WHOLE GRAINS: ARE THEY WORTH IT?

A Thesis

Presented to

The Faculty of the Department

of Health and Human Performance

University of Houston

In Partial Fulfillment

Of the Requirements for the Degree of

Master of Science of Nutrition

By

Kirstin R. Vollrath, RD, LD

May, 2014

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ABSTRACT

Background: Whole grains are an important component of a healthful, high quality diet. Consumption of whole grains may reduce the risk of cardiovascular disease and is associated with lower body weight. Whole grains are relatively inexpensive when compared to other high quality foods such as fruits and vegetables, lean meat and fish. The cost of whole grain foods is high relative to refined grain foods but this gap has been shrinking in recent years. Substituting whole grains for refined grains may be a cost effective method for increasing diet quality. **Methods:** Observed dietary intake of grain products from 24-hour recalls were matched with national average retail price data and compared to a substitution model diet that meets dietary guidelines for whole grains. Comparisons were made across sociodemographic strata on cost and a subset of nutrients prevalent in grain foods as a measure of diet quality. **Results:** The substitution model diet was more expensive for all sociodemographic groups with larger cost effects for young adults and those with lower levels of income and education. The substitution model diet provided more dietary fiber and magnesium but less folate than observed diets. **Discussion:** Cost may keep some American adults from consuming whole grains at recommended levels. Consuming a diet with whole grains is beneficial for health but should be combined with foods fortified with folic acid to ensure all dietary guidelines are met.

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Introduction

Whole grains are an important component of a healthful, high quality diet. Consumption of whole grains may reduce the risk of cardiovascular disease and is associated with lower body weight. Whole grains may also be associated with reduced incidence of Type 2 Diabetes Mellitus (T2DM) (United States Department of Agriculture (USDA), 2010a). Whole grain foods are good dietary sources of fiber, B vitamins, iron, vitamin E, magnesium and zinc. Dietary fiber is a shortfall nutrient in the American diet identified by the Dietary Guidelines for Americans (DGA) 2010 (USDA, 2010a). Refined grains are milled, which removes the bran and germ. This process strips B vitamins, iron, and fiber. Enrichment does not add these nutrients back in equivalent amounts. In fact, only thiamin, riboflavin, niacin and folate are reintroduced at amounts higher than are originally found in the grain foods. No fiber is included in the enrichment program. Also lost in refinement but not included in the enrichment program are Vitamin B_6, Vitamin E, magnesium and zinc.

For the first time in 2000, the DGA highlighted the health benefits of grain consumption, especially that of whole grains, and distinguished the consumption of grains as a separate guideline from fruits and vegetables. The 2005 DGA quantified the guidelines for grains by recommending that half of all grain intake be from whole grain foods. Because whole grain foods are not included in the enrichment program, the DGA committee did not want to recommend limiting refined grain consumption overmuch (DGA; USDA, 2010a). Enrichment of thiamin, riboflavin and folate have decreased incidence of pellagra, beriberi and neural tube defects since the introduction of the enrichment program in 1938 (Adams, 2013). In 2010, the latest release of the DGA continued to highlight the health benefits of consuming half of total grain intake as whole grains while specifically denouncing saturated fats and added sugars, commonly found in refined grain snacks and desserts. Fewer than 5% of Americans consume the recommended amount of whole grains, relying instead on refined grains (Todd & Lin, 2012)

In 2004, the main sources of total refined grain intake in the American diet were yeast breads (26%), pizza (11%), grain-based desserts (10%) and tortillas, burritos and tacos (8%) (DGA; USDA, 2005). Many of these foods have equivalent products made with whole grains but despite the known health benefits, few consumers choose this option. Personal dietary choice has been predicted by demographic group according to taste, nutrition, cost, convenience and weight control (Glanz, Basil, Maibach, Goldberg, & Snyder, 1998). For low-income families, taste and cost were the key determinants (Drewnowski & Darmon, 2005b). Very few studies have examined taste preferences between whole grain and refined grain foods. One study by Bakke and colleagues found that a large proportion of people like whole wheat bread and refined grain bread equally (Bakke & Vickers, 2007).

If taste preferences are similar with grain food products, cost may be the key determinant in dietary choice of grain foods. Whole grains are relatively inexpensive ($/kcal, $/g, or $/average portion) when compared to other high quality foods such as fruits and vegetables, lean meat and fish (Carlson & Frazão, 2012; Darmon, Darmon, Maillot, & Drewnowski, 2005; Drewnowski, 2010b; Touvier et al., 2010). The cost of whole grain foods is high relative to refined grain foods (Harriman, 2013; Jetter & Cassady, 2006) but this gap has been shrinking in recent years (Mancino & Kuchler, 2011; Todd & Lin, 2012). Substituting whole grains for refined grains may be a cost effective method for increasing diet quality. To date, no studies have examined the relationship of the dietary recommendation for whole grains and cost by demographic group.

Purpose of the Study

The primary goals of this study are to 1) estimate the difference between diet quality, as measured by nutrient density, and diet cost of grain consumption at observed levels and at the recommended guideline level (50% of total grain consumption) across socioeconomic strata, and 2) determine if these differences reflect a change of public health significance. For the purposes of this study, a change of public health significance is a change that is greater than 10% of the recommended daily value (RDV) for individual nutrients. For cost, energy and sugar, which have no RDV, a change of public health significance is a change greater than 10% from the observed intake.

Research Question

1. Are there estimated differences in nutrient density and diet cost between the observed and the modeled diet for different age groups, race/ethnicities, income levels or education levels?
2. Are there changes of public health significance in nutrient density and diet cost between the observed and the modeled diet for different age groups, race/ethnicities, income levels or education levels?

Hypotheses

1. Fiber will change by an amount of public health significance (i.e., 2.5 gm) between observed and modeled diets for males, non-hispanic blacks, young adults (ages 20-

29), lower income individuals (PIR <1, PIR 1-2, PIR 2-3) and those with lower levels of education (< HS, HS/GED) but not for other sociodemographic groups.

2. Vitamin B_6 will change by an amount of public health significance (i.e., 0.2 mg) between observed and modeled diets for males, non-hispanic blacks, young adults (ages 20-29), lower income individuals (PIR <1, PIR 1-2, PIR 2-3) and those with lower levels of education (< HS, HS/GED) but not for other sociodemographic groups.
3. Vitamin E will change by an amount of public health significance (i.e., 2 mg) between observed and modeled diets for males, non-hispanic blacks, young adults (ages 20-29), lower income individuals (PIR <1, PIR 1-2, PIR 2-3) and those with lower levels of education (< HS, HS/GED) but not for other sociodemographic groups.
4. Magnesium will change by an amount of public health significance (i.e., 40 mg) between observed and modeled diets for males, non-hispanic blacks, young adults (ages 20-29), lower income individuals (PIR <1, PIR 1-2, PIR 2-3) and those with lower levels of education (< HS, HS/GED) but not for other sociodemographic groups.
5. Zinc will change by an amount of public health significance (i.e., 1.5 mg) between observed and modeled diets for males, non-hispanic blacks, young adults (ages 20-29), lower income individuals (PIR <1, PIR 1-2, PIR 2-3) and those with lower levels of education (< HS, HS/GED) but not for other sociodemographic groups.
6. Diet cost will change by an amount of public health significance between observed and modeled diets for males, non-hispanic blacks, young adults (ages 20-29), lower

income individuals (PIR <1, PIR 1-2, PIR 2-3) and those with lower levels of education (< HS, HS/GED) but not for other sociodemographic groups.

7. As part of the enrichment program, thiamin will not change by an amount of public health significance (i.e., 0.15 mg) between observed and modeled diets for any sociodemographic group.
8. As part of the enrichment program, folate will not change by an amount of public health significance (i.e., 40 mcg) between observed and modeled diets for any sociodemographic group.
9. As part of the enrichment program, niacin will not change by an amount of public health significance (i.e., 2 mg) between observed and modeled diets for any sociodemographic group.
10. As part of the enrichment program, riboflavin will not change by an amount of public health significance (i.e., 0.17 mg) between observed and modeled diets for any sociodemographic group.
11. As part of the enrichment program, iron will not change by an amount of public health significance (i.e., 1.8 mg) between observed and modeled diets for any sociodemographic group.
12. Utilized in both whole grain and refined grain products, sugar will not change by an amount of public health significance between observed and modeled diets for any sociodemographic group.
13. Utilized in both whole grain and refined grain products, sodium will not change by an amount of public health significance (i.e., 240 gm) between observed and modeled diets for any sociodemographic group.

Review of Related Literature

Historical Perspective

Agricultural Policy

Since the Lincoln administration, the U.S. government has subsidized select crops, including sugar, to meet the demands of consumers (Popkin, 2011). Atwater developed nutrition and agricultural policy at the USDA with the goal of providing adequate protein and energy at a low cost to improve the diets of laborers (Carpenter, 2003). After World War II, the U.S. government began investing heavily in the agricultural sector, particularly in grains and oilseed crops; providing cheap feed for livestock. Agricultural policy has focused on increasing yields while minimizing costs for producers in order to meet the nutritional needs and consumption demands of a growing population. Both nutritional needs and demand have been centered on animal based diets. The last 40 years have seen a decline in the price of soybeans and corn, while the price of fruits and vegetables has increased. (Popkin, 2011). Technology has allowed food processors to provide cheaper calories, often in the form of refined carbohydrates and added fats (Lakdawala, Goldman, & Shang, 2005). The result has been the increased consumption of energy-dense diets (Drewnowski & Darmon, 2005c; Maillot, Darmon, Darmon, Lafay, & Drewnowski, 2007; Popkin, 2011). Energy dense diets typically contain fast foods, snacks and desserts but few whole grains, fruits or vegetables (Martí-Henneberg et al., 1999). Between 1985 and 2000, daily energy intake for adults increased by 300 calories with 46% of this energy increase due to increased refined grain consumption, 24% for added fats and 23% for added sugars (Putnam, Allshouse, & Kantor, 2000). The USDA found that low-income families were more likely to consume lower-cost, energy dense diets (Kaufman, McDonald, Lutz, & Smallwood, 1997). Energy dense diets have been positively associated with total energy intake (Prentice & Poppitt, 1996). Technology in the home has led to decreased levels of physical activity needed to perform typical household tasks (Lakdawala et al., 2005). Energy intake above energy expenditure leads to weight gain. Increased energy intake of nutrient poor diets, coupled with decreased energy expenditure, has led to rising rates of obesity and associated chronic diseases.

Rates of obesity and overweight have been increasing dramatically since 1990 (Ogden, Carroll, Kit, & Flegal, 2012). Recent data show that 72% of men and 64% of women are overweight or obese (Flegal, Carroll, Ogden, & Curtin, 2010). Obesity is more prevalent among those with limited resources, racial-ethnic minorities, and women, especially those with lower income and lower education (Flegal et al., 2010; United States Department of Agriculture, 2010).

It was not until the end of the twentieth century that researchers began to explore the economics of obesity. Most of these efforts focused on costs to society (Keeler, Manning, Newhouse, Sloss, & Wasserman, 1989) and the impact of weight or physical appearance on wages (Hammermesh & Biddle, 1994; Register & Williams, 1990). Research by Lakdawalla and Philipson focused on the relationship between obesity and technological innovation of both agricultural practices as well as in the home. Declining food prices and a decrease in physical activity together were causally linked to increases in weight (Lakdawalla & Philipson, 2009).

At the same time, efforts to model diets on a budget were taking place. Nicole Darmon and her colleagues in France used linear programming to develop a model for food selection when a cost constraint is imposed (Darmon, Ferguson, & Briend, 2002). The group predicted food choices for the average diet based on typically consumed foods found in dietary intake data from a cross-sectional study in the Val-de-Marne area of Paris (n=847). Mean retail food prices were published by the Institut National de la Statistique et des Etudes Economiques (INSEE). Darmon and colleagues attempted to incorporate consumer preference in food selection by basing models on the foods consumed in the average French diet. Results reflected an array of diet costs that forced food choices toward sugar, fat and cereals and low micronutrient density. Budget constraints are likely to result in compromised nutrition (Darmon et al., 2002).

In 2003, Adam Drewnowski presented an economic analysis of fat and sugar. He found that people in higher income countries consume more fat and sugar than people in lower income countries and low-income individuals in higher income countries consume lower quality diets than higher income individuals (Drewnowski, 2003). In this study, Drewnowski proposed an addendum to an economic law developed by Engel in 1857. Engel's law states that the proportion of income spent on food diminishes as income increases. Drewnowski's addendum was that diet structure changes with income as well (Drewnowski, 2003). Lower income families in the U.S. purchase lower cost food items and a greater proportion of fats, sweets and alcohol (Wilde, Ranney, & McNamara, 2000). A behavioral model developed by the USDA in 2002 found that people will first consume less expensive food to maintain energy intake at a lower cost when faced with declining income (Basiotis & Lino, 2003). Combined, these findings led Drewnowski to develop a theoretical framework for examining the relationship of obesity and the food environment with diet cost as the principle intervening factor.

Theoretical Framework

Based on the economic theory of utility maximization, the economic framework for obesity was developed by Drewnowski in 2004. Utility maximization assumes a person will choose to purchase a basket of goods that will provide maximum benefit within any constraints that may exist. In the case of food, there are two constraints that exist. The first is the budget constraint - how much a person has to spend on their food. The second is an energy constraint – the amount of energy each day a person must consume to subsist. This daily energy requirement generally falls between 2000-2500 kcals for an adult (Drewnowski, 2004).

Utility maximization theory assumes individuals will continue to consume additional units of a good until the next unit consumed is equal to or greater than its marginal cost. The marginal cost is the price of an additional unit of the good. The marginal benefit, or the increase in utility from consuming another unit, is the satisfaction derived from consuming that additional unit. In the case of food, that can be the reduction of hunger or pleasure. Each additional unit will provide a diminishing level of benefit. One slice of pizza can provide a great amount of satisfaction but each additional slice of pizza will provide a little less satisfaction than the slice consumed previously until no more pizza is desired or can be afforded.

Preferences determine the variety of goods that comprise the market basket described above. Taste, cost, convenience, nutrition and weight control predict preferences of food choice by demographic group (K Glanz et al., 1998). For low-income families, taste and cost were the key determinants (Drewnowski & Darmon, 2005a). Energy-dense foods and energy dense diets, generally containing a higher proportion of added sugars and fats, have been observed to be highly palatable (Drewnowski, 1998). Energy-dense foods tend to provide dietary energy at a low cost (Drewnowski, 1998). Combined, these findings suggest a high marginal benefit for food consumption, especially those foods that are energy-dense, while imposing only a minimal marginal cost. For low-income families who have a tighter budget constraint, the low cost of energy-dense foods may be a rational choice to maximize utility.

Drewnowski based the energy-cost framework on a model developed and confirmed by Basiotis in 1992 (Drewnowski & Specter, 2004). The Basiotis model showed that as income declines, households consume less expensive foods first in order to maintain energy intake at a lower cost (Basiotis, 1992). Drewnowski added to this theory that households will consume less expensive but more energy-dense foods in this situation. The energy-cost curve framework is depicted in Figure 1.

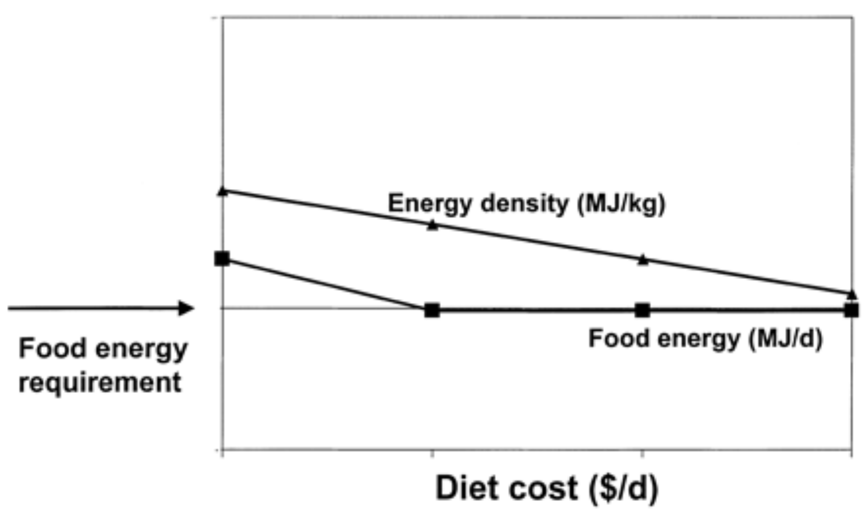

Figure 1. Energy density-cost curve showing the relationship between diet costs, dietary energy density, and energy intakes (Drewnowksi and Specter 2004)

The Economical Diet

In 1894, W.O. Atwater, often considered the founder of USDA nutrition research, published the Farmers Bulletin regarding the nutritive value and cost of food (Atwater, 1894). This was the first known attempt at modeling a high quality diet at the lowest possible cost. At this time, most people in the U.S. spent at least half of their income on food (Atwater, 1894). By 2012, Americans spent 6.1% of income on food consumed at home and an additional 5.3% on foods consumed away from home (USDA, 2013).

Atwater distinguished between cheap foods and economical foods. Cheap foods are those that provide the "most nutriment for the least money," while economical food is "the cheapest and at the same time best adapted to the wants of the eater." Little was known about vitamins and minerals in 1894 and thus Atwater based his economical diet on energy and protein, considered to be the nutrient with the most inadequate intake. The goal of the diet was to provide adequate calories and protein at the least possible price. An example of his work can be seen in Table 1.

