietary quality. This is true for the population as a whole, as well as for the subgroups defined by income or age. Appendix Table 2 also shows the ratio of the density of each nutrient before and after intervention. Those ratios indicate that although significant, the effects are small.

Dietary Improvement Associated with a Nationwide GSP for RTE Cereals

Our results predict that a nationwide GSP lead to small increases in whole grains and decreases in added sugars from cereal consumption. At the US population level, the density of added sugars and whole grains improves by 2.5%. The density of calories and sodium is predicted to decline, on average, by less than 1% (Appendix Table 2).

Population subgroups defined by income and age vary in the before-intervention quality of their RTE cereal choices (Appendix Table 2). Higher income individuals consume more nutritious cereals than their lower income counterparts; that is, cereals consumed by higher income individuals are significantly lower in calorie density (370 kcal/100 grams), added sugars (14.71 tsp/1,000 kcal) and sodium density (1379 mg/1,000 kcal) and higher in whole grain density (3.57 ounces/1,000 kcal), as compared with a density of 375 kcal/100 grams and an energy density of

16.22 tsp of added sugars, 1457 mg of sodium, and 2.89 ounces of whole grains per 1,000 calories among low-income adults.

Children consume RTE cereals that are significantly less nutritious than those of adults living with or without children. The differences in added sugars and whole grains are particularly noticeable. On a per-1,000 calorie basis, children consume the most added sugars and least whole grains—18.95 tsp of added sugars and 2.41 ounces of whole grains vs. 15.16 tsp and 3.34 ounces for adults living with children and 12.66 tsp and 3.98 ounces for adults without children. Adults living in households with children eat RTE cereals that are more dense in added sugars and calories and less dense in whole grains than other adults, but not different in sodium density. These results suggest lower income consumers and children would benefit most from changes in RTE cereal choice. The magnitudes of predicted changes from GSP for most subgroups were roughly similar, so although all subgroups improved their nutrient intakes from RTE cereals, the nationwide GSP does not seem to reduce the differences in diet quality by subpopulation groups. The small magnitude of these changes reflects the fact that 1-star cereals gain larger market shares than 2- and 3-star cereals from GSP. Although 1-star cereals are nutritionally superior to 0-star cereals, nutrition profiles by star value (Table 1) indicate that switching from 0-star to 2- and 3-star would lead to larger improvement in the selected nutrients than switching from 0- to 1-star. Further, the dietary improvements vary across nutrients. The added-sugars density of 1-star cereals is less than half that of 0-star cereals (see Table 1), while their whole grain density is 187% of that of 0-star cereals. However, the calorie density of 1-star cereals is not much lower than that of 0-star cereals (97%) and the sodium density is actually higher, so any improvements in calorie and sodium density would have to arise from shifts to 2- and 3-starred cereals.

Dietary Improvement Associated with a Pricing Intervention for RTE Cereals

When we examine the effect of applying a10% price increase to 0-star cereals and a 10% price decrease to 2- and 3-star cereals, we predict an almost 5% decline in the density of added sugars and an increase in the density of whole grains by 7% for the US population as a whole (Appendix Table 2). The predicted improvements in calorie and sodium density are very small at around 1%.

Subgroup analyses indicate similar changes across income and age groups for added sugars, calories, and sodium. For whole grains, there may be some differences in improvements across groups. The lower income individuals, on average, are predicted to improve the whole-grains density more than higher income individuals—8% vs. 6%. On average, children are predicted to improve their whole grains intake more than adults as a result of the pricing intervention than adults—9% for children vs. 6% for adults with children and 5% for adults without children.

We note that a nationwide GSP and a pricing strategy would improve the nutritional quality of RTE cereals consumed, but neither of the intervention is predicted to close the nutritional gap by demographics: lower income individuals continue to have lower whole grain densities than higher income individuals, and children continue to have the lowest whole-grain density of any subgroup examined. These results reflect the fact that the GSP and pricing effects as produced by Rahkovsky et al. (2013) are for the nation and do not vary across population subgroups.

Closing Remarks

RTE cereals eaten by Americans vary considerably in nutritional quality. Cereals in the least nutritious 0-star category, which made up 30% of reported cereal consumption, were highest in density of calories, added sugars, and sodium and lowest in whole grains. Shifting consumption to cereals that GSP rates as more nutritious offers the opportunity for dietary improvement. This is particularly true for lower income individuals and for children (i.e., those younger than 20 years old), whose cereal consumption is of significantly lower nutritional quality with regard to density of calories, added sugars, sodium, and whole grains.