Table 1. A Pecuniary Economy of Food in 1894

25 cents will pay for:

Food Item	Total Weight (lb)	Protein (g)	Energy (kcal)
Animal			
Oysters	1.43	40.82	370
Eggs	1.7	95.25	1,115
Milk	8.33	136.08	2,705
Beef, round	3.13	254.01	2,675
Vegetable			
Wheat Flour	12.5	621.42	20,565
Wheat Bread	8.33	358.34	10,680
Potatoes	25	204.12	8,000

Adapted from Atwater's Pecuniary Economy of Food (Atwater 1894)

George Stigler, an economist and nobel laureate, expanded upon Atwater's earlier work. In 1945, he published "The Cost of Subsistence" and attempted, through linear programming, to find the minimum cost of obtaining an adequate amount of calories, protein, vitamins and minerals. The results of his work are depicted in Table 2. Stigler claimed the high cost of conventional diets recommended at the time was unnecessary because the dietitians making the recommendations were factoring in palatability, variety, prestige and other cultural factors of consumption (Stigler, Journal, & May, 2014).

Table 2. – Minimum Cost Annual Diet 1945

Commodity	Quantity	Cost
Wheat Flour	370 pounds	$13.33
Evaporated Milk	57 cans	$3.84
Cabbage	111 pounds	$4.11
Spinach	23 pounds	$1.85
Dried Navy Beans	285 pounds	$16.80
Total		$39.93

Adapted from Stigler's Minimum Cost Annual Diet (Stigler 1945)

In the 1960's, the economy food plan was created as the basis for food stamp allocations. The economy food plan was the precursor for the USDA Thrifty Food Plan (TFP) that is in use today. The TFP has been in place since 1975 with revisions in 1983, 1999 and 2006 (Gerrior, 1995). The TFP is created using non-linear optimization techniques to develop minimum-cost diets with adequate nutrient and energy intake for four levels of income. Nutrient adequacy, for the latest version of the TFP, is based on Recommended Dietary Amounts (RDAs), Adequate Intakes (AI), and Acceptable Macronutrient Ranges (AMDRs), the DGA 2005 (USDA, 2005), and the 2005 MyPyramid food intake recommendations. Foods included in the plan are based upon average consumption patterns of low-income (< 130% of poverty threshold) individuals from the 2001-2002 National Health and Nutrition Examination Survey (NHANES). NHANES is a nationally representative health examination survey that includes 24-hour dietary recalls for participants. Food prices are based upon national average retail food prices in the 2001-2002 Center for Nutrition Policy and Promotion (CNPP) Food Price Database and adjusted for inflation. In December 2013, the TFP cost an estimated $127.60 per week for a family of 4, or approximately $4.56 per person per day (TFP accessed Feb 7, 2014). After the DGA 2005, TFP maximization formulas have included the whole grain recommendation. In a 2005 study comparing a TFP market basket with a healthier market basket alternative, Jetter and Cassady (2006) found that the healthier market basket was more expensive due to the lean meats and poultry as well as whole grain foods (Jetter & Cassady, 2006).

Recent Studies

With rising rates of obesity, some researchers have begun to examine the relationship of diet cost and quality. Causes of obesity are multifactorial and both biological and environmental aspects of obesity have been examined. A clear link between the overconsumption of sugars and fats and obesity has been established (Frazao & Allshouse, 2003; Kant, Schatzkin, Graubard, & Schairer, 2000). Added sugars and fats, associated with low diet quality, have become increasingly cheaper due to technological innovations (Lakdawalla & Philipson, 2009). Approaches to measuring both diet quality and diet cost have differed resulting in different outcomes.

Diet Quality Measures

Assessing overall dietary patterns is an alternative nutritional epidemiological approach to the traditional focus on single nutrients. Diet quality indexes provide a metric for multidimensional aspects of the diet. A description of some of the most popular diet quality metrics follows. In 1995, the USDA developed the Healthy Eating Index (HEI) to quantify adherence to federal dietary guidance outlined in the Dietary Guidelines for Americans (McCullough et al., 2000). The HEI was updated in 2005 to reflect the updated diet recommendations from the DGA 2005 (Guenther, Reedy, & Krebs-Smith, 2008). The Alternative Healthy Eating Index (AHEI) was developed by USDA researchers as an alternative to the HEI in 2002 and was based on foods and nutrients predictive of major chronic disease risk, especially cardiovascular disease (CVD) (Marjorie L McCullough et al., 2002). The AHEI was adjusted in 2010 to include current scientific research (Chiuve et al., 2012). The Recommended Food Score (RFS) was developed in 2000 by Kant et al and based on consumption of foods recommended by current dietary guidelines (Kant et al., 2000). The Diet Quality Index (DQI) was developed in 1994 based on dietary recommendations from Diet and Health, a report from the National Research Council regarding dietary intake patterns and chronic disease (Patterson, Haines, & Popkin, 1994). The DQI was later updated to reflect new dietary guidelines to become the DQR-I (Haines, Siega-Riz, & Popkin, 1999). The alternate Mediterranean Diet Index (aMED) was developed in 1995 based on foods typically consumed in a Mediterranean diet (Trichopoulou, Costacou, Barnia, & Trichopoulos, 2003). All five of these scores have been evaluated for correlation with biomarkers of health. HEI and DQR-I were not significantly associated with any biomarkers for inflammation or risk of CVD (Fung et al., 2005). AHEI and aMED are positively associated with most of these biomarkers and RFS was significantly associated with only one biomarker for CVD (Fung et al., 2005).

Drewnowski and colleagues created the Nutrient Rich Foods Index (NRFI 9.3), which calculates a score for an individual food based on 9 nutrients to encourage as per current federal dietary guidelines, including protein, fiber, Vitamins A, C, E, calcium, iron, magnesium, and potassium, and 3 nutrients to limit, including saturated fat, added sugar and sodium. Use of the index allows for classifying or ranking individual foods based on their healthfulness (Iii, Keast, & Drewnowski, 2009). Drewnowski then used the NRFI 9.3 to determine maximum nutrient-density per food dollar. The NFRI 9.3 score was calculated for each food in the USDA Food and Nutrition Database for Dietary Studies 1.0 (FNDDS 1.0). FNDDS is a database used to code, process and analyze food intake data from NHANES dietary recalls. Cost of each food was also calculated using mean national food prices from the CNPP food price database (Drewnowski, 2010b). Drewnowski found a strong positive relationship between nutrient density and cost and a strong inverse relationship between energy density and cost.

Each of the dietary scoring systems discussed above provides diet quality scores for the total diet based on relative contributions by food group. These diet quality indexes are valuable for assessing overall diet quality but do not indicate consumption patterns for specific components of the diet. The absence of this element makes using diet quality scores ineffective for analyzing detailed intake of particular food types within a food group. For example, the HEI-2005 assigns a sub-score for the grain group between 0 and 5 depending on the total amount of grain consumed and the proportion that is whole grain. If the diet contains adequate grain consumption and at least 50% of grain intake is whole grain, the maximum sub-score of 5 is assigned. If the grain portion of a diet is assigned a sub-score of 2.3, it is impossible to discern which portion of the sub-score is attributable to whole grain intake and which is attributable to total grain intake. Unlike total dietary quality indexes, the NRFI 9.3 attempts to provide a quality measure of individual foods, irrespective of food group. The NFRI is valuable for this quality metric; however, it is limited by the set of nutrients used to calculate the score. Individual food groups tend to contribute a unique subset of nutrients to the overall diet that is not necessarily identical to those included in the NRFI 9.3.

To resolve this issue, Monsivais and Rehm (2012) took an alternative approach by evaluating a substantive, or clinically significant, change in diet quality when substituting whole fruit for fruit juice among children. They used benchmark parameters of nutrients specifically found in the fruit food group. They compared the difference between the observed diet and each model diet to a benchmark threshold change of 10% of recommended daily values for each nutrient (2.5 g fiber, 350 mg potassium, 100 mg calcium, and 6 mg vitamin C). The 10% daily value threshold represented a change of public health significance. Because no RDV for energy intake exists, a difference of 10% between observed and modeled energy intake represented a change of public health significance (Monsivais & Rehm, 2012). All of the models in this study resulted in an increase in diet cost but only the first model represented a substantive change in cost. All substitution models resulted in decreased energy intake and increased fiber; however, vitamin C, calcium and potassium intake was lower in the model diets (Monsivais & Rehm, 2012). The benefit of this approach is that it allows for a greater understanding of relative contributions of particular food types, such as fruit juice versus whole fruit or whole grains versus refined grains, within a food group. Both whole grains and whole fruits provide more fiber and phytochemicals than refined grains or fruit juice. By examining food types within a food group, relative nutritive contributions to the diet can be analyzed in greater detail. A diet index score, such as the HEI-2005, is not able to measure these relative contributions of food type within a food group. As long as total fruit group intake is sufficient, a maximum score for the food group is imparted.

Diet Cost Measures

Similar to diet quality, diet cost metrics differ among studies. The most popular method is the price of food energy ($/kcal) (Drewnowski & Darmon, 2005b). Development economists have long used the price of food energy transition from subsistence, cereal-based diets to more animal-based diets. The price per calorie is an indicator of food choices. Drewnowski's energy density cost framework relies upon the price of food energy, using the price per calorie as a determinant of food choice (Carlson & Frazão, 2012). The USDA has a long history of using the price of food energy since Atwater first developed his table of economical foods (Rao, Afshin, Singh, & Mozaffarian, 2013).

The price of edible weight ($/g) is another metric used to calculate diet cost. Foods are sold in many formats with varying proportions of inedible parts, such as seeds, shells or bones. This method allows for a comparison of the edible portion of foods, excluding inedible refuse (Carlson & Frazão, 2012). Volume, not weight, typically determines serving sizes; therefore, comparing very different foods by weight will not reflect a typical serving size or their relative nutrient density. For example, 1 large apple (223g) is equal in weight to approximately 7.5 cups of raw spinach (FNDDS accessed 2/17/14) (Carlson & Frazão, 2012).

The price of average portions consumed ($/average portion) allows a comparison of the cost of foods in amounts typically eaten in one sitting. Therefore, the cost of a 1-inch slice of watermelon can be compared to a 1-oz package of pretzels in a meaningful way (Carlson & Frazão, 2012). These measures can be useful in assessing the cost of typical intakes across populations but are less useful at the individual level because average portion sizes vary across individuals. For example, a 90-year old woman will eat very different portions sizes than a 20 year-old male. The price per average portion would have to be adjusted appropriately to calculate diet cost for each of these individuals.

Each of these measures requires a food price. Food price data is dynamic and dependent upon geographic and seasonal differences. The federal government provides databases of food prices available at both the commodity level and at the retail price level for different periods of time. Commodity prices reflect the price of the raw materials, while the retail price reflects the consumer purchase price of the finished good.

The Council for Community and Economic Research (C2ER) maintains a database of food price data for specific food items, but the sample is not representative of the U.S. and is skewed toward higher-priced goods typically purchased by high-income households (Council for Community and Economic Research, 2012). The Bureau of Labor Statistics (BLS) uses U.S Census survey data to create the Consumer Price Index (CPI), which represents average expenditures for demographic groups and is inappropriate for use at the individual level (United States Bureau of Labor Statistics, 2007).

The Center for Nutrition Policy and Promotion (CNPP) Food Price Database provides average national prices of foods in their "as-consumed" form. This database was developed using consumed foods from NHANES 2003-2004, the USDA Food and Nutrient Database for Dietary Studies (FNDDS) version 2.0, the National Nutrient Database for Standard Reference (Release 20), and the Nielson Homescan™ Consumer Panel. The purpose of the database is to estimate the cost of foods consumed for 2003-2004. This is the last version of the CNPP database that estimates individual foods costs.

For later cycles of NHANES, the CNPP price database was replaced with the Quality Food at Home Price Database (QFAHPD), which provides weighted average, regional, and quarterly prices for specific subsets of food groups. Because the QFAHPD clustered foods within food groups based on healthy and less healthy options, such as refined and whole grains, it is not appropriate for use for calculating individual diet cost. It is most useful for analyzing aggregate consumption trends (Todd, Mancino, Leibtag, & Tripodo, 2010).

Comparing Diet Cost and Diet Quality

The goal of research on the relationship of diet cost and diet quality has been to determine if healthy food costs more than junk food. Further research has explored the cost of a healthful diet as a mediating factor for obesity in low SES individuals.

Bernstein et al (2010) examined the relationship of food cost to healthfulness of diet among adult females in the U.S. Dietary intake data came from the 2002 Food Frequency Questionnaire (FFQ) from the Nurse's Health Study. Diet quality was represented by AHEI and cost was estimated for $/average portion consumed based on standard serving sizes and food prices from the CNPP database. The results of this study were that spending more money was associated with a healthier diet and the greatest gains in healthfulness may be achieved by increasing spending on nuts, soy, beans and whole grains and less money on red and processed meats as well as high-fat dairy (Bernstein, Bloom, Rosner, Franz, & Willett, 2010). A major limitation of this study is the use of AHEI to assess diet quality, which was unable to discern between nutrient contributions to the diet between refined and whole grains. The authors assumed a cost-effective increase in healthfulness would be attributable to whole grains, since they are more nutrient dense, but no specific comparison was made.

Both Maillot and her colleagues and Drewnowski have analyzed the cost of food groups based on nutrient density (Drewnowski, 2010a; Maillot et al., 2007). Maillot and her colleagues completed an econometric analysis using dietary and retail price data from the French Individuelle Nationale des Consommations Alinmentaires 1 (INCA1) study. They assigned nutrient profiles to 7 major food groups and 25 subgroups based on 23 qualifying nutrients (those positively associated with health) and 3 disqualifying nutrients (saturated fat, added sugar and sodium) (Maillot et al., 2007). Drewnowski used the USDA Food and

Nutrient Database for Dietary Studies (FNDDS 1.0) and national food price data from CNPP to test associations between nutrients and unit price ($/100g). The study compared nutrient density between foods groups along with relationships between energy density and price within food groups (Drewnowski, 2010a). Results from both of these studies found that food groups that are highly nutrient dense are low in energy density and higher in cost than food groups lower in nutrient density.

In 2011, Katz et al (2011) compared prices of more and less nutritious food choices in 6 supermarkets in Jackson County, MO. Foods were categorized for healthfulness by the Nutrition Detectives™ (ND) program and an item-to-item cost comparison was conducted based on posted prices. Their results found that the average price for more nutritious foods did not differ significantly from less nutritious foods overall, but that the price of more nutritious bread cost more than less nutritious bread (Katz et al., 2011).

Todd et al (2012) released a USDA study on geographic differences in the relative price of healthy foods. Data from the QFAHPD was used for all analyses. The authors compared prices per 100 grams of food and found that there are regional differences in average and in relative prices between healthy and unhealthy foods. Some healthier foods, such as low fat milk compared to whole milk, were universally less expensive while others, such as whole grains, were universally more expensive. The authors concluded that difference in relative prices may disproportionately affect lower income households (Todd & Lin, 2012).

Comparing diet cost and diet quality within the context of SES, Jetter and Cassady (2006) conducted market basket surveys in the Los Angeles area to compare the standard market basket for the USDA TFP with a healthier market basket. The healthier basket was comprised of foods similar to the TFP but with food items that were lower in fats and added sugars and higher in fiber from low fat meats, dairy and whole grain products. The purpose of the study was to evaluate cost and availability for both market baskets in neighborhoods with different income levels. Results indicate that many of the healthier food options were unavailable in neighborhoods served by small grocery stores and that higher cost associated with the healthier market basket was, on average, equal to 35% - 40% of low-income consumer's annual food budgets (Jetter & Cassady, 2006).

Rehm et al (2011) examined the relationship of diet quality with diet cost among socioeconomic strata of the U.S. population. Diet quality for observed diets from NHANES 2003-2004 was measured by HEI-2005 and food prices were used from the CNPP food price database. Results showed that higher diet costs were strongly associated with consuming more servings of fruits and vegetables and fewer calories from sold fat, alcoholic beverages and added sugars. Higher income and education and living in a food secure household were also significantly associated with a higher cost diet (Rehm, Monsivais, & Drewnowski, 2011).

Most of the studies discussed above (Bernstein et al., 2010; Drewnowski, 1998; Drewnowski, 2010b; Jetter & Cassady, 2006; Maillot et al., 2007; Monsivais, Mclain, & Drewnowski, 2010; Monsivais & Rehm, 2012; Rehm et al., 2011; Todd & Lin, 2012), but not all (Katz et al., 2011) have concluded that healthier diets cost more. Diet quality is related to better health outcomes (Chiuve et al., 2012; Fung et al., 2005; McCullough et al., 2002). Taste, cost, convenience, nutrition and weight control predict preferences of food choice by demographic group (Glanz et al., 1998). For low-income families, taste and cost were the key determinants (Drewnowski & Darmon, 2005c). Energy-dense foods and energy dense diets, generally containing a higher proportion of added sugars and fats, have been observed to be highly palatable (Drewnowski, 1998). Energy-dense foods tend to provide dietary energy at a low cost (Drewnowski, 1998). Although it does not appear impossible to purchase a nutritionally adequate diet at a lower cost (Carlson & Frazão, 2012; Katz et al., 2011), factors such as palatability (Drewnowski, 1998), availability (Jetter & Cassady, 2006), convenience (Jetter & Cassady, 2006) and the lower cost of nutrient poor, energy dense foods are a high incentive to consume a less healthful diet (Drewnowski & Darmon, 2005c; Jetter & Cassady, 2006; Rehm et al., 2011; Todd & Lin, 2012). These factors should be considered when developing social, health and agricultural policy to promote better health outcomes through consumption of higher quality diets.

Of the specific foods types and food groups studied, whole grains have been specifically noted for their high nutrient density and low cost relative to other nutrient-dense food groups, such as fruits and vegetables and lean meats and seafood (Bernstein et al., 2010; Drewnowski & Darmon, 2005a; Maillot, Ferguson, Drewnowski, & Darmon, 2008). Whole wheat bread has been found to be comparably palatable to refined grain breads (Bakke & Vickers, 2007). Whole grain foods may be the most cost-effective and well-accepted means of increasing diet quality.

Whole Grains

In 1999, the FDA has defined whole grain foods as:

> "foods that contain 51 percent or more whole grain ingredient(s) by weight per reference amount customarily consumed (RACC). It proposed that compliance with this definition could be assessed by reference to the dietary fiber level of whole wheat, the predominant grain in the U.S. diet. Whole wheat contains 11 grams of dietary fiber per 100 grams; thus, the qualifying amount of dietary fiber

required for a food to bear the prospective claim could be determined by the following formula: 11 grams x 51% x RACC/100."

Whole grains are an important component of a healthful, high quality diet. Consumption of whole grains may reduce the risk of cardiovascular disease, is associated with lower body weight, and may also be associated with reduced incidence of T2DM (USDA, 2010a; Ye, Chacko, Chou, Kugizaki, & Liu, 2012). Whole grains contain dietary fiber and bioactive compounds in the bran and germ including vitamins, minerals, trace elements, polyphenols, alkylresorcinols and carotenoids (Clemens, Kranz, & Mobley, 2012; Fardet, 2010; Slavin, 2003). Refined grains are milled, which removes the bran and germ. This process strips B vitamins, iron and fiber; enrichment fails to add these nutrients back in equivalent amounts. For the first time in 2000, the DGA highlighted the health benefits of grain consumption, especially that of whole grains, and distinguished the consumption of grains as a separate guideline from fruits and vegetables. The 2005 DGA quantified the guidelines for grains by recommending that half of all grain intake be from whole grain foods. In 2010, the latest release of the DGA continued to highlight the health benefits of consuming half of total grain intake as whole grains while specifically denouncing saturated fats and added sugars, commonly found in refined grain snacks and desserts. Ninety-three percent of Americans fail to meet the recommended intake for whole grains (Lin & Yen, 2007) putting nearly all Americans at health risk.

Although comprehensive research has been conducted regarding the healthfulness of whole grains, there are few studies that analyze whole grain consumption patterns and preferences in the U.S. Two separate studies by Lin and Yen (2007) and Kantor et al (2001) analyzed data from the USDA's Continuing Survey of Food Intakes by Individuals (CSFII) conducted in 1994-1996 and 1998, including the companion module, The Diet and Health

Knowledge Survey (DHKS), which asked adults about their information, attitudes and practices with respect to diet and health. The purpose of the Lin and Yen (2007) study was to identify who consumes whole grains, how much and under what circumstances. They found that all Americans fell short of the dietary recommendation to make half of all grain intake whole grains. Adults consumed more than children, females consumed more than males and Hispanics tend to consume more whole grains compared to Whites, Blacks and Asians. Whole grain consumption increased with educational attainment and household income. Foods consumed at home contained more whole grains than those foods eaten away from home (Lin & Yen, 2007).

The study by Kantor et al was completed in 2001. The first part of the study analyzed data from the DHKS to assess individual preferences for grain products. The authors concluded that whole grain intake may be limited by a number of factors including: lack of consumer awareness of health benefits, difficulty in identifying whole grain products in the marketplace, consumer perceptions of inferior taste or palatability and lack of familiarity with preparation methods (Kantor, Variyam, Allshouse, Putnam, & Lin, 2001).

In the second part of the study, the authors used supermarket scanner data from Information Resources to identify whole grain products based on scanner product label information. Volume sales and product prices were estimated from the scanner data as well. From 1995-1999, volume sales increased the most for small-volume products such as some whole grain pastas, specialty flours and ready-to-eat cereals made with spelt and brown rice. Sales volume for two large volume products, oat bran ready-to-eat cereal and whole-grain spaghetti more than doubled in the same time frame. Despite these increases, whole grain sales only made up a tiny fraction of total grain food sales in this time period. Scanner data also indicated that average prices for whole grain versions of the same food product was one third higher in 1999. The authors suggested higher production and marketing costs, a premium on "healthfoods," and a shorter shelf life contributed toward the higher prices (Kantor et al., 2001).

Studies completed prior to the FDA definition of whole grains in 1999 and DGA 2005, which first quantified the whole grain recommended intake are limited in their analyses as there was no specific benchmark to which consumption levels could be compared. Kantor et al (2001) documented this limitation in their recommendations for future research and methods. Since their study in 2001, the DGA 2005 did determine a recommended quantity of whole grains for daily consumption, allowing researchers to compare observed intake to recommended levels.

In 2011, Mancino and Kuchler conducted a study to determine if the DGA 2005 whole grain recommendation had an impact on whole grain consumption. The authors used Nielson Homescan data from 1998 - 2002 and 2003 – 2007 for monthly bread expenditures to estimate an Almost Ideal Demand System (AIDS) model. The findings reflect that, after controlling for price, demand for whole grain bread increased for higher-income consumers but not for lower-income consumers. Across the two timeframes, monthly total bread purchases declined by 8.3% and whole grain bread purchases rose by almost 70% while refined grain bread purchases fell by 13%. For low-income consumers, there was only a slight increase in whole grain bread purchases but the results indicate this was only in response to declining whole-grain prices (Mancino & Kuchler, 2011).

Studies examining the relationship of diet quality and cost have repeatedly pointed to whole grains as a source of low-cost nutrition (Darmon et al., 2005; Drewnowski, 2010b;

Katz et al., 2011; Monsivais et al., 2010). Whole grains are nutrient dense and an important component of a high quality diet by all diet quality metrics. A large proportion of people like whole wheat bread and refined grain bread equally (Bakke & Vickers, 2007). If taste preferences are similar between whole and refined grain food products, and whole grains are relatively inexpensive when compared to other high quality foods such as fruits and vegetables, lean meat and fish (Carlson & Frazão, 2012; Darmon et al., 2005; Drewnowski, 2010b; Touvier et al., 2010), substituting whole grains for refined grains may be the most cost effective method for increasing diet quality.

Relative cost of whole grains is declining yet consumption of whole grains remains below recommended amounts, especially in lower SES groups (Rehm et al., 2011; Todd & Lin, 2012). The primary goals of this study are to 1) estimate the difference between diet quality, as measured by nutrient density, and diet cost of grain consumption at observed levels and at the recommended guideline level (50% of total grain consumption) across socioeconomic strata, and 2) determine if these differences reflect a change of public health significance. For the purposes of this study, a change of public health significance is one that is greater than 10% from the observed value for cost and energy and a change greater than 10% of the recommended daily value (RDV) for individual nutrients.

Research Question

1. Are there estimated differences in nutrient density and diet cost between the observed and the modeled diet for different age groups, race/ethnicities, income levels or education levels?

2. Are there changes of public health significance in nutrient density and diet cost between the observed and the modeled diet for different age groups, race/ethnicities, income levels or education levels?

Hypotheses

1. Fiber will change by an amount of public health significance (i.e., 2.5 gm) between observed and modeled diets for males, non-hispanic blacks, young adults (ages 20-29), lower income individuals (PIR <1, PIR 1-2, PIR 2-3) and those with lower levels of education (< HS, HS/GED) but not for other sociodemographic groups.
2. Vitamin B_6 will change by an amount of public health significance (i.e., 0.2 mg) between observed and modeled diets for males, non-hispanic blacks, young adults (ages 20-29), lower income individuals (PIR <1, PIR 1-2, PIR 2-3) and those with lower levels of education (< HS, HS/GED) but not for other sociodemographic groups.
3. Vitamin E will change by an amount of public health significance (i.e., 2 mg) between observed and modeled diets for males, non-hispanic blacks, young adults (ages 20-29), lower income individuals (PIR <1, PIR 1-2, PIR 2-3) and those with lower levels of education (< HS, HS/GED) but not for other sociodemographic groups.
4. Magnesium will change by an amount of public health significance (i.e., 40 mg) between observed and modeled diets for males, non-hispanic blacks, young adults (ages 20-29), lower income individuals (PIR <1, PIR 1-2, PIR 2-3) and those with lower levels of education (< HS, HS/GED) but not for other sociodemographic groups.

5. Zinc will change by an amount of public health significance (i.e., 1.5 mg) between observed and modeled diets for males, non-hispanic blacks, young adults (ages 20-29), lower income individuals (PIR <1, PIR 1-2, PIR 2-3) and those with lower levels of education (< HS, HS/GED) but not for other sociodemographic groups.
6. Diet cost will change by an amount of public health significance between observed and modeled diets for males, non-hispanic blacks, young adults (ages 20-29), lower income individuals (PIR <1, PIR 1-2, PIR 2-3) and those with lower levels of education (< HS, HS/GED) but not for other sociodemographic groups.
7. As part of the enrichment program, thiamin will not change by an amount of public health significance (i.e., 0.15 mg) between observed and modeled diets for any sociodemographic group.
8. As part of the enrichment program, folate will not change by an amount of public health significance (i.e., 40 mcg) between observed and modeled diets for any sociodemographic group.
9. As part of the enrichment program, niacin will not change by an amount of public health significance (i.e., 2 mg) between observed and modeled diets for any sociodemographic group.
10. As part of the enrichment program, riboflavin will not change by an amount of public health significance (i.e., 0.17 mg) between observed and modeled diets for any sociodemographic group.
11. As part of the enrichment program, iron will not change by an amount of public health significance (i.e., 1.8 mg) between observed and modeled diets for any sociodemographic group.

12. Utilized in both whole grain and refined grain products, sugar will not change by an amount of public health significance between observed and modeled diets for any sociodemographic group.
13. Utilized in both whole grain and refined grain products, sodium will not change by an amount of public health significance (i.e., 240 gm) between observed and modeled diets for any sociodemographic group.

Methodology

Subjects

The National Center for Health Statistics, Centers for Disease Control and Prevention (CDC) has conducted nationally representative health examination surveys since 1960. Since 1999, these became a continuous survey with data release every two years. A complex, stratified, multistage probability cluster sampling design is used to obtain a nationally representative sample of the US civilian, non-institutionalized population. In this four-stage sampling design, primary sampling units (PSUs), made up mainly of individual counties in the U.S., are randomly selected. Random selection of segments within the PSUs is next, followed by selection of dwelling units (DUs) within segments and, lastly, individuals within DUs are randomly selected. The study design includes oversampling of some subgroups that are of particular public health interest. Survey sample weights are provided to reflect the relative proportion of these groups in the population as a whole.

Individuals complete a questionnaire, administered in the home, followed by a physical examination in the mobile examination unit (MEC). In the MEC, participants are asked to complete a 24-hour dietary recall. 24-hour dietary recalls use the multiple-pass method to estimate types and amounts of energy, nutrients and other food components from foods and beverages consumed by an individual in the preceding 24-hour period (midnight to midnight). The USDA Food and Nutrient Database for Dietary Studies (FNDDS) version 2.0 is the source all nutrient data in NHANES dietary files. Protocol and methods are fully documented in NHANES Analytic Guidelines, 2014.

All completed and reliable Day One 24-hour dietary recalls for participants 20 years and older from each cycle of NHANES 2003-2004 was included for analysis (n = 4032).

Use of the NHANES 2003-2004 cycle allows the merging of dietary recall data with the nationally representative food prices released by the CNPP. I used NHANES demographic data for stratification in analysis and weight according to NHANES assigned survey weights and methods. Statistical analysis was conducted by age (20-29y, 30-44y, 45-64y, 65-74 or >75y), gender, race/ethnicity (White and Non-White), family poverty to income ratio (PIR) (<1, 1-2, 2-3, >3) and educational attainment (< HS, HS/GED, some college, college graduate) as recommended in NHANES methodology (Curtin et al., 2012). Race/ethnicity for non-white participants was combined due to the size of these groups within the sample.

Food Cost Data

The CNPP Food Price Database provides average national prices of foods in their "as-consumed" form. This database was developed using consumed foods from NHANES 2003-2004, FNDDS 2.0, the National Nutrient Database for Standard Reference (Release 20), and the Nielson Homescan™ Consumer Panel. The CNPP uses FNDDS and the National Nutrient Database to disaggregate foods consumed by NHANES participants into their "as-purchased" form, or ingredients. These food components are matched to purchase data in the Nielson Homescan™ Consumer Panel, which tracks household food purchases. The CNPP Price database presents prices in $/100g. Methods and data set information are fully documented in Carlson et al 2008.

I computed total diet cost for grain foods for each participant in the 2003-2004 NHANES database by multiplying the number of grams of each grain food consumed with the food price per gram (from the CNPP) then summed these values for each participant. Foods were identified as primarily grain-based according to the USDA food commodity code of '5.' Exclusions included mixed grain foods (e.g., lasagna) and those classified as cakes, pies and cookies because federal recommendations limit these foods in a healthy diet and because there is no WG equivalent available for comparison. See Table 3 for descriptive analysis of grain foods identified in the dietary recalls.

Table 3. Instances of Grain Food Types for Inclusion or Exclusion

	n = 14550	%
Included Grain Food Types	9467	65.07%
Flour and Dry Mixes	0	0.00%
Yeast Breads, Rolls	4086	43.16%
Quick Breads	1366	14.43%
Crackers and Salty Snacks	1691	17.86%
Pancakes, Waffles, French Toast, Other Grain Products	247	2.61%
Pastas, Cooked Cereals, Rice	1056	11.15%
Cereals, Not Cooked	1021	10.78%
Excluded Grain Food Types	5083	34.93%
Grain Mixtures, Frozen Plate Meals, Soups	1847	36.34%
Meat Substitutes, Mainly Cereal Protein	471	9.27%
Cakes, Cookies, Pies and Pastries	2765	54.40%

Whole grain classification

The MyPyramid Equivalents Database, 2.0 (MPED 2.0) translates foods consumed in the dietary recalls from NHANES 2003-2004 into the number of MyPyramid serving equivalents for the 32 MyPyramid major groups and subgroups. Mixed foods are disaggregated into their individual ingredients to be classified to specific MyPyramid groups and subgroups. MyPyramid grain serving equivalents are defined in ounces and rounded to commonly-used, consumer friendly measures. For example, 1 slice of bread, 1 small roll, ½ cup cooked pasta or rice.

The grain group is further subcategorized as whole grain (WG) and non-whole/refined grain (RG). The MPED 2.0 uses USDA food codes and ingredient descriptions to identify WG and RG foods and food components. For example, cracked wheat bread contains three types of grain ingredients: whole-wheat flour, white wheat flour and bran. The whole-wheat flour is assigned to the WG subgroup, while the other two ingredients are assigned to the RG subgroup.

Substitution Model

For observed diets, I calculated intake of grain foods in grams for total grain intake and as percent of whole grains relative to total grain intake. For the modeled diet, I created an artificial consumption level of 50% whole grains relative to total grains by substituting each instance of a grain food with one half each of the RG and WG equivalents of the food (Table 6). The RG and WG equivalents were determined by USDA Food Codes and descriptions and matched *a priori* for all grain foods as identified by the USDA Food Code of '5.' Exclusions included mixed grain foods (e.g., lasagna) and those classified as cakes, pies and cookies. (See Appendix 1 for a full list of RG and WG equivalents). The result was a substitution model for each dietary recall based on recommended levels of whole grain consumption.

Table 4. Example Substitution of Non-Whole Grain with Whole Grain Equivalents

Observed	1 regular slice whole wheat bread 1 cup white rice 3 cups white flour pasta
Model - 50% Whole Grain	0.5 regular slice whole wheat bread 0.5 regular slice white bread 0.5 cup white rice 0.5 cup brown rice 1.5 cups white flour pasta 1.5 cups whole-wheat flour pasta

Diet Quality

A number of scoring systems have been developed over time in attempts to measure the quality of an individual diet. These scores are all based, in some way, on the ideal diet as specified in the most recent DGA. When evaluating an observed diet, these scoring systems can be informative. However, when applied to a model diet, the score will appear near perfect and will only reflect the extent to which the model diet has mirrored the DGA. For example, the Health Eating Index-2005 assesses the grain group a score from 1-5, with a score of 5 indicating that at least 50% of all grains consumed were whole (McCullough et al., 2000).

In order to provide a more informative qualitative assessment between the observed and substitution model diets, the differences in intake for a subset of nutrients that are most commonly found in grain foods were compared to a benchmark threshold of 10% of RDV. Because no RDV for energy intake exists, a difference of ≥10% of the observed energy intake represented a change of public health significance. For this study, a change of greater than 10% of RDV represents a change of public health significance. Monsivais and Rehm (2012) utilized this method of diet quality assessment to compare the observed diets of children with substitution model diets that replaced fruit juice with different proportions of whole fruit and fruit juice. They compared the difference between the observed diet and each model diet to a benchmark threshold change of 10% of recommended daily values for each nutrient of interest (2.5 g fiber, 350 mg potassium, 100 mg calcium, and 6 mg vitamin C). The 10% daily value threshold represented a change of public health significance (Monsivais & Rehm, 2012).