Simplified front-of-package or shelf tag systems of identifying more nutritious choices within a food category have been adopted by several food manufacturers and retailers globally (Fischer et al. 2011; IOM 2012). Rahkovsky et al. (2013) demonstrated that the GSP, one US supermarket's shelf-tag system, can influence RTE cereal purchase choice. Our simulation of the nutritional effects of implementing a hypothetical nationwide GSP indicates that it would lead to statistically significant improvements in diet quality but the effects would be small. It should be noted that these effects are calculated for the population as a whole, including both consumers and non-consumers of RTE cereals. This is similar to the manner in which Bachman et al. (2008) estimated the contribution of major food categories, including RTE cereal, to whole grain and added sugar intakes of Americans, and allows insight into the public health importance of changes identified. Effects on regular cereal consumers would likely be larger.

Effects were not uniform across the nutritional variables of interest, with the GSP intervention having a bigger effect on added sugars and whole grains than on calories and sodium. This is unsurprising given that most of the simulated shift in cereal consumption was from 0-star to 1-star cereals. One-star cereals were considerably superior to 0-star cereals in relationship to added sugars and whole grains but less different in calorie content and actually higher in sodium content. For improvement in calorie or sodium density, more of a shift to the 2- and 3-star cereals would be necessary. The GSP simplifies decision-making for consumers by grouping products according to the program's nutritional criteria, but inevitably in grouping nutrient information there is a trade-off between gains in simplicity and loss in detail. For consumers who are highly concerned about a specific nutrient, such as sodium, the star rating system may not be as satisfactory as the specific information on the Nutrition Facts label. But for the many shoppers who do not regularly read the Nutrition Facts label or have trouble understanding it, the GSP could be helpful.

The nutritional effects of our price manipulation followed a similar pattern to those of the GSP manipulation—higher for added sugars and whole grains than for calories and sodium—but they were of a somewhat larger magnitude. This does not imply that any pricing intervention would be more or less effective than a nationwide GSP, since the effect of a pricing intervention is determined by the magnitude of price changes.

The findings from this study may be useful to policymakers and members of the food industry seeking to provide consumers with healthful options and assist them in making healthful choices. While the US government-mandated Nutrition Facts labels provide detailed nutrition information, simpler information such as the GSP may be easier for some consumers to use. The visibility of a shelf tag may also increase consumers' awareness of nutrition as a factor in their choice decision. As policymakers seek to assess the merits of such systems (IOM 2012), this paper provides information on the potential dietary effects of changes in purchases associated with a shelf-tag labeling system. For food manufacturers and retailers considering the use of a front-of-package or shelf-tag label on their products, it provides information on the likely impacts on customers' diets.

Private-sector pricing strategies such as sales on more nutritious cereals may be helpful in promoting diet and health, especially when paired with nutrition information or health promotion strategies. Price manipulations by the public sector such as taxes on less nutritious cereals or subsidies on more nutritious cereals by the private sector may also encourage consumers to make healthful choices. Food taxes could be regressive, falling more heavily on lower-income consumers, while non-trivial price subsidies could be considerably more costly than informational approaches. These potential consequences make it necessary that the benefits and costs of public interventions such as taxes and subsidies would need to be well-established.

The small effects of GSP and price interventions indicate that other preferences, such as taste, have important influences on choice. This suggests a role for food technologists in improving the taste of nutritionally improved products. Some population subgroups make less nutritious cereal choices than others, particularly children, an issue of current public health concern (Harris et al., 2012). Further improvements in the quality of children's nutritional intakes from RTE cereals may require additional, more targeted interventions, such as development and marketing of more healthful cereals that are appealing to children.

This study investigated potential dietary outcomes of a nutrition information system and a pricing strategy, using the empirical results reported in Rahkovsky et al. (2013). We note several future research needs arising from both studies. These results apply to only one product category, RTE cereals. In participating stores, the GSP rating system is used with a wide range of food items. If the GSP has similar effects on other product categories, for example encouraging more purchases of whole-grain breads, the overall dietary effects of the program could be larger. However, consumers' purchase decisions may vary across product categories with healthfulness of more or less importance in a given category, so further investigation is needed before we can generalize findings.

It should be noted that the elasticities developed by Rahkovsky et al. (2013) used store-level data to estimate cereal demand for the whole population. Demand elasticity may vary across subgroups, which would generate more differences in response to the manipulation and the resulting dietary outcomes. Due to data limitations, the demand model estimated by Rahkovsky et al. (2013) included only four cereal groups but not other foods that are substitutes or complements of cereals. Future research is needed to investigate possible demographic differences in cereal demand and to incorporate other food groups in order to capture the substitution and complementary effects on diet.