For this study, the subset of grain specific nutrients of interest includes fiber, sodium, thiamin, folate, niacin, riboflavin, iron, vitamin B_6, vitamin E, magnesium, zinc, and sugar as well as energy. Dietary fiber is a shortfall nutrient in the American diet identified by the DGA 2010 (United States Department of Agriculture, 2010a). Sodium and sugar are a nutrients that are consumed in excess in the American diet and are prevalent in baked grain foods (United States Department of Agriculture, 2010a). Thiamin, folate, niacin, riboflavin and iron are all part of the grain enrichment program but are not replaced in equivalent amounts (Food and Drug Administration, 2013). Vitamin B_6, vitamin E, magnesium and zinc are all naturally present in whole grains but are lost in the refinement process (Food and Drug Administration, 2013).

Data Analysis

Preliminary analyses reflected normal distribution of the data and, as such, no corrections beyond survey weights were required. Descriptive analyses were conducted for all sociodemographic groups. Survey-weighted means were estimated for energy, individual nutrients and cost for each sociodemographic strata of the population (age, gender, race/ethnicity, income and education level) for both observed intake as well as the substitution diet modeled intake. Effects of substitution were quantified for cost ($), energy (kcals), sugar, and eleven nutrients.

Survey-weighted *t-tests* were used to determine whether there were significant differences between the means of the observed and modeled outcome variables (i.e., energy, cost, sugar, and eleven nutrients) for each sociodemographic strata of the population. The primary focus of the analysis was whether there is both an estimated difference and a change of public health significance (≥10% of RDV or from the observed value) in both nutrient intake and diet cost when the observed diet was replaced with a model whole grain diet. This method was used because I imposed a change in nutrient intake and diet cost. For all nutrients, a substantive change of 10% of recommended daily values represented a change of public health significance. A 10% change from the observed value for total grain cost, sugar, and energy represents a change of public health significance. A survey-weighted *t-test* was used for all statistical testing after the estimation of survey-weighted means to account for the complex nature of NHANES survey data. All analyses were completed using Stata version 11.2 (2011, *Stata Statistical Software: release 11*.2; Statacorp LP, College Station, TX).

Results

All completed and reliable Day One 24-hour dietary recalls for participants 20 years and older from each cycle of NHANES 2003-2004 was included for analysis (n = 4032). The sample of subjects in NHANES is nationally representative of the civilian noninstitutionalized U.S. population. Some groups are oversampled, such as Hispanic and those over age 70, in order to provide better analysis of these groups. Descriptive analyses of sociodemographic data can be found in Table 5, which reflects are fairly even sample across each strata of the population. Due to small number of race/ethnicity data within some survey stratum, it was necessary to combine all non-white race ethnicities for analyses. Table 6 provides descriptive analysis of poverty-to-income ratio (PIR) for both Mexican Americans and Non-Hispanic Blacks, reflecting a fairly even spread across income levels for each of these racial/ethnic groups.

Table 5. Sociodemographic Descriptive Data

	n=4032	%
Age		
20-30	706	17.51
31-44	976	24.21
45-64	1110	27.53
65-74	608	15.08
75+	632	15.67
Race/Ethnicity		
White	2183	54.14
Non-White	1849	45.86
Mexican American	823	20.41
Black	752	18.65
Other	274	6.80
Education		
< HS Diploma	1173	29.09
HS Diploma	1005	24.93
Some College	1084	26.88
College Graduate	763	18.92
Missing/Refused	7	0.17
Poverty to Income Ratio (PIR)		
<=1	687	17.04
<=2	1036	25.69
<=3	637	15.80
3+	1458	36.16
Missing/Refused	214	5.31

Table 6. Mexican Americans and Non-Hispanic Blacks by Income Level

Mexican Americans (n=823)	#	%
PIR ≤ 1	248	30.13
PIR 1 - 2	260	31.59
PIR 2 - 3	114	13.85
PIR 3+	161	19.56
Missing/Refused	40	4.86
Non-Hispanic Black (n=752)		
PIR ≤ 1	176	23.40
PIR 1 - 2	214	28.46
PIR 2 - 3	117	15.56
PIR 3+	239	31.78
Missing/Refused	6	0.01

Diet Cost

Diet costs by demographic strata are provided in Table 7. For the entire sample, diet cost increased by almost 18% when substituting WG products for RG products representing public health significance. The difference in diet cost for grain products between observed and the modeled diets was significantly higher and represented a change of public health significance (> 10% change) for all groups except those 75 years and older. The greatest difference in cost between observed and modeled diets was for Non-White individuals with an increase of 54.55%. Other large increases in cost (> 25%) occurred for adults aged 20-44, adults with a poverty-to-income ratio (PIR) < 2, and those without a high school diploma.

Table 7. Diet Cost for Observed and Substitution Model Diets (Standard Error) (n=4032)

		Observed Price[1] ($)	**Model Price[1] ($)**	**Change as % of Observed[2]**
	Overall Average	0.39* (0.01)	0.46* (0.01)	17.95%
Gender	Male (n=1936)	0.44* (0.01)	0.53* (0.02)	20.45%
	Female (n=2095)	0.33* (0.01)	0.4* (0.01)	21.21%
Age	20-29 Years (n=706)	0.37* (0.02)	0.51* (0.02)	37.84%
	30-44 Years (n=976)	0.39* (0.01)	0.49* (0.02)	25.64%
	45-64 Years (n=1110)	0.38* (0.02)	0.43* (0.02)	13.16%
	65-74 Years (n=607)	0.39* (0.02)	0.42* (0.01)	7.69%
	> 75 Years (n=632)	0.37* (0.01)	0.38* (0.01)	2.70%
Race	White (n=2183)	0.4* (0.01)	0.45* (0.01)	12.50%
	Non-White (n=1849)	0.33* (0.01)	0.51* (0.01)	54.55%
Income	PIR < 1 (n=687)	0.34* (0.01)	0.45* (0.03)	32.35%
	PIR 1-2 (n=1036)	0.36* (0.01)	0.45* (0.02)	25.00%
	PIR 2-3 (n=637)	0.4* (0.02)	0.49* (0.02)	22.50%
	PIR 3+ (n=1457)	0.41* (0.01)	0.46* (0.01)	12.20%
Education	< HS Diploma (n=1173)	0.33* (0.01)	0.47* (0.03)	42.42%
	GED/HS Diploma (n=1005)	0.38* (0.01)	0.43* (0.02)	13.16%
	Some College (n=1084)	0.38* (0.01)	0.44* (0.02)	15.79%
	College Graduate (n=763)	0.45* (0.02)	0.5* (0.02)	11.11%

[1]Values are survey-weighted means (SE)
[2]Values reflect the difference in observed and substitution model diet intake as a percentage change of observed intake
* $P \leq .001$ ** $P \leq .01$ *** $P \leq .05$. RDV, Recommended Daily Value

Diet Quality: Non-Enrichment Program Nutrients

It was expected that those nutrients that are not part of the grain enrichment program would differ significantly between the observed and model diets. Fiber intake by demographic strata is provided in Table 8. There was a significant difference in fiber intake between observed and modeled diets but was short of a change of public health significance for all groups (7.5%-8.5% of RDV for most groups). The smallest effects for fiber were seen in individuals 75 years and older with an increase of 5% RDV. Males and those under 45 years old had fairly large increases in fiber intake with an approximate change of 9% of the RDV. Magnesium intake by demographic strata is provided in Table 9. The difference in magnesium intake was significant with an average increase of 6.79% of the RDV for all groups. Magnesium intake for males increased the most at 8% of the RDV followed by adults aged 20-29 (7.47% of RDV) and adults aged 30-44 (7.62% of RDV) as well as those with the lowest levels of income (7.16% of RDV) and education (7.05% of RDV). Zinc intake increased fairly evenly across all strata of the population with an average increase of 3.2% of RDV. There were minimal and, sometimes, insignificant differences between observed and modeled diets for vitamin E and vitamin B_6 for all groups, which is reflected in Tables 10-12. The average increase in vitamin E intake was <1% of RDV. Average vitamin B_6 intake increased by 1.5% of RDV between observed and model diets but decreased for the oldest individuals (-2% of RDV) and those with the lowest level of education (0.5% of RDV).

Table 8. Fiber Intake for Observed and Substitution Model Diets (Standard Error) (n=4032)

		Observed Fiber[1] (g)	Model Fiber[1] (g)	Change as % of Observed[2]
	Overall Average	4.6* (0.12)	6.58* (0.1)	7.92%
Gender	Male (n=1936)	5.36* (0.15)	7.7* (0.13)	9.36%
	Female (n=2095)	3.89* (0.14)	5.55* (0.14)	6.64%
Age	20-29 Years (n=706)	4.6* (0.19)	6.84* (0.19)	8.96%
	30-44 Years (n=976)	4.62* (0.21)	6.9* (0.23)	9.12%
	45-64 Years (n=1110)	4.55* (0.19)	6.38* (0.17)	7.32%
	65-74 Years (n=607)	4.45* (0.19)	6.27* (0.18)	7.28%
	> 75 Years (n=632)	4.73* (0.21)	6.08* (0.14)	5.40%
Race	White (n=2183)	4.72* (0.09)	6.61* (0.1)	7.56%
	Non-White (n=1849)	4.89* (0.1)	6.89* (0.12)	8.00%
Income	PIR < 1 (n=687)	4.35* (0.29)	6.4* (0.24)	8.20%
	PIR 1-2 (n=1036)	4.27* (0.18)	6.38* (0.18)	8.44%
	PIR 2-3 (n=637)	4.93* (0.26)	7.02* (0.28)	8.36%
	PIR 3+ (n=1457)	4.74* (0.13)	6.63* (0.17)	7.56%
Education	< HS Diploma (n=1173)	4.44* (0.25)	6.4* (0.24)	7.84%
	GED/HS Diploma (n=1005)	4.3* (0.17)	6.38* (0.17)	8.32%
	Some College (n=1084)	4.44* (0.14)	6.41* (0.14)	7.88%
	College Graduate (n=763)	5.24* (0.22)	7.17* (0.23)	7.72%

[1]Values are survey-weighted means (SE)
[2]Values reflect the difference in observed and substitution model diet intake as a percentage change in RDV
[*] P ≤ .001 [**] P ≤ .01 [***] P ≤ .05. RDV, Recommended Daily Value

Table 9. Magnesium Intake for Observed and Substitution Model Diets (Standard Error) (n=4032)

		Observed Magnesium[1] (mg)	**Model Magnesium[1] (mg)**	**Change as % of Observed[2]**
	Overall Average	53.71* (1.59)	80.86* (1.25)	6.79%
Gender	Male (n=1936)	61.88* (2.05)	94.21* (1.62)	8.08%
	Female (n=2095)	46.17* (1.55)	68.54* (1.54)	5.59%
Age	20-29 Years (n=706)	57.1* (2.61)	86.97* (2.48)	7.47%
	30-44 Years (n=976)	54.15* (2.65)	84.64* (2.75)	7.62%
	45-64 Years (n=1110)	52.22* (2.35)	77.39* (1.96)	6.29%
	65-74 Years (n=607)	51.49* (2.52)	75.69* (2.56)	6.05%
	> 75 Years (n=632)	53.21* (1.93)	74.01* (1.7)	5.20%
Race	White (n=2183)	54.25* (1.08)	80.03* (1.24)	6.45%
	Non-White (n=1849)	57.29* (1.3)	85.04* (1.51)	6.94%
Income	PIR < 1 (n=687)	50.27* (3.56)	78.9* (3.37)	7.16%
	PIR 1-2 (n=1036)	50.66* (1.76)	79.09* (1.97)	7.11%
	PIR 2-3 (n=637)	59.82* (3.6)	87.38* (3.44)	6.89%
	PIR 3+ (n=1457)	54.67* (1.83)	80.77* (2.09)	6.53%
Education	< HS Diploma (n=1173)	51.98* (3.41)	80.17* (3.4)	7.05%
	GED/HS Diploma (n=1005)	50.22* (2.15)	77.72* (2.31)	6.88%
	Some College (n=1084)	50.98* (1.77)	78.01* (1.79)	6.76%
	College Graduate (n=763)	62.44* (2.93)	88.56* (3.11)	6.53%

[1]Values are survey-weighted means (SE)

[2]Values reflect the difference in observed and substitution model diet intake as a percentage change in RDV

[*] $P \leq .001$ [**] $P \leq .01$ [***] $P \leq .05$. RDV, Recommended Daily Value

Table 10. Vitamin E Intake for Observed and Substitution Model Diets (Standard Error) (n=4032)

		Observed Vitamin E[1] (mg)	Model Vitamin E[1] (mg)	Change as % of Observed[2]
	Overall Average	0.97* (0.04)	1.12* (0.03)	0.75%
Gender	Male (n=1936)	1.03* (0.05)	1.26* (0.04)	0.77%
	Female (n=2095)	0.91* (0.06)	0.99* (0.05)	0.27%
Age	20-29 Years (n=706)	1.04** (0.08)	1.19** (0.07)	0.75%
	30-44 Years (n=976)	1.01** (0.1)	1.2** (0.1)	0.95%
	45-64 Years (n=1110)	0.87** (0.04)	1.04** (0.05)	0.85%
	65-74 Years (n=607)	1.01 (0.12)	1.07 (0.07)	0.30%
	> 75 Years (n=632)	1.04 (0.14)	1.05 (0.08)	0.05%
Race	White (n=2183)	1.1 (0.05)	1.2 (0.04)	0.50%
	Non-White (n=1849)	0.8* (0.03)	0.94* (0.03)	0.70%
Income	PIR < 1 (n=687)	0.81* (0.08)	0.97* (0.06)	0.80%
	PIR 1-2 (n=1036)	0.82* (0.04)	0.94* (0.03)	0.60%
	PIR 2-3 (n=637)	1.11*** (0.1)	1.24*** (0.08)	0.65%
	PIR 3+ (n=1457)	1.04* (0.06)	1.21* (0.06)	0.85%
Education	< HS Diploma (n=1173)	0.91 (0.09)	0.98 (0.07)	0.35%
	GED/HS Diploma (n=1005)	0.93* (0.07)	1.08* (0.06)	0.75%
	Some College (n=1084)	0.93* (0.07)	1.1* (0.05)	0.85%
	College Graduate (n=763)	1.11* (0.09)	1.29* (0.07)	0.90%

[1]Values are survey-weighted means (SE)
[2]Values reflect the difference in observed and substitution model diet intake as a percentage change in RDV
[*] $P \leq .001$ [**] $P \leq .01$ [***] $P \leq .05$. RDV, Recommended Daily Value

Table 11. Vitamin B6 Intake for Observed and Substitution Model Diets (Standard Error) (n=4032)

		Observed Vitamin B6[1] (mg)	**Model Vitamin B6[1] (mg)**	**Change as % of Observed[2]**
	Overall Average	0.4* (0.02)	0.43* (0.01)	1.50%
Gender	Male (n=1936)	0.46* (0.02)	0.49* (0.02)	1.50%
	Female (n=2095)	0.35*** (0.02)	0.37*** (0.02)	1.00%
Age	20-29 Years (n=706)	0.42* (0.03)	0.46* (0.03)	2.00%
	30-44 Years (n=976)	0.4*** (0.04)	0.43*** (0.03)	1.50%
	45-64 Years (n=1110)	0.35* (0.02)	0.39* (0.02)	2.00%
	65-74 Years (n=607)	0.44 (0.021)	0.44 (0.022)	0.00%
	> 75 Years (n=632)	0.55*** (0.04)	0.51*** (0.03)	-2.00%
Race	White (n=2183)	0.45 (0.02)	0.46 (0.01)	0.50%
	Non-White (n=1849)	0.38 (0.02)	0.4 (0.01)	1.00%
Income	PIR < 1 (n=687)	0.35*** (0.03)	0.38*** (0.02)	1.50%
	PIR 1-2 (n=1036)	0.37** (0.02)	0.39** (0.02)	1.00%
	PIR 2-3 (n=637)	0.46 (0.03)	0.49 (0.02)	1.50%
	PIR 3+ (n=1457)	0.41** (0.03)	0.44** (0.022)	1.50%
Education	< HS Diploma (n=1173)	0.45 (0.05)	0.44 (0.04)	-0.50%
	GED/HS Diploma (n=1005)	0.38** (0.04)	0.4** (0.03)	1.00%
	Some College (n=1084)	0.38** (0.04)	0.41** (0.03)	1.50%
	College Graduate (n=763)	0.42* (0.021)	0.47* (0.022)	2.50%

[1]Values are survey-weighted means (SE)
[2]Values reflect the difference in observed and substitution model diet intake as a percentage change in RDV
[*] $P \leq .001$ [**] $P \leq .01$ [***] $P \leq .05$. RDV, Recommended Daily Value

Table 12. Zinc Intake for Observed and Substitution Model Diets (Standard Error) (n=4032)

		Observed Zinc[1] (mg)	**Model Zinc[1] (mg)**	**Change as % of Observed[2]**
	Overall Average	2.16* (0.08)	2.64* (0.06)	3.20%
Gender	Male (n=1936)	2.46* (0.11)	3.05* (0.09)	3.93%
	Female (n=2095)	1.88* (0.12)	2.26* (0.09)	2.53%
Age	20-29 Years (n=706)	2.27* (0.17)	2.8* (0.14)	3.53%
	30-44 Years (n=976)	2.2* (0.16)	2.73* (0.14)	3.53%
	45-64 Years (n=1110)	1.97* (0.11)	2.47* (0.11)	3.33%
	65-74 Years (n=607)	2.28* (0.15)	2.61* (0.12)	2.20%
	> 75 Years (n=632)	2.35* (0.16)	2.69* (0.11)	2.27%
Race	White (n=2183)	2.39* (0.08)	2.79* (0.06)	2.67%
	Non-White (n=1849)	1.84* (0.07)	2.41* (0.06)	3.80%
Income	PIR < 1 (n=687)	1.84* (0.12)	2.36* (0.1)	3.47%
	PIR 1-2 (n=1036)	1.81* (0.08)	2.35* (0.08)	3.60%
	PIR 2-3 (n=637)	2.51* (0.23)	2.99* (0.18)	3.20%
	PIR 3+ (n=1457)	2.28* (0.13)	2.74* (0.12)	3.07%
Education	< HS Diploma (n=1173)	2.05* (0.2)	2.53* (0.18)	3.20%
	GED/HS Diploma (n=1005)	2.01* (0.17)	2.51* (0.14)	3.33%
	Some College (n=1084)	2.16* (0.19)	2.61* (0.16)	3.00%
	College Graduate (n=763)	2.38* (0.16)	2.92* (0.14)	3.60%

[1]Values are survey-weighted means (SE)
[2]Values reflect the difference in observed and substitution model diet intake as a percentage change in RDV
[*] P ≤ .001 [**] P ≤ .01 [***] P ≤ .05. RDV, Recommended Daily Value

Diet Quality: Enrichment Program Nutrients

It was expected that those nutrients that are part of the grain enrichment program would not differ significantly between the observed and model diets since these nutrients are added back to grain products during processing. Folate intake by demographic strata is provided in Table 13. Folate intake was significantly lower for the model diet and represented a change of public health significance (change > 10% of the RDV), or was very close to a change of public health significance (change ≥ 8.3% of RDV), for all groups. The average decrease in folate intake was 10.2% of RDV. There were significant decreases in intake for thiamin, riboflavin, and iron, reflected in Tables 14-16. These differences, however, represent a fairly moderate effect as intake decreased by approximately 4% of the RDV for thiamin and 2.94% of RDV for riboflavin. Average iron intake declined by 3.72% of RDV between observed and model diets. The greatest effects for iron were seen for older individuals with a decrease of 5.11% of RDV for adults aged 65-74 and a decrease of 5.06% of RDV for adults over 74 years old. There were minimal and, sometimes, insignificant differences between observed and modeled diets for niacin with an average decrease of 0.7% of RDV, as reflected in table 17.

Table 13. Folate Intake for Observed and Substitution Model Diets (Standard Error) (n=4032)

		Observed Folate[1] (mg)	Model Folate[1] (mg)	Change as % of Observed[2]
	Overall Average	167.44* (4.85)	126.63* (3.74)	-10.20%
Gender	Male (n=1936)	189.73* (5.15)	144.7* (4.15)	-11.26%
	Female (n=2095)	146.87* (6.32)	109.97* (4.73)	-9.23%
Age	20-29 Years (n=706)	171.96* (8.14)	131.21* (6.56)	-10.19%
	30-44 Years (n=976)	175.68* (11.09)	131.34* (8.03)	-11.09%
	45-64 Years (n=1110)	159.97* (7.38)	119.99* (5.8)	-10.00%
	65-74 Years (n=607)	162.61* (8.63)	124.29* (6.09)	-9.58%
	> 75 Years (n=632)	164.64* (6.96)	129.58* (5.45)	-8.76%
Race	White (n=2183)	174.85* (3.89)	133.27* (2.89)	-10.40%
	Non-White (n=1849)	146.65* (3.79)	113.34* (2.99)	-8.33%
Income	PIR < 1 (n=687)	155.77* (10.75)	115.61* (7.2)	-10.04%
	PIR 1-2 (n=1036)	150.3* (6.55)	113* (5.05)	-9.33%
	PIR 2-3 (n=637)	189.75* (10.76)	144.36* (7.67)	-11.35%
	PIR 3+ (n=1457)	171.47* (9.06)	130.26* (6.59)	-10.30%
Education	< HS Diploma (n=1173)	160.3* (10.85)	121.86* (8.6)	-9.61%
	GED/HS Diploma (n=1005)	163.46* (9.9)	122.08* (7.6)	-10.35%
	Some College (n=1084)	167.56* (11.14)	125.07* (8.17)	-10.62%
	College Graduate (n=763)	177.06* (7.56)	137.33* (6.18)	-9.93%

[1]Values are survey-weighted means (SE)
[2]Values reflect the difference in observed and substitution model diet intake as a percentage change in RDV
[*] $P \leq .001$ [**] $P \leq .01$ [***] $P \leq .05$. RDV, Recommended Daily Value

Table 14. Thiamin Intake for Observed and Substitution Model Diets (Standard Error) (n=4032)

		Observed Thiamin[1] (mg)	**Model Thiamin[1] (mg)**	**Change as % of Observed[2]**
	Overall Average	0.59* (0.01)	0.53* (0.01)	-4.00%
Gender	Male (n=1936)	0.69* (0.01)	0.62* (0.01)	-4.67%
	Female (n=2095)	0.5* (0.02)	0.45* (0.02)	-3.33%
Age	20-29 Years (n=706)	0.61* (0.03)	0.56* (0.02)	-3.33%
	30-44 Years (n=976)	0.61* (0.03)	0.55* (0.02)	-4.00%
	45-64 Years (n=1110)	0.55* (0.02)	0.5* (0.02)	-3.33%
	65-74 Years (n=607)	0.6* (0.02)	0.53* (0.02)	-4.67%
	> 75 Years (n=632)	0.61* (0.03)	0.55* (0.02)	-4.00%
Race	White (n=2183)	0.62* (0.01)	0.55* (0.01)	-4.67%
	Non-White (n=1849)	0.56*** (0.01)	0.52*** (0.01)	-2.67%
Income	PIR < 1 (n=687)	0.55* (0.03)	0.5* (0.02)	-3.33%
	PIR 1-2 (n=1036)	0.55* (0.02)	0.5* (0.02)	-3.33%
	PIR 2-3 (n=637)	0.65* (0.03)	0.59* (0.03)	-4.00%
	PIR 3+ (n=1457)	0.6* (0.02)	0.54* (0.02)	-4.00%
Education	< HS Diploma (n=1173)	0.59* (0.03)	0.53* (0.03)	-4.00%
	GED/HS Diploma (n=1005)	0.57* (0.02)	0.51* (0.02)	-4.00%
	Some College (n=1084)	0.57* (0.03)	0.52* (0.02)	-3.33%
	College Graduate (n=763)	0.63* (0.03)	0.58* (0.03)	-3.33%

[1]Values are survey-weighted means (SE)
[2]Values reflect the difference in observed and substitution model diet intake as a percentage change in RDV
[*] P ≤ .001 [**] P ≤ .01 [***] P ≤ .05. RDV, Recommended Daily Value

Table 15. Riboflavin Intake for Observed and Substitution Model Diets (Standard Error) (n=4032)

		Observed Riboflavin[1] (mg)	**Model Riboflavin[1] (mg)**	**Change as % of Observed[2]**
	Overall Average	0.51* (0.01)	0.46* (0.01)	-2.94%
Gender	Male (n=1936)	0.59* (0.02)	0.53* (0.02)	-3.53%
	Female (n=2095)	0.43* (0.02)	0.39* (0.01)	-2.35%
Age	20-29 Years (n=706)	0.51* (0.03)	0.47* (0.03)	-2.35%
	30-44 Years (n=976)	0.52* (0.03)	0.47* (0.02)	-2.94%
	45-64 Years (n=1110)	0.46* (0.02)	0.42* (0.02)	-2.35%
	65-74 Years (n=607)	0.55* (0.02)	0.48* (0.02)	-4.12%
	> 75 Years (n=632)	0.57* (0.03)	0.5* (0.03)	-4.12%
Race	White (n=2183)	0.56* (0.01)	0.5* (0.01)	-3.53%
	Non-White (n=1849)	0.45*** (0.01)	0.42*** (0.01)	-1.76%
Income	PIR < 1 (n=687)	0.46* (0.02)	0.41* (0.02)	-2.94%
	PIR 1-2 (n=1036)	0.46* (0.02)	0.41* (0.02)	-2.94%
	PIR 2-3 (n=637)	0.56** (0.03)	0.51** (0.03)	-2.94%
	PIR 3+ (n=1457)	0.52* (0.02)	0.47* (0.02)	-2.94%
Education	< HS Diploma (n=1173)	0.5* (0.04)	0.45* (0.03)	-2.94%
	GED/HS Diploma (n=1005)	0.49* (0.03)	0.44* (0.03)	-2.94%
	Some College (n=1084)	0.5* (0.03)	0.44* (0.03)	-3.53%
	College Graduate (n=763)	0.55* (0.03)	0.5* (0.02)	-2.94%

[1]Values are survey-weighted means (SE)
[2]Values reflect the difference in observed and substitution model diet intake as a percentage change in RDV
[*] $P \leq .001$ [**] $P \leq .01$ [***] $P \leq .05$. RDV, Recommended Daily Value

Table 16. Iron Intake for Observed and Substitution Model Diets (Standard Error) (n=4032)

		Observed Iron[1] (mg)	**Model Iron[1] (mg)**	**Change as % of Observed[2]**
	Overall Average	6.14* (0.15)	5.47* (0.12)	-3.72%
Gender	Male (n=1936)	7.14* (0.2)	6.36* (0.15)	-4.33%
	Female (n=2095)	5.21* (0.18)	4.65* (0.16)	-3.11%
Age	20-29 Years (n=706)	6.19* (0.35)	5.62* (0.27)	-3.17%
	30-44 Years (n=976)	6.04* (0.28)	5.49* (0.23)	-3.06%
	45-64 Years (n=1110)	5.85* (0.27)	5.18* (0.21)	-3.72%
	65-74 Years (n=607)	6.65* (0.25)	5.73* (0.21)	-5.11%
	> 75 Years (n=632)	6.84* (0.34)	5.93* (0.25)	-5.06%
Race	White (n=2183)	6.67* (0.15)	5.85* (0.12)	-4.56%
	Non-White (n=1849)	5.58*** (0.16)	5.16*** (0.13)	-2.33%
Income	PIR < 1 (n=687)	5.66* (0.31)	5.05* (0.23)	-3.39%
	PIR 1-2 (n=1036)	5.74* (0.27)	5.12* (0.21)	-3.44%
	PIR 2-3 (n=637)	6.7* (0.32)	6.05* (0.27)	-3.61%
	PIR 3+ (n=1457)	6.25* (0.29)	5.56* (0.23)	-3.83%
Education	< HS Diploma (n=1173)	5.95* (0.38)	5.36* (0.31)	-3.28%
	GED/HS Diploma (n=1005)	5.98* (0.3)	5.32* (0.26)	-3.67%
	Some College (n=1084)	6.00* (0.37)	5.30* (0.28)	-3.89%
	College Graduate (n=763)	6.63* (0.39)	5.95* (0.28)	-3.78%

[1]Values are survey-weighted means (SE)
[2]Values reflect the difference in observed and substitution model diet intake as a percentage change in RDV
[*] $P \leq .001$ [**] $P \leq .01$ [***] $P \leq .05$. RDV, Recommended Daily Value

Table 17. Niacin Intake for Observed and Substitution Model Diets (Standard Error) (n=4032)

		Observed Niacin[1] (mg)	**Model Niacin[1] (mg)**	**Change as % of Observed[2]**
	Overall Average	6.19* (0.14)	6.05* (0.14)	-0.70%
Gender	Male (n=1936)	7.22* (0.17)	7.01* (0.17)	-1.05%
	Female (n=2095)	5.25** (0.18)	5.12** (0.17)	0.65%
Age	20-29 Years (n=706)	6.41 (0.27)	6.4 (0.25)	-0.05%
	30-44 Years (n=976)	6.44*** (0.29)	6.29*** (0.28)	-0.75%
	45-64 Years (n=1110)	5.74 (0.22)	5.63 (0.22)	-0.55%
	65-74 Years (n=607)	6.35* (0.25)	6.00* (0.24)	-1.75%
	> 75 Years (n=632)	6.50** (0.32)	6.14** (0.26)	-1.80%
Race	White (n=2183)	6.56 (0.13)	6.27 (0.12)	-1.45%
	Non-White (n=1849)	5.75 (0.14)	5.86 (0.13)	0.55%
Income	PIR < 1 (n=687)	5.76 (0.3)	5.66 (0.26)	-0.50%
	PIR 1-2 (n=1036)	5.76 (0.21)	5.67 (0.2)	-0.45%
	PIR 2-3 (n=637)	6.74 (0.31)	6.66 (0.27)	-0.40%
	PIR 3+ (n=1457)	6.32** (0.25)	6.13** (0.24)	-0.95%
Education	< HS Diploma (n=1173)	6.15 (0.37)	6.06 (0.33)	-0.45%
	GED/HS Diploma (n=1005)	6.00** (0.3)	5.82** (0.29)	-0.90%
	Some College (n=1084)	6.05** (0.33)	5.86** (0.29)	-0.95%
	College Graduate (n=763)	6.64 (0.31)	6.54 (0.29)	-0.50%

[1]Values are survey-weighted means (SE)
[2]Values reflect the difference in observed and substitution model diet intake as a percentage change in RDV
* $P \leq .001$ ** $P \leq .01$ *** $P \leq .05$. RDV, Recommended Daily Value

Diet Quality: Intake to Limit

Sugar and sodium are nutrients that are recommended to be limited in the American diet. Energy intake should be appropriate for each individual based on body composition and overall size (USDA, 2010a). It was expected that neither sugar nor sodium nor energy would be significantly different between observed and model diets since sugar and sodium are both used in the processing of both whole and refined grain products and there is little difference in energy between whole and refined grains.

Sugar intake increase significantly for those with the highest levels of income (4.01% from observed) and education (5.17% from observed) as well as for the oldest individuals (7.94% from observed), as reflected in Table 18. There were minimal and, sometimes, insignificant differences between observed and modeled diets for sodium with an average decrease of 0.74% of RDV, as reflected in Table 19. Although there was a significant difference between observed and modeled diets for energy, there was not a change of public health significance, as reflected in Table 20. Overall, there was a 2.71% decrease in caloric intake from the observed to the model diet representing a change of approximately 10 kcals.

Table 18. Sugar Intake for Observed and Substitution Model Diets (Standard Error) (n=4032)

		Observed Sugar[1] (g)	**Model Energy[1] (g)**	**Change as % of Observed[2]**
	Overall Average	8.42* (0.28)	8.69* (0.27)	3.21%
Gender	Male (n=1936)	9.63** (0.45)	9.93** (0.41)	3.12%
	Female (n=2095)	7.31 (0.22)	7.54 (0.24)	3.15%
Age	20-29 Years (n=706)	8.92 (0.5)	9.02 (0.52)	1.12%
	30-44 Years (n=976)	8.64 (0.54)	8.68 (0.51)	0.46%
	45-64 Years (n=1110)	7.88** (0.32)	8.29** (0.36)	5.20%
	65-74 Years (n=607)	8.72** (0.55)	9.14** (0.56)	4.82%
	> 75 Years (n=632)	8.31* (0.53)	8.97* (0.52)	7.94%
Race	White (n=2183)	8.94* (0.31)	9.29* (0.32)	3.91%
	Non-White (n=1849)	7.38 (0.27)	7.4 (0.26)	0.27%
Income	PIR < 1 (n=687)	6.97 (0.51)	7.05 (0.48)	1.15%
	PIR 1-2 (n=1036)	7.5 (0.34)	7.74 (0.36)	3.20%
	PIR 2-3 (n=637)	10.02 (0.78)	10.23 (0.77)	2.10%
	PIR 3+ (n=1457)	8.73*** (0.55)	9.08*** (0.52)	4.01%
Education	< HS Diploma (n=1173)	7.58 (58)	7.76 (0.58)	2.37%
	GED/HS Diploma (n=1005)	8.98 (0.69)	9.07 (0.65)	1.00%
	Some College (n=1084)	8.08** (0.54)	8.4** (0.54)	3.96%
	College Graduate (n=763)	8.9** (0.48)	9.36** (0.43)	5.17%

[1]Values are survey-weighted means (SE)
[2]Values reflect the difference in observed and substitution model diet intake as a percentage change of observed intake
* $P \leq .001$ ** $P \leq .01$ *** $P \leq .05$. RDV, Recommended Daily Value

Table 19. Sodium Intake for Observed and Substitution Model Diets (Standard Error) (n=4032)