References

Andreyeva, T., M. Long, and K. Brownell. 2010. The Impact of Food Prices on Consumption: A Systematic Review of Research on Price Elasticity of Demand for Food. *American Journal of Public Health* 100(2):216-222.

Bachman, J., J. Reedy, A. Subar, and S. Krebs-Smith. 2008. Sources of Food Group Intakes among the US Population, 2001-2002. *Journal American Dietetic Association* 108(5):804-814.

Barten, A.P. 1964. Family Composition, Prices and Expenditure Patterns, edited by P.E. Hart, G. Mills and J.K. Whitaker, J.K. in *Econometric Analysis for National Economic Planning.* Butterworth: London.

Bowman, S., J. Friday, and A. Moshfegh. 2008. *MyPyramid Equivalents Database, 2.0 for USDA Survey Foods, 2003-2004.* (U.S. Department of Agriculture, Economic Research Service) http://www.ars.usda.gov/ba/bhnrc/fsrg.

Castetbon, K., J. Harris, and M. Schwartz. 2012. Purchases of Ready-to-eat Cereals Vary Across US Household Sociodemographic Categories According to Nutritional Value and Advertising Targets. *Public Health Nutrition* 15(8):1456-1465.

Centers for Disease Control and Prevention, National Center for Health Statistics (CDC-NCHS) 2013. *National Health and Nutrition Examination Survey, 2005–2006 and 2007-2008.* (US Department of Health and Human Services) http://www.cdc.gov/nchs/nhanes/wweia.htm.

Finkelstein, E., J. Trogdon, J. Cohen, and W. Dietz. 2009. Annual Medical Spending Attributable To Obesity: Payer-And Service-Specific Estimates. *Health Affairs* 28(5):822-831.

Fischer, L., L. Sutherland, L. Kaley, T. Fox, C. Hasler , J. Nobel, M. Kantor, and J. Blumberg. 2011. Development and Implementation of the Guiding Stars Nutrition Guidance Program. *American Journal of Health Promotion* 26(2):55-63.

Food and Drug Administration (FDA). 2013. Labeling & Nutrition. http://www.fda.gov/Food/IngredientsPackagingLabeling/LabelingNutrition/default.htm.

French, S., M. Story, J. Fulkerson, and A. Gerlach. 2003. Food Environment in Secondary Schools: À La Carte, Vending Machines, and Food Policies and Practices. *American Journal of Public Health* 93(7):1161-1168.

Guenther, P., J. Reedy, S. Krebs-Smith, B. Reeve, and P. Basiotis. 2007. *Development and Evaluation of the Healthy Eating Index-2005.* (US Department of Agriculture, Center for Nutrition Policy and Promotion, Washington, DC.)

Guthrie, J., B. Lin, A. Okrent, and R. Volpe. 2013. Americans' Food Choices at Home and Away: How Do They Compare With Recommendations? *Amber Waves* (U.S. Department of Agriculture, Economic Research Service) http://www.ers.usda.gov/amber-waves/2013-february/americans'-food-choices-at-home-and-away.aspx.

Harris, J., M. Schwartz, K. Brownell, V. Sarda, C. Dembek, C. Munsell, C. Shin, A. Ustjanauskas, and M. Weinberg. 2012. *Cereal FACTS 2012: Limited progress in the nutritional quality and marketing of children's cereals.* Yale University. http://www.cerealfacts.org/media/Cereal_FACTS_Report_2012_7.12.pdf

Institute of Medicine (IOM). 2012. *Front-of-Package Nutrition Rating Systems and Symbols: Promoting Healthier Choices*. Washington, DC: The National Academies Press.

Lin, B., and S. Yen. 2007. *The US Grain Consumption Landscape: Who Eats Grain, in What form, Where, and How Much?* Economic Research Service, US Department of Agriculture. Economic Research Report No. 50, 35.

Lin, B., T. Smith, J. Lee, and K. Hall. 2011. Measuring weight outcomes for obesity intervention strategies: The case of a sugar-sweetened beverage tax. *Economics and Human Biology* 9(4): 329–341

Mancino, L. and F. Kuchler. 2012, Demand for Whole-Grain Bread Before and After the Release of the Dietary Guidelines. *Applied Economic Perspectives and Policy* 34(1):76-101.

Mancino, L., F. Kuchler, and E. Leibtag. 2008. Getting Consumers to Eat More Whole-grains: the Role of Policy, Information, and Food Manufacturers. *Food Policy* 33(6):489-496.