		Observed Sodium[1] (mg)	Model Sodium[1] (mg)	Change as % of Observed[2]
	Overall Average	710.79* (10.58)	693.06* (10.31)	-0.74%
Gender	Male (n=1936)	826.37** (15.4)	807.11** (12.4)	-0.80%
	Female (n=2095)	604.14** (14.18)	587.84** (14.06)	-0.68%
Age	20-29 Years (n=706)	734.98 (28.92)	727.61 (23.62)	-0.31%
	30-44 Years (n=976)	765.6* (23.79)	739.14* (21.87)	-1.10%
	45-64 Years (n=1110)	685.56** (17.44)	668.95** (17.54)	-0.69%
	65-74 Years (n=607)	677.15* (20.07)	657.51* (20.84)	-0.82%
	> 75 Years (n=632)	606.21 (18.08)	592.94 (15.18)	-0.55%
Race	White (n=2183)	710.9 (11.62)	685.53 (10.83)	-1.06%
	Non-White (n=1849)	680.74 (13.09)	695.46 (12.25)	0.61%
Income	PIR < 1 (n=687)	712.58*** (24.88)	692.73*** (22.78)	-0.83%
	PIR 1-2 (n=1036)	678.26 (17.09)	682.77 (16.32)	0.19%
	PIR 2-3 (n=637)	762.7** (37.22)	738.6** (37.33)	-1.00%
	PIR 3+ (n=1457)	712.73* (17.26)	689.16* (17.49)	-0.98%
Education	< HS Diploma (n=1173)	678.95 (24.97)	685.14 (23.26)	0.26%
	GED/HS Diploma (n=1005)	707.18* (22.93)	684.45* (21.36)	-0.95%
	Some College (n=1084)	706.29** (16.02)	680.12** (13.99)	-1.09%
	College Graduate (n=763)	744.81** (23.05)	725.52** (22.72)	-0.80%

[1]Values are survey-weighted means (SE)
[2]Values reflect the difference in observed and substitution model diet intake as a percentage change in RDV
[*] P ≤ .001 [**] P ≤ .01 [***] P ≤ .05. RDV, Recommended Daily Value

Table 20. Energy Intake for Observed and Substitution Model Diets (Standard Error) (n=4032)

		Observed Energy[1] (kcal)	**Model Energy[1] (kcal)**	**Change as % of Observed[2]**
	Overall Average	394.03* (5.04)	383.34* (5.22)	-2.71%
Gender	Male (n=1936)	459.05* (7.7)	446.74* (7.2)	-2.68%
	Female (n=2095)	334.03* (6.9)	324.84* (7)	-2.75%
Age	20-29 Years (n=706)	426.92* (12.13)	413.49* (11.31)	-3.15%
	30-44 Years (n=976)	423.89* (12.09)	411.86* (11.55)	-2.84%
	45-64 Years (n=1110)	374.7** (9.59)	365.12** (9.4)	-2.56%
	65-74 Years (n=607)	361.93* (10.79)	353.11* (10.84)	-2.44%
	> 75 Years (n=632)	331.76* (7.79)	325.25* (7.65)	-1.96%
Race	White (n=2183)	387.97 (5.99)	378.53 (5.85)	-2.43%
	Non-White (n=1849)	398.26 (6.75)	388.38 (6.52)	-2.48%
Income	PIR < 1 (n=687)	382.4* (13.16)	372.83* (12.51)	-2.50%
	PIR 1-2 (n=1036)	386.19* (8.74)	374.44* (8.55)	-3.04%
	PIR 2-3 (n=637)	421.17* (16.43)	409.35* (16.26)	-2.81%
	PIR 3+ (n=1457)	396.3* (11.39)	386.14* (11.53)	-2.56%
Education	< HS Diploma (n=1173)	378.24* (12.54)	369.63* (12.67)	-2.28%
	GED/HS Diploma (n=1005)	389.47* (11.92)	376.82* (11.83)	-3.25%
	Some College (n=1084)	383.9* (7.65)	374.14* (7.85)	-2.54%
	College Graduate (n=763)	424.55* (15.31)	413.17* (15.26)	-2.68%

[1]Values are survey-weighted means (SE)
[2]Values reflect the difference in observed and substitution model diet intake as a percentage change of observed intake
* $P \leq .001$ ** $P \leq .01$ *** $P \leq .05$. RDV, Recommended Daily Value

Discussion

The primary goals of this study were to 1) estimate the difference between diet quality, as measured by nutrient density, and diet cost of grain consumption at observed levels and at the recommended guideline level (50% of total grain consumption) across socioeconomic strata, and 2) determine if these differences reflected a change of public health significance. For the purposes of this study, a change of public health significance referred to a change that was greater than 10% of the recommended daily value (RDV) for individual nutrients. For cost, energy and sugar, which have no RDV, a change of public health significance was a change greater than 10% from the observed intake.

The findings presented here indicate that meeting the DGA 2010 recommendation of consuming at least half of all grain foods as whole grains would result in beneficial changes to diet quality but there would be some negative consequences as well. The greatest gains in dietary quality were realized by an increased consumption of dietary fiber in the substitution model diet but these gains were offset by a decreased consumption of folate in the substitution model diet.

While fiber did not increase by an amount of public health significance as defined by this study (change > 10% of RDV), the amount of fiber consumed did approach public health significance (7% - 9% of RDV) and increased by approximately 50% above observed intake,. Because this study excluded mixed foods as well as grain foods high in saturated fats and added sugars categorized as cakes, cookies or pies, it is likely that some fiber intake was not captured. In addition, this study was concerned solely with the DGA recommendation of consuming half of all grains as whole, not with the total grain consumption recommendation of a minimum of 6 ounce-equivalents of grain. It is possible that total grain consumption was lower than what is recommended.

Fiber is a shortfall nutrient for all Americans (DGA; USDA, 2010a). The RDV for fiber is 25g. Average intake from grain foods in this study was 4.6g in the observed diets and 6.6g in the substitution model diet. Greater intake of fiber is associated with a decreased risk of CVD, which is the leading cause of death in the U.S. (Ye et al., 2012). Consumption of dietary fiber also reduces the relative risk for T2DM, obesity and dyslipidemia. A moderate intake of soluble fiber is likely to have significant favorable effects on risk and the progression of CVD (Anderson et al., 2009). Meeting dietary guidelines for whole grain consumption in the substitution model diet increased intake of fiber by 7% - 9% of the RDV, representing approximately 2g of dietary fiber. Males and adults under 45 years old achieved the greatest increases in fiber consumption. Individuals over 75 years old realized the smallest gains for dietary fiber. Based on this sample, it is not surprising that adults in the U.S. barely consume the AI for dietary fiber of 14g/day (Jones, Lineback, & Levine, 2006).

Whole grain foods are one of the greatest sources of dietary fiber. With such low overall intake of fiber and the smaller-than-expected impact on fiber intake of increasing whole grain consumption to the recommended level of 50% of all grain products, it may be necessary to increase the recommended amount of whole grain intake to a larger percentage in order to meet fiber recommendations. The current recommendation for consuming at least half of all grains as whole grains was determined by the DGA Committee by reviewing current literature for the intake levels associated with the greatest health benefits. The DGA Committee found that consuming 3 or more servings (3 oz equivalents) of whole grain foods in a 2000 kilocalorie diet can reduce the risk of CVD and T2DM and help with weight maintenance. To assess nutrient adequacy from recommended dietary patterns, an assumption was made by the DGA Committee that 26% of grain intake would be from fortified RTE cereal, which is well above actual intake levels (USDA DGAC, 2010). The high proportion of intake from fortified cereals provides adequate levels of folate, iron and Vitamin A but is not a realistic expectation or one that is communicated in the grain recommendations. Because whole grain foods are not part of the enrichment program and contain lower levels of folate, iron, thiamin and riboflavin than refined but enriched products, recommending that all grain foods be consumed as whole would result in inadequate intake for these nutrients. Including whole grains in the enrichment program could mitigate these shortfalls.

The substitution of whole grains for refined grains would decrease intake of folate by more than 10% of the recommended daily value for most Americans, representing a change of public health significance. The RDV for folate is 400 mcg. Average intake in the observed diet was 167.4mcg, while the average intake for the substitution model diet was 126.6mcg. In this study, females overall would see decreases in folate intake by 9.23% of the RDV, which approaches public health significance. Individuals under 65 years old would see a decrease in folate intake of 10% of RDV or more, which does represent public health significance. Due to the size of the sample, it is not possible to analyze females under 45 but, based on the current results, it is likely that females in their reproductive years would miss out on a significant source of folate if they should choose whole grains over refined grain products.

Folate is a nutrient of concern for women of reproductive capacity (DGA; USDA, 2010a). The rate of unintended pregnancies was 49% in 2006, with the highest rates for younger women and those with lower income and education. Unintended pregnancies are associated with increased risks for both the mother and the baby as the mother may not be in optimal health at the time of conception (Finer & Zolna, 2011). Increased intake of folate to 400mcg/day in women of reproductive capacity is associated with a 72% protective effect over neural tube defects in children (Besser, Williams, & Cragan, 2007). The potential decrease in folate intake associated with replacing whole grains for refined grains could impact the risk for neural tube defects.

Folate is a part of the grain enrichment program and is added back to flour after the refining process strips it out. Enrichment of nutrients does not occur in equivalent amounts and, in fact, are reintroduced in amounts greater than what originally existed in the grain. With this in mind, it may be necessary to include whole grain products as part of the enrichment program in order to avoid the potential negative consequence of decreased folate intake with increased whole grain consumption. These findings are consistent with the discussions of nutrient adequacy in the DGA 2010 where it is recommended that some consumption of whole grain should include products that are fortified with folic acid, especially for women of reproductive capacity (DGA; USDA, 2010a).

Intake of iron, riboflavin and thiamin, which are also part of the grain enrichment program, would decrease in smaller amounts of approximately 2%-4% of recommended daily values. The current RDVs are 18mg for iron, 1.7mg for riboflavin and 1.5 mg for thiamin. Average intake in the observed diet for iron was 6.1mg, while the model diet intake was 5.5mg. Average intake in the observed diet for riboflavin was 0.51mg, while the model diet intake was 0.46mg. Average intake in the observed diet for thiamin was 0.59mg, while the model diet intake was 0.53mg. Although these values were statistically significant, the changes in intake were not of public health significance according to the standards set forth in this study. The decrease in intake of these nutrients with an increase in whole grain consumption is a cause for concern, however. The prevalence of iron deficiency anemia in non-Hispanic white women is 9-12% and almost 20% in black and Mexican-American women. Infants and children are also especially at risk for iron deficiency (Killip, Bennett, & Chambers, 2007). Including whole grain products in the enrichment program could help mitigate these deficiencies.

Energy intake did not differ much between the observed and substitution model diets. Although decreased energy intake would not occur by simply replacing refined grain foods with whole grain equivalents, there is the potential for a decrease in overall energy intake when a larger proportion of whole grain foods are consumed. This is due to increased fiber intake, which results in greater levels of satiety (Slavin & Green 2007). Consumption of high fiber cereal grains have been shown to lower both subjective appetite and plasma glucose compared to lower fiber cereal grains (Hamedani, Akhavan, Samra, & Anderson, 2009). Soluble fibers increase viscosity of gut contents, while insoluble fibers provide bulk and slow transit time through the gut. Increased viscosity is associated with decreased absorption of glucose and some lipids. Both higher viscosity and greater bulk can slow gastric emptying, which results in longer periods of satiation (Read & Eastwood 1992; Jenkins, Wolever, Leeds, Gassull, Dilawari, Goff, Metz & Alberti 1978). Consumption of whole grain foods is inversely associated with weight and body fat. A 20-month, prospective cohort study (n=252) found that for each 1g increase in total fiber consumption, weight was reduced by 0.25 kg and percent body fat decreased by .025 percentage points (Tucker & Thomas, 2009).

Cost was significantly higher for all groups, both statistically and at a level of public health significance. Not surprisingly, those most affected by the increase in cost associated with meeting the dietary guidelines for whole grains were young adults and individuals with the lowest levels of income and education. These findings are consistent with other studies that have analyzed diet cost across sociodemographic strata of the population (Aggarwal, Monsivais, Cook, & Drewnowski, 2011; Darmon et al., 2002; Rehm et al., 2011). Also consistent with other study findings is the higher cost of whole grains relative to refined grains (Jetter & Cassady, 2006; Katz et al., 2011; L. Mancino & Kuchler, 2011).

The findings of this study support the theory of the energy-density cost curve put forth by Drewnowski. Individuals with the lowest levels of income face the greatest relative increase in cost at more than 32% higher than observed dietary grain cost when consuming the recommended level of whole grains. This increase translates to $0.11, which is equal to 2.4% of the total TFP daily per person cost of $4.56. An increase of $0.11 is likely insubstantial for many Americans but is most likely not feasible for those individuals with lower levels of income where every penny matters. Cost is one aspect of the food environment that may not fully support the ability of all Americans to achieve recommended levels of intake for all food groups putting many at an increased health risk.

There were a number of limitations for this study. The first includes the use of a single, nationally representative database of food prices that does not account for regional or seasonal variations in food prices. The 2003-2004 CNPP Price database provides the latest retail price data in as-consumed form for all foods consumed in the NHANES 24-hour dietary recalls. The QFAHPD, which replaced the CNPP Price database, does not provide retail food prices for individual foods, but rather for generalized food types. The price data maintained in the QFAHPD does account for region and seasonal differences but does not reflect prices faced by the lowest income consumers. Some further efforts have been made by individual researchers to capture retail individual food prices in specific regions in order to capture price fluctuations due to regional availability and cost (Hurvitz, Moudon, Rehm, Streichert, & Drewnowski, 2009). By tracking food prices at the consumer retail level, actual diet costs can be more closely approximated.

The second limitation is an extension of the first limitation. This study was based on data from NHANES 2003-2004. Since that time, whole grain intake has increased (L. Mancino & Kuchler, 2011; Rehm et al., 2011) and prices of food, including grain products, have fluctuated substantially (Todd, Leibtag, & Penberthy, 2011; Todd & Lin, 2012). These factors may contribute to different results should the same substitution model diet be applied to more recent data.

The third limitation is that all effects of grain replacement are due to the projected substitution model. Modeling did attempt to take into consideration individual food preferences by replacing refined grain foods consumed in the observed diet with a whole grain equivalent product. It is possible that individuals would not consider this replacement satisfactory for consumption of all grain food products due to taste, convenience or other factors. As a result, the substitution model diet accounts for maximizing benefits of grain consumption recommendations.

A fourth limitation is the exclusion of mixed grain foods as well as grain foods high in saturated fat and added sugars (SoFAS), such as cakes, pies and cookies. These foods were excluded due to a lack of data allowing for a whole grain equivalent. SoFAS were also excluded because the DGA recommends limiting intake of these foods and a WG equivalent is unlikely to provide benefits to counter the negative impacts of consuming foods high in SoFAS. If the mixed grain foods had been included, overall grain intake would have been higher and the impacts on fiber and other nutrients may have resulted in different outcomes.

The fifth limitation is the definition of a 10% change in RDV as a representation of public health significance. This threshold was used due to the precedent set in the study by Monsivais and Rehm (2012). This threshold level may, in fact, be too low for shortfall nutrients, such as fiber and folate, since even a small change in intake levels of these nutrients can have an impact in health outcomes.

Replacement of refined grain foods with whole grain equivalents at recommended levels has the potential to increase fiber in the US diet in a cost-effective manner for many Americans. Adults in the U.S. barely consume the AI for dietary fiber of 14g/day (Jones et al., 2006). A moderate intake of soluble fiber is likely to have significant favorable effects on risk and the progression of CVD (Anderson et al., 2009), which is the leading cause of death in the U.S. (Ye et al., 2012). Soluble fiber intake of approximately 6g/day is associated with an estimated risk reduction for CVD by 9%. Whole grains are a nutrient dense source of dietary fiber and are low in cost relative to other nutrient dense foods (Darmon et al., 2002; Drewnowski & Darmon, 2005a).

The concurrent decrease in folate intake associated with the substitution model diet reflects a potential need to include whole grain food products in the enrichment program. Enrichment of wheat flour began in 1938 in an attempt to overcome deficiencies of B vitamins in servicemen as well as the general population. Folic acid was added to the enrichment program in 1998. The enrichment of wheat flour with B vitamins has produced substantial decreases in incidence of pellagra, beriberi and neural tube defects (Adams, 2013). As the USDA DGA committee has recognized the benefits of whole grain consumption, it continues to recognize the need for enriched grain products. Further research is recommended to consider increasing the DGA recommendation for grains to be a larger percentage of whole grain products and the impacts of expanding the grain enrichment program to include whole grain products.

Although the additional cost difference between observed and substitution model diets was larger than 10% of observed diet total grain cost, the change represents an increase of only $0.07 for the sample overall. Young adults, non-whites, and those with the lowest levels of income and education would be most affected by the increase in price. Since there are large disparities in the rates of CVD, with non-Hispanic blacks and lower income and education individuals disproportionately affected (Cooper et al., 2000), the additional risk-reducing benefits appear to be worth the additional cost.

Nutrition education for meeting dietary recommendations should focus on cost-effective methods especially for those of lower SES. Both the Supplemental Nutrition Assistance Program-Education (SNAP-Ed) and the Expanded Food and Nutrition Education Program (EFNEP) have shown positive behavioral changes, including those related to shopping for nutritious foods on a budget. These behavioral changes were maintained or improved when reassessed after 6-12 months (Koszewski, Sehi, & Tuttle, 2011). Food assistance programs that target low-income individuals could include greater incentives for whole grain intake. Examples of such programs already exist to provide incentives to increase intake of fruits and vegetables. The most effective of these strategies tend to be grocery-store based interventions that include point-of-purchase information, reduced prices or coupons, increased availability, variety and convenience as well as promotions and advertising (Glanz & Yaroch, 2004).

The DGA 2005 had a significant impact on availability and sales of whole-grain foods, much of which occurred through reformulation of existing products by food manufacturers (Mancino, Kuchler, & Leibtag, 2008). This is one example of agricultural and food marketing policies and partnerships with food growers and manufacturers that helped increase the whole grain presence in popular food products. Other efforts include the Plant Pathways Elucidation Project (P2EP) in North Carolina. P2EP is a consortium of university scientists, industry leaders and college students exploring together how plant pathways benefit human health. One of their initiatives includes a partnership between North Carolina Research Campus (NCRC) and General Mills to develop oats with higher and more consistent levels of beta-glucan, a soluble fiber that is clinically proven to lower cholesterol (NCRC 2012). Continued support of these policies and partnerships as well as those that reduce whole grain food costs should be supported to incent better health outcomes.

Further research in this area should examine regional and seasonal price differences in grain foods in order to more accurately approximate true diet cost. This would include expanding USDA retail food price data to include more recent years along with regional and seasonal price differences over time. In addition, further attempts to identify the whole grain food products that are most acceptable as a substitute to the refined grain equivalent should be pursued. Acceptability should encompass taste, texture, flavor, appearance, cost, reputation, and convenience and knowledge of food identification and preparation but it would be beneficial to identify any other factors that may contribute to refined grain preference over whole. Finally, future research should look to quantify the change in intake that truly provides a clinical impact of public health significance for each nutrient. The development of recommended intakes is based on maximizing positive health outcomes but it the impact of incremental changes in nutrient intakes is not well understood. As we strive to close to the gap between actual nutrient intake and recommended intake, these incremental changes may provide meaningful health outcomes and reduced disease risks.

Appendix 1

USDA Food Code	Description	Whole Grain Food Code Equivalent	Description
51000100	Bread, NS as to major flour	51201010	Bread, whole wheat, 100%
51000110	Bread, NS as to major flour, toasted	51201020	Bread, whole wheat, 100%, toasted
51000180	Bread, made from home recipe or purchased at a bakery, NS as to major flour	51201060	Bread, whole wheat, 100%, made from home recipe or purchased at bakery
51000200	Roll, NS as to major flour	51220000	Roll, whole wheat, 100%
51000300	Roll, hard, NS as to major flour	51220000	Roll, whole wheat, 100%
51101000	Bread, white	51201010	Bread, whole wheat, 100%
51101010	Bread, white, toasted	51201020	Bread, whole wheat, 100%, toasted
51101050	Bread, white, made from home recipe or purchased at a bakery	51201060	Bread, whole wheat, 100%, made from home recipe or purchased at bakery
51101060	Bread, white, made from home recipe or purchased at a bakery, toasted	51201070	Bread, whole wheat, 100%, made from home recipe or purchased at bakery, toasted
51102010	Bread, white with whole wheat swirl	51201010	Bread, whole wheat, 100%
51102020	Bread, white with whole wheat swirl, toasted	51201020	Bread, whole wheat, 100%, toasted
51105010	Bread, Cuban	51201010	Bread, whole wheat, 100%
51105040	Bread, Cuban, toasted	51201020	Bread, whole wheat, 100%, toasted
51106010	Bread, Native, Puerto Rican style (Pan Criollo)	51201010	Bread, whole wheat, 100%
51106020	Bread, Native, Puerto Rican style, toasted (Pan Criollo)	51201020	Bread, whole wheat, 100%, toasted
51106100	Bread, Native water, Puerto Rican style (Pan de agua)	51201010	Bread, whole wheat, 100%
51106310	Bread, caressed, Puerto Rican style, toasted (Pan sobao)	51201020	Bread, whole wheat, 100%, toasted

51107010	Bread, French or Vienna	51201010	Bread, whole wheat, 100%
51107040	Bread, French or Vienna, toasted	51201020	Bread, whole wheat, 100%, toasted
51108010	Focaccia, Italian flatbread, plain	51201010	Bread, whole wheat, 100%
51108100	Naan, Indian flatbread	51201010	Bread, whole wheat, 100%
51109010	Bread, Italian, Grecian, Armenian	51201010	Bread, whole wheat, 100%
51109040	Bread, Italian, Grecian, Armenian, toasted	51201020	Bread, whole wheat, 100%, toasted
51109100	Bread, pita	51201150	Bread, pita, whole wheat, 100%
51109110	Bread, pita, toasted	51201150	Bread, pita, whole wheat, 100%
51110010	Bread, batter	51201010	Bread, whole wheat, 100%
51111010	Bread, cheese	51201010	Bread, whole wheat, 100%
51111040	Bread, cheese, toasted	51201020	Bread, whole wheat, 100%, toasted
51113010	Bread, cinnamon	51201010	Bread, whole wheat, 100%
51113100	Bread, cinnamon, toasted	51201020	Bread, whole wheat, 100%, toasted
51119010	Bread, egg, Challah	51201010	Bread, whole wheat, 100%
51119040	Bread, egg, Challah, toasted	51201020	Bread, whole wheat, 100%, toasted
51121010	Bread, garlic	51201010	Bread, whole wheat, 100%
51121040	Bread, garlic, toasted	51201020	Bread, whole wheat, 100%, toasted
51121110	Bread, onion	51201010	Bread, whole wheat, 100%
51122000	Bread, reduced calorie and/or high fiber, white or NFS	51201010	Bread, whole wheat, 100%
51122050	Bread, reduced calorie and/or high fiber, Italian	51201010	Bread, whole wheat, 100%
51122060	Bread, reduced calorie and/or high fiber, Italian, toasted	51201020	Bread, whole wheat, 100%, toasted
51122100	Bread, reduced calorie and/or high fiber, white or NFS, with fruit and/or nuts	51201010	Bread, whole wheat, 100%

51122310	Bread, white, special formula, added fiber, toasted	51201020	Bread, whole wheat, 100%, toasted
51123010	Bread, high protein	51201010	Bread, whole wheat, 100%
51126010	Bread, milk and honey	51201010	Bread, whole wheat, 100%
51126020	Bread, milk and honey, toasted	51201020	Bread, whole wheat, 100%, toasted
51127010	Bread, potato	51201010	Bread, whole wheat, 100%
51127020	Bread, potato, toasted	51201020	Bread, whole wheat, 100%, toasted
51129010	Bread, raisin	51201010	Bread, whole wheat, 100%
51129020	Bread, raisin, toasted	51201020	Bread, whole wheat, 100%, toasted
51133010	Bread, sour dough	51201010	Bread, whole wheat, 100%
51133020	Bread, sour dough, toasted	51201020	Bread, whole wheat, 100%, toasted
51135000	Bread, vegetable	51201010	Bread, whole wheat, 100%
51140100	Bread, dough, fried	51300180	Bread, puri or poori (Indian puffed bread), whole wheat, NS as to 100%, fried
51150000	Roll, white, soft	51220000	Roll, whole wheat, 100%
51150100	Roll, white, soft, toasted	51220000	Roll, whole wheat, 100%
51151060	Roll, white, soft, made from home recipe or purchased at a bakery	51220000	Roll, whole wheat, 100%
51152000	Roll, white, soft, reduced calorie and/or high fiber	51220000	Roll, whole wheat, 100%
51153000	Roll, white, hard	51220000	Roll, whole wheat, 100%
51154550	Roll, egg bread	51220000	Roll, whole wheat, 100%
51154600	Roll, cheese	51220000	Roll, whole wheat, 100%
51155000	Roll, French or Vienna	51220000	Roll, whole wheat, 100%
51155010	Roll, French or Vienna, toasted	51220000	Roll, whole wheat, 100%
51156500	Roll, garlic	51220000	Roll, whole wheat, 100%
51157000	Roll, hoagie, submarine	51220000	Roll, whole wheat, 100%
51158100	Roll, Mexican, bolillo	51220000	Roll, whole wheat, 100%
51159000	Roll, sour dough	51220000	Roll, whole wheat, 100%
51180010	Bagel	51208100	Bagel, whole wheat, 100%, with raisins
51180030	Bagel, with raisins	51208100	Bagel, whole wheat, 100%, with raisins

51180080	Bagel, with fruit other than raisins	51208100	Bagel, whole wheat, 100%, with raisins
51182010	Bread stuffing	51201010	Bread, whole wheat, 100%
51182020	Bread stuffing made with egg	51201010	Bread, whole wheat, 100%
51184000	Bread sticks, hard	51220000	Roll, whole wheat, 100%
51184010	Bread stick, soft	51220000	Roll, whole wheat, 100%
51184020	Bread stick, NS as to hard or soft	51220000	Roll, whole wheat, 100%
51184030	Bread stick, soft, prepared with garlic and parmesan cheese	51220000	Roll, whole wheat, 100%
51184100	Bread stick, hard, low sodium	51220000	Roll, whole wheat, 100%
51185000	Croutons	51201020	Bread, whole wheat, 100%, toasted
51186010	Muffin, English	51303010	Muffin, English, wheat or cracked wheat
51186020	Muffin, English, toasted	51303010	Muffin, English, wheat or cracked wheat
51186100	Muffin, English, with raisins	51303010	Muffin, English, wheat or cracked wheat
51187000	Melba toast	51201020	Bread, whole wheat, 100%, toasted
51188100	Pannetone (Italian-style sweetbread)	51201020	Bread, whole wheat, 100%, toasted
51188500	Zwieback toast	51201020	Bread, whole wheat, 100%, toasted
51201010	Bread, whole wheat, 100%	51201010	Bread, whole wheat, 100%
51201020	Bread, whole wheat, 100%, toasted	51201020	Bread, whole wheat, 100%, toasted
51201060	Bread, whole wheat, 100%, made from home recipe or purchased at bakery	51201060	Bread, whole wheat, 100%, made from home recipe or purchased at bakery
51201070	Bread, whole wheat, 100%, made from home recipe or purchased at bakery, toasted	51201070	Bread, whole wheat, 100%, made from home recipe or purchased at bakery, toasted
51201150	Bread, pita, whole wheat, 100%	51201150	Bread, pita, whole wheat, 100%
51207010	Bread, sprouted wheat	51207010	Bread, sprouted wheat
51208100	Bagel, whole wheat, 100%, with raisins	51208100	Bagel, whole wheat, 100%, with raisins
51220000	Roll, whole wheat, 100%	51220000	Roll, whole wheat, 100%

51300110	Bread, whole wheat, other than 100% or NS as to 100%	51201010	Bread, whole wheat, 100%
51300120	Bread, whole wheat, other than 100% or NS as to 100%, toasted	51201020	Bread, whole wheat, 100%, toasted
51300140	Bread, whole wheat, other than 100% or NS as to 100%, made from home recipe or purchased at bakery	51201060	Bread, whole wheat, 100%, made from home recipe or purchased at bakery
51300150	Bread, whole wheat, other than 100% or NS as to 100%, made from home recipe or purchased at bakery, toasted	51201070	Bread, whole wheat, 100%, made from home recipe or purchased at bakery, toasted
51300180	Bread, puri or poori (Indian puffed bread), whole wheat, NS as to 100%, fried	51300180	Bread, puri or poori (Indian puffed bread), whole wheat, NS as to 100%, fried
51300210	Bread, whole wheat, NS as to 100%, with raisins	51201010	Bread, whole wheat, 100%
51300220	Bread, whole wheat, NS as to 100%, with raisins, toasted	51201020	Bread, whole wheat, 100%, toasted
51301010	Bread, wheat or cracked wheat	51201010	Bread, whole wheat, 100%
51301020	Bread, wheat or cracked wheat, toasted	51201020	Bread, whole wheat, 100%, toasted
51301040	Bread, wheat or cracked wheat, made from home recipe or purchased at bakery	51201060	Bread, whole wheat, 100%, made from home recipe or purchased at bakery
51301050	Bread, wheat or cracked wheat, made from home recipe or purchased at bakery, toasted	51201070	Bread, whole wheat, 100%, made from home recipe or purchased at bakery, toasted
51301120	Bread, wheat or cracked wheat, with raisins	51201010	Bread, whole wheat, 100%
51301510	Bread, wheat or cracked wheat, reduced calorie and/or high fiber	51201010	Bread, whole wheat, 100%
51301520	Bread, wheat or cracked wheat, reduced calorie and/or high fiber, toasted	51201020	Bread, whole wheat, 100%, toasted

51301540	Bread, French or Vienna, whole wheat, other than 100% or NS as to 100%, made from hom	51201060	Bread, whole wheat, 100%, made from home recipe or purchased at bakery
51301600	Bread, pita, whole wheat, other than 100% or NS as to 100%	51201150	Bread, pita, whole wheat, 100%
51301620	Bread, pita, wheat or cracked wheat	51201150	Bread, pita, whole wheat, 100%
51301700	Bagel, wheat	51208100	Bagel, whole wheat, 100%, with raisins
51301750	Bagel, whole wheat, other than 100% or NS as to 100%	51208100	Bagel, whole wheat, 100%, with raisins
51301760	Bagel, whole wheat, other than 100% or NS as to 100%, toasted	51208100	Bagel, whole wheat, 100%, with raisins
51301800	Bagel, wheat, with raisins	51208100	Bagel, whole wheat, 100%, with raisins
51301820	Bagel, wheat, with fruit and nuts	51208100	Bagel, whole wheat, 100%, with raisins
51301900	Bagel, wheat bran	51208100	Bagel, whole wheat, 100%, with raisins
51302020	Bread, wheat bran, toasted	51201020	Bread, whole wheat, 100%, toasted
51302500	Muffin, English, wheat bran	51303010	Muffin, English, wheat or cracked wheat
51303010	Muffin, English, wheat or cracked wheat	51303010	Muffin, English, wheat or cracked wheat
51303030	Muffin, English, whole wheat, other than 100% or NS as to 100%	51303010	Muffin, English, wheat or cracked wheat
51303050	Muffin, English, wheat or cracked wheat, with raisins	51303010	Muffin, English, wheat or cracked wheat
51303070	Muffin, English, whole wheat, other than 100% or NS as to 100%, with raisins	51303010	Muffin, English, wheat or cracked wheat
51320010	Roll, wheat or cracked wheat	51220000	Roll, whole wheat, 100%
51320500	Roll, whole wheat, NS as to 100%	51220000	Roll, whole wheat, 100%
51401010	Bread, rye	51201010	Bread, whole wheat, 100%
51401020	Bread, rye, toasted	51201020	Bread, whole wheat, 100%, toasted
51401030	Bread, marble rye and pumpernickel	51201010	Bread, whole wheat, 100%

51404010	Bread, pumpernickel	51201010	Bread, whole wheat, 100%
51404020	Bread, pumpernickel, toasted	51201020	Bread, whole wheat, 100%, toasted
51404500	Bagel, pumpernickel	51208100	Bagel, whole wheat, 100%, with raisins
51407010	Bread, black	51201010	Bread, whole wheat, 100%
51420000	Roll, rye	51220000	Roll, whole wheat, 100%
51421000	Roll, pumpernickel	51220000	Roll, whole wheat, 100%
51501010	Bread, oatmeal	51201010	Bread, whole wheat, 100%
51501020	Bread, oatmeal, toasted	51201020	Bread, whole wheat, 100%, toasted
51501040	Bread, oat bran	51201010	Bread, whole wheat, 100%
51501050	Bread, oat bran, toasted	51201020	Bread, whole wheat, 100%, toasted
51501080	Bagel, oat bran	51208100	Bagel, whole wheat, 100%, with raisins
51502010	Roll, oatmeal	51220000	Roll, whole wheat, 100%
51502100	Roll, oat bran	51220000	Roll, whole wheat, 100%
51503000	Muffin, English, oat bran	51303010	Muffin, English, wheat or cracked wheat
51601010	Bread, multigrain, toasted	51601010	Bread, multigrain, toasted
51601020	Bread, multigrain	51601020	Bread, multigrain
51601220	Bread, multigrain, with raisins, toasted	51601220	Bread, multigrain, with raisins, toasted
51602010	Bread, multigrain, reduced calorie and/or high fiber	51601020	Bread, multigrain
51620000	Roll, multigrain	51220000	Roll, whole wheat, 100%
51630000	Bagel, multigrain	51208100	Bagel, whole wheat, 100%, with raisins
51630100	Bagel, multigrain, with raisins	51208100	Bagel, whole wheat, 100%, with raisins
51630200	Muffin, English, multigrain	51303010	Muffin, English, wheat or cracked wheat
51804020	Bread, soy, toasted	51201020	Bread, whole wheat, 100%, toasted
51805010	Bread, sunflower meal	51201010	Bread, whole wheat, 100%
51805020	Bread, sunflower meal, toasted	51201020	Bread, whole wheat, 100%, toasted
51806010	Bread, rice	51201010	Bread, whole wheat, 100%
51807000	Injera (American-style Ethiopian bread)	51201010	Bread, whole wheat, 100%