Martinez, S. 2013. *Introduction of New Food Products With Voluntary Health- and Nutrition-Related Claims, 1989-2010*. (U.S. Department of Agriculture, Economic Research Service) Economic Information Bulletin No. 108, 54.

Oehlert, G. 1992. A Note on the Delta Method. *American Statistician* 46(1): 27–29.

O'Grady, M. and J. Capretta. 2012. Assessing the Economics of Obesity and Obesity Interventions. (Robert Wood Johnson Foundation). http://www.rwjf.org/files/research/74094.5743.assessingobesityinterventions.0312.pdf

Powell, L. and F. Chaloupka. 2009. Food Prices and Obesity: Evidence and Policy Implications for Taxes and Subsidies. *Milbank Quarterly* 87(1): 229-57

Rahkovsky, I., B. Lin, C. Lin, and J. Lee. 2013. Effects of the Guiding Stars program on Purchases of Ready-to-Eat Cereals with Different Nutritional Attributes. *Food Policy* 43(4): 100-107.

Rahkovsky, I., S. Martinez, and F. Kuchler. 2012. *New Food Choices Free of Trans Fats are Aligning US Diets with Health Recommendations*, (U.S. Department of Agriculture, Economic Research Service) Economic Information Bulletin No. 95. p33.

Rothman, R., R. Housam, H. Weiss, D. Davis, R. Gregory, T. Gebretsadik, A. Shinatni, and T. Elasy. 2006. Patient Understanding of Food Labels: The Role of Literacy and Numeracy. *American Journal of Preventive Medicine* 31(5):391-398. (SAS Institute Inc. 2009). SAS™ User's Guide: Basics, Version 9.2 Edition. Gary, NC: SAS Institute Inc.

Schwartz, M., L. Vartanian, C. Wharton, and K. Brownell. 2008. Examining the Nutritional Quality of Breakfast Cereals Marketed to Children. *Journal of American Dietetic Association* 108(4):702-705.

Sutherland, L., L. Kaley, and L. Fischer. 2010. Guiding Stars: the Effect of a Nutrition Navigation Program on Consumer Purchases at the Supermarket. *American Journal of Clinical Nutrition* 91(4):1090-1094.

Theil, H., 1980. System-wide Explorations in International Economics, Input-Output Analysis, and Marketing Research. North-Holland, New York.

Todd, J. and B. Lin. 2012. What Role Do Food and Beverage Prices Have on Diet and Health Outcomes? *Amber Waves* (U.S. Department of Agriculture, Economic Research Service) http://www.ers.usda.gov/amber-waves/2012-september/what-role-do-food-and-beverage-prices.aspx.

Tsai, A., D. Williamson, and H. Glick. 2011. Direct Medical Cost of Overweight and Obesity in the USA: A Quantative Systematic Review. *Obesity Review* 12(1):50-61.

US Department of Agriculture, Agricultural Research Service. 2013. *USDA National Nutrient Database for Standard Reference*. Release 25. Nutrient Data Laboratory Home Page: http://www.ars.usda.gov/ba/bhnrc/ndl

US Department of Agriculture and US Department of Health and Human Services (USDA and USDHHS). 2011. *Dietary Guidelines for Americans, 2010*. 7th Edition, Washington, D.C.: US Government Printing Office, December.

World Health Organization (WHO). 2004. *Global Strategy on Diet, Physical Activity and Health.* Geneva, Switzerland: World Health Organization.

Appendix

Table 1. Demand elasticity estimates – before and after GSP implementation at Hannaford and control stores

	Before				After			
	Price Elasticity				Price Elasticity			
Hannaford	0-star	1-star	2-star	3-star	0-star	1-star	2-star	3-star
0-star	-1.4861*	0.176*	0.136*	0.0023	-0.9412*	-0.0557*	-0.126*	-0.0486*
1-star	0.8487*	-1.2829*	-0.3501*	-0.043*	0.0543	-0.9291*	0.03	0.0176
2-star	0.779*	-0.4004*	-1.1983*	-0.0033	-0.1333*	0.0357	-0.7143*	-0.0115
3-star	0.2206*	-0.1483*	-0.153*	-0.9188*	-0.247*	0.0608*	-0.0469*	-0.6287*
Control								
0-star	-1.187*	0.1176*	0.1035*	0.0294*	-1.257*	0.1789*	0.1133*	0.0283*
1-star	0.6039*	-1.7925*	-0.0426	0.0856*	0.5708*	-1.8306*	0.7966*	0.0345*
2-star	0.9069*	-0.064	-1.9394*	-0.0283	0.05142*	0.1168*	-1.7459*	-0.0101
3-star	0.7596*	0.4048*	-0.0845	-2.1972*	0.5495*	0.2109*	-0.0413**	-1.8363*

*Statistically different from zero at α = 0.05 level.
** Statistically different from zero at α = 0.10 level.

Table 2. Predicted changes in dietary intakes under a hypothetical nationwide GSP and pricing intervention

	Calories	Added Sugars	Whole Grains	Sodium
	kcal/100 grams	*teaspoon/1,000 kcal*	*ounce/1,000 kcal*	*milligram/1,000 kcal*
	Mean (99% confidence interval)			
US population				
Before intervention	371.97 (371.90, 372.03)	15.23 (15.21, 15.24)	3.33(3.33, 3.34)	1407 (1406, 1408)
National GSP				
After	371.05 (370.98, 371.11)	14.84 (14.83, 14.85)	3.41 (3.41, 3.42)	1403 (1402, 1404)
After/Before*100	99.75	97.47	102.48	99.72
Pricing intervention				
After	369.68 (369.61, 369.75)	14.48(14.47, 14.49)	3.57 (3.56, 3.57)	1391 (1390, 1393)
After/Before*100	99.39	95.12	107.05	98.86
High income				
Before intervention	370.26 (370.18, 370.35)	14.71 (14.70, 14.73)	3.57 (3.56, 3.57)	1379 (1378, 1381)
National GSP				
After	369.33 (369.24, 369.41)	14.33 (14.32, 14.35)	3.65 (3.64, 3.65)	1375 (1373, 1376)
After/Before*100	99.75	97.41	102.32	99.71
Pricing intervention				
After	367.98 (367.90, 368.07)	14.02 (14.01, 14.04)	3.79 (3.78, 3.79)	1362 (1360, 1363)
After/Before*100	99.38	95.31	106.24	98.77
Low income				
Before intervention	375.23 (375.17, 375.30)	16.22 (16.21, 16.24)	2.89 (2.88, 2.89)	1457 (1456, 1459)
National GSP				
After	374.35 (374.28, 374.41)	15.82 (15.81, 15.84)	2.97 (2.97, 2.98)	1454 (1453, 1456)
After/Before*100	99.76	97.53	102.88	99.79
Pricing intervention				
After	373.05 (372.98, 373.12)	15.41 (15.39, 15.43)	3.13 (3.13, 3.14)	1448 (1447, 1450)
After/Before*100	99.42	94.99	108.45	99.38
Children				
Before intervention	383.99 (383.93, 384.05)	18.95 (18.93, 18.96)	2.41 (2.40, 2.41)	1476 (1475, 1477)
National GSP				
After	383.17 (383.11, 383.23)	18.57 (18.56, 18.59)	2.49 (2.49, 2.50)	1473 (1471, 1474)
After/Before*100	99.79	98.03	103.64	99.8
Pricing intervention				
After	382.12 (382.05, 382.18)	18.17 (18.16, 18.19)	2.63 (2.62, 2.64)	1471 (1470, 1472)
After/Before*100	99.51	95.92	109.41	99.66

Table 2. *Continued*

	Calories	Added Sugars	Whole Grains	Sodium
	kcal/100 grams	*teaspoon/1,000 kcal*	*ounce/1,000 kcal*	*milligram/1,000 kcal*
	Mean (99% confidence interval)			
Adults with children				
Before intervention	371.43 (371.31, 371.54)	15.16 (15.13, 15.18)	3.34 (3.33, 3.35)	1385 (1383, 1387)
National GSP				
After	370.51 (370.39, 370.63)	14.78 (14.76, 14.81)	3.41 (3.40, 3.42)	1380 (1378, 1382)
After/Before*100	99.75	97.53	102.17	99.64
Pricing intervention				
After	369.36 (369.24, 369.48)	14.52 (14.50, 14.55)	3.53 (3.53, 3.54)	1367 (1365, 1370)
After/Before*100	99.44	95.82	105.85	98.7
Adults without children				
Before intervention	364.33 (364.22, 364.44)	12.66 (12.65, 12.68)	3.98 (3.98, 3.99)	1372 (1370, 1373)
National GSP				
After	363.51 (363.40, 363.63)	12.27 (12.25, 12.29)	4.07 (4.07, 4.08)	1369 (1367, 1371)
After/Before*100	99.78	96.88	102.24	99.78
Pricing intervention				
After	362.51 (362.39, 362.62)	12.15 (12.13, 12.16)	4.18 (4.17, 4.19)	1356 (1354, 1358)
After/Before*100	99.5	95.92	104.92	98.83