52101000	Biscuit, baking powder or buttermilk type, NS as to made from mix, refrigerated dough, or home recipe	52104040	Biscuit, whole wheat
52101030	Biscuit dough, fried	52104040	Biscuit, whole wheat
52101040	Crumpet	52104040	Biscuit, whole wheat
52101100	Biscuit, baking powder or buttermilk type, made from mix	52104040	Biscuit, whole wheat
52102040	Biscuit, baking powder or buttermilk type, made from refrigerated dough	52104040	Biscuit, whole wheat
52103000	Biscuit, baking powder or buttermilk type, commercially baked	52104040	Biscuit, whole wheat
52104010	Biscuit, baking powder or buttermilk type, made from home recipe	52104040	Biscuit, whole wheat
52104040	Biscuit, whole wheat	52104040	Biscuit, whole wheat
52104100	Biscuit, cheese	52104040	Biscuit, whole wheat
52104200	Biscuit, cinnamon-raisin	52104040	Biscuit, whole wheat
52105100	Scone	52104040	Biscuit, whole wheat
52105200	Scone, with fruit	52104040	Biscuit, whole wheat
52201000	Cornbread, prepared from mix	52104040	Biscuit, whole wheat
52202060	Cornbread, made from home recipe	52104040	Biscuit, whole wheat
52204000	Cornbread stuffing	52104040	Biscuit, whole wheat
52206010	Cornbread muffin, stick, round	52104040	Biscuit, whole wheat
52206060	Cornbread muffin, stick, round, made from home recipe	52104040	Biscuit, whole wheat
52208750	Gordita/sope shell, plain, no filling, grilled, no fat added	52215260	Tortilla, whole wheat
52208760	Gordita/sope shell, plain, no filling, fried in oil	52215260	Tortilla, whole wheat
52209010	Hush puppy	52104040	Biscuit, whole wheat
52215000	Tortilla, NFS	52215260	Tortilla, whole wheat
52215100	Tortilla, corn	52215260	Tortilla, whole wheat
52215200	Tortilla, flour (wheat)	52215260	Tortilla, whole wheat
52215260	Tortilla, whole wheat	52215260	Tortilla, whole wheat
52215300	Taco shell, corn	52215260	Tortilla, whole wheat
52215350	Taco shell, flour	52215260	Tortilla, whole wheat
52220110	Cornmeal bread, Dominican style (Arepa Dominicana)	52104040	Biscuit, whole wheat

52301000	Muffin, NFS	52303500	Muffin, wheat
52302010	Muffin, fruit and/or nuts	52303500	Muffin, wheat
52302100	Muffin, fruit, fat free, cholesterol free	52303500	Muffin, wheat
52302500	Muffin, chocolate chip	52303500	Muffin, wheat
52302600	Muffin, chocolate	52303500	Muffin, wheat
52303500	Muffin, wheat	52303500	Muffin, wheat
52304010	Muffin, wheat bran	52303500	Muffin, wheat
52304040	Muffin, bran with fruit, lowfat	52303500	Muffin, wheat
52304060	Muffin, bran with fruit, no fat, no cholesterol	52303500	Muffin, wheat
52304150	Muffin, oat bran	52303500	Muffin, wheat
52304200	Muffin, oat bran with fruit and/or nuts	52303500	Muffin, wheat
52306010	Muffin, plain	52303500	Muffin, wheat
52306500	Muffin, pumpkin	52303500	Muffin, wheat
52306550	Muffin, zucchini	52303500	Muffin, wheat
52306700	Muffin, carrot	52303500	Muffin, wheat
52308010	Matzo, fritters	52104040	Biscuit, whole wheat
52308020	Matzo ball	52104040	Biscuit, whole wheat
52403000	Bread, nut	52303500	Muffin, wheat
52404060	Bread, pumpkin	52303500	Muffin, wheat
52405010	Bread, fruit, without nuts	52303500	Muffin, wheat
52405100	Bread, fruit and nut	52303500	Muffin, wheat
52407000	Bread, zucchini	52303500	Muffin, wheat
52408000	Bread, Irish soda	52104040	Biscuit, whole wheat
54001000	Crackers, NS as to sweet or nonsweet	54102010	Crackers, graham
54101010	Cracker, animal	54102010	Crackers, graham
54102010	Crackers, graham	54102010	Crackers, graham
54102020	Crackers, graham, chocolate covered	54102020	Crackers, graham, chocolate covered
54102050	Crackers, oatmeal	54102010	Crackers, graham
54102060	Crackers, Cuban	54102010	Crackers, graham
54102100	Crackers, graham, lowfat	54102010	Crackers, graham
54102110	Crackers, graham, fat free	54102010	Crackers, graham
54102200	Crackers, graham, sandwich-type, with filling	54102200	Crackers, graham, sandwich-type, with filling
54201010	Crackers, matzo, low sodium	54204010	Cracker, 100% whole wheat, low sodium
54202010	Crackers, saltine, low sodium	54204010	Cracker, 100% whole wheat, low sodium
54202050	Crackers, saltine, fat free, low sodium	54204010	Cracker, 100% whole wheat, low sodium

54203010	Crackers, toast thins (rye, wheat, white flour), low sodium	54204010	Cracker, 100% whole wheat, low sodium
54204010	Cracker, 100% whole wheat, low sodium	54204010	Cracker, 100% whole wheat, low sodium
54205010	Cracker, snack, low sodium	54204010	Cracker, 100% whole wheat, low sodium
54205030	Cracker, cheese, low sodium	54204010	Cracker, 100% whole wheat, low sodium
54205100	Cracker, snack, lowfat, low sodium	54204010	Cracker, 100% whole wheat, low sodium
54210010	Cracker, multigrain, salt free	54204010	Cracker, 100% whole wheat, low sodium
54301000	Cracker, snack	54304500	Cracker, high fiber, no added fat
54301100	Cracker, snack, reduced fat	54304500	Cracker, high fiber, no added fat
54301200	Cracker, snack, fat free	54304500	Cracker, high fiber, no added fat
54304000	Cracker, cheese	54304500	Cracker, high fiber, no added fat
54304100	Cracker, cheese, reduced fat	54304500	Cracker, high fiber, no added fat
54304500	Cracker, high fiber, no added fat	54304500	Cracker, high fiber, no added fat
54305000	Crispbread, wheat, no added fat	54304500	Cracker, high fiber, no added fat
54305500	Crispbread, wheat or rye, extra crispy	54304500	Cracker, high fiber, no added fat
54307000	Crackers, matzo	54304500	Cracker, high fiber, no added fat
54308000	Crackers, milk	54304500	Cracker, high fiber, no added fat
54309000	Crackers, oat	54304500	Cracker, high fiber, no added fat
54313000	Crackers, oyster	54304500	Cracker, high fiber, no added fat
54318500	Rice cake, cracker-type	54318500	Rice cake, cracker-type
54319000	Crackers, rice	54318500	Rice cake, cracker-type
54319010	Puffed rice cake	54319010	Puffed rice cake
54319020	Popcorn cake	54319020	Popcorn cake
54322000	Crispbread, rye, no added fat	54322000	Crispbread, rye, no added fat
54325000	Crackers, saltine	54337000	Cracker, 100% whole wheat
54325050	Crackers, saltine, whole wheat	54337000	Cracker, 100% whole wheat
54327950	Crackers, cylindrical, peanut-butter filled	54337000	Cracker, 100% whole wheat

54328000	Crackers, sandwich-type, NFS	54337000	Cracker, 100% whole wheat
54328100	Cracker, sandwich-type, peanut butter filled	54337000	Cracker, 100% whole wheat
54328200	Cracker, sandwich-type, cheese-filled	54337000	Cracker, 100% whole wheat
54334000	Crackers, toast thins (rye, pumpernickel, white flour)	54337000	Cracker, 100% whole wheat
54336000	Crackers, water biscuits	54337000	Cracker, 100% whole wheat
54337000	Cracker, 100% whole wheat	54337000	Cracker, 100% whole wheat
54337050	Cracker, 100% whole wheat, reduced fat	54337050	Cracker, 100% whole wheat, reduced fat
54338000	Crackers, wheat	54337000	Cracker, 100% whole wheat
54338100	Crackers, wheat, reduced fat	54337050	Cracker, 100% whole wheat, reduced fat
54350000	Crackers, baby food	54337000	Cracker, 100% whole wheat
54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted
54401020	Salty snacks, corn or cornmeal base, corn chips, corn-cheese chips	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted
54401050	Salty snacks, corn or cornmeal base, corn puffs and twists; corn-cheese puffs and twists	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted
54401080	Salty snacks, corn or cornmeal base, tortilla chips	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted
54401090	Salty snacks, corn or cornmeal base, corn chips, corn-cheese chips, unsalted	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted
54401100	Salty snacks, corn or cornmeal base, tortilla chips, light (baked with less oil)	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted
54401120	Salty snacks, corn or cornmeal base, tortilla chips, fat free, made with Olean	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted
54401150	Salty snacks, corn or cornmeal base, tortilla chips, lowfat, baked without fat	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted

54401170	Salty snacks, corn or cornmeal base, tortilla chips, lowfat, baked without fat, unsalted	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted
54401210	Salty snacks, corn based puffs and twists, cheese puffs and twists, lowfat	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted
54402080	Salty snacks, corn or cornmeal base, tortilla chips, unsalted	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted
54402200	Salty snack mixture, mostly corn or cornmeal based, with pretzels, without nuts	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted
54402600	Salty snacks, multigrain, chips	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted
54403000	Popcorn, popped in oil, unbuttered	54403000	Popcorn, popped in oil, unbuttered
54403010	Popcorn, air-popped (no butter or no oil added)	54403010	Popcorn, air-popped (no butter or no oil added)
54403020	Popcorn, popped in oil, buttered	54403020	Popcorn, popped in oil, buttered
54403040	Popcorn, air-popped, buttered	54403040	Popcorn, air-popped, buttered
54403050	Popcorn, flavored	54403050	Popcorn, flavored
54403060	Popcorn, popped in oil, lowfat, low sodium	54403060	Popcorn, popped in oil, lowfat, low sodium
54403070	Popcorn, popped in oil, lowfat	54403070	Popcorn, popped in oil, lowfat
54403090	Popcorn, popped in oil, unsalted	54403090	Popcorn, popped in oil, unsalted
54403110	Popcorn, sugar syrup or caramel-coated	54403110	Popcorn, sugar syrup or caramel-coated
54403120	Popcorn, sugar syrup or caramel-coated, with nuts	54403120	Popcorn, sugar syrup or caramel-coated, with nuts
54406010	Onion-flavored rings	54406010	Onion-flavored rings
54408000	Pretzels, NFS	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted
54408010	Pretzels, hard	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted
54408020	Pretzels, soft	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted
54408030	Pretzel, hard, unsalted	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted

54408200	Pretzel, hard, chocolate-coated	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted
54408250	Pretzel, yogurt-covered	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted
54408300	Pretzels, cheese-filled	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted
54420010	Multigrain mixture, pretzels, cereal and/or crackers, nuts	54420100	Oriental party mix, with peanuts, sesame sticks, chili rice crackers and fried green peas
54420100	Oriental party mix, with peanuts, sesame sticks, chili rice crackers and fried green peas	54420100	Oriental party mix, with peanuts, sesame sticks, chili rice crackers and fried green peas
54420200	Multigrain mixture, bread sticks, sesame nuggets, pretzels, rye chips	54420100	Oriental party mix, with peanuts, sesame sticks, chili rice crackers and fried green peas
54430010	Yogurt chips	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted
54440010	Bagel chip	54401010	Salty snacks, corn or cornmeal base, nuts or nuggets, toasted
55101000	Pancakes, plain	55105200	Pancakes, whole wheat
55101010	Pancakes, reduced calorie, high fiber	55105200	Pancakes, whole wheat
55103000	Pancakes, with fruit	55105200	Pancakes, whole wheat
55103100	Pancakes, with chocolate chips	55105200	Pancakes, whole wheat
55105000	Pancakes, buckwheat	55105200	Pancakes, whole wheat
55105100	Pancakes, cornmeal	55105200	Pancakes, whole wheat
55105200	Pancakes, whole wheat	55105200	Pancakes, whole wheat
55105300	Pancakes, sour dough	55105200	Pancakes, whole wheat
55201000	Waffle, plain	55205000	Waffle, 100% whole wheat or 100% whole grain
55202000	Waffle, wheat, bran, or multigrain	55205000	Waffle, 100% whole wheat or 100% whole grain
55203000	Waffle, fruit	55205000	Waffle, 100% whole wheat or 100% whole grain
55203500	Waffle, nut and honey	55205000	Waffle, 100% whole wheat or 100% whole grain

55205000	Waffle, 100% whole wheat or 100% whole grain	55205000	Waffle, 100% whole wheat or 100% whole grain
55206000	Waffle, oat bran	55205000	Waffle, 100% whole wheat or 100% whole grain
55207000	Waffle, multi-bran	55205000	Waffle, 100% whole wheat or 100% whole grain
55211000	Waffle, plain, fat free	55205000	Waffle, 100% whole wheat or 100% whole grain
55211050	Waffle, plain, lowfat	55205000	Waffle, 100% whole wheat or 100% whole grain
55301000	French toast, plain	55205000	Waffle, 100% whole wheat or 100% whole grain
55301050	French toast sticks, plain	55205000	Waffle, 100% whole wheat or 100% whole grain
55401000	Crepe, plain	55105200	Pancakes, whole wheat
55501000	Flour and water patty	55105200	Pancakes, whole wheat
55502000	Flour and water gravy	52104040	Biscuit, whole wheat
55610200	Dumpling, fried, Puerto Rican style	52104040	Biscuit, whole wheat
55610300	Dumpling, plain	52104040	Biscuit, whole wheat
55801000	Funnel cake	55205000	Waffle, 100% whole wheat or 100% whole grain
56101000	Macaroni, cooked, NS as to fat added in cooking	56102000	Macaroni, whole wheat, cooked, NS as to fat added in cooking
56101010	Macaroni, cooked, fat not added in cooking	56102010	Macaroni, whole wheat, cooked, fat not added in cooking
56101030	Macaroni, cooked, fat added in cooking	56102020	Macaroni, whole wheat, cooked, fat added in cooking
56102000	Macaroni, whole wheat, cooked, NS as to fat added in cooking	56102000	Macaroni, whole wheat, cooked, NS as to fat added in cooking
56102010	Macaroni, whole wheat, cooked, fat not added in cooking	56102010	Macaroni, whole wheat, cooked, fat not added in cooking
56102020	Macaroni, whole wheat, cooked, fat added in cooking	56102020	Macaroni, whole wheat, cooked, fat added in cooking

56104010	Macaroni, cooked, vegetable, fat not added in cooking	56102010	Macaroni, whole wheat, cooked, fat not added in cooking
56104020	Macaroni, cooked, vegetable, fat added in cooking	56102020	Macaroni, whole wheat, cooked, fat added in cooking
56112000	Noodles, cooked, NS as to fat added in cooking	56102000	Macaroni, whole wheat, cooked, NS as to fat added in cooking
56112010	Noodles, cooked, fat not added in cooking	56102010	Macaroni, whole wheat, cooked, fat not added in cooking
56112030	Noodles, cooked, fat added in cooking	56102020	Macaroni, whole wheat, cooked, fat added in cooking
56116000	Noodles, chow mein	56102000	Macaroni, whole wheat, cooked, NS as to fat added in cooking
56116990	Long rice noodles (made from mung beans) cooked, NS as to fat added in cooking	56102000	Macaroni, whole wheat, cooked, NS as to fat added in cooking
56117000	Long rice noodles (made from mung beans), cooked, fat not added in cooking	56102010	Macaroni, whole wheat, cooked, fat not added in cooking
56117010	Long rice noodles (made from mung beans), cooked, fat added in cooking	56102020	Macaroni, whole wheat, cooked, fat added in cooking
56117100	Chow fun rice noodles, cooked, fat not added in cooking	56102010	Macaroni, whole wheat, cooked, fat not added in cooking
56130000	Spaghetti, cooked, NS as to fat added in cooking	56133000	Spaghetti, cooked, whole wheat, fat not added in cooking
56130010	Spaghetti, cooked, fat not added in cooking	56133010	Spaghetti, cooked, whole wheat, fat added in cooking
56131000	Spaghetti, cooked, fat added in cooking	56200350	Cereal, cooked, instant, NS as to grain
56133000	Spaghetti, cooked, whole wheat, fat not added in cooking	56133000	Spaghetti, cooked, whole wheat, fat not added in cooking
56133010	Spaghetti, cooked, whole wheat, fat added in cooking	56133010	Spaghetti, cooked, whole wheat, fat added in cooking
56200350	Cereal, cooked, instant, NS as to grain	56200350	Cereal, cooked, instant, NS as to grain

56200390	Barley, cooked, NS as to fat added in cooking	56102000	Macaroni, whole wheat, cooked, NS as to fat added in cooking
56200400	Barley, cooked, fat not added in cooking	56102010	Macaroni, whole wheat, cooked, fat not added in cooking
56200510	Buckwheat groats, cooked, fat added in cooking	56200510	Buckwheat groats, cooked, fat added in cooking
56200990	Grits, cooked, corn or hominy, NS as to regular, quick or instant, NS as to fat added in cooking	56202960	Oatmeal, cooked, NS as to regular, quick or instant; NS as to fat added in cooking
56201000	Grits, cooked, corn or hominy, NS as to regular, quick, or instant, fat not added in cooking	56203000	Oatmeal, cooked, NS as to regular, quick or instant, fat not added in cooking
56201010	Grits, cooked, corn or hominy, regular, fat not added in cooking	56203010	Oatmeal, cooked, regular, fat not added in cooking
56201020	Grits, cooked, corn or hominy, regular, fat added in cooking	56203050	Oatmeal, cooked, regular, fat added in cooking
56201030	Grits, cooked, corn or hominy, regular, NS as to fat added in cooking	56202980	Oatmeal, cooked, regular, NS as to fat added in cooking
56201040	Grits, cooked, corn or hominy, NS as to regular, quick, or instant, fat added in cooking	56203060	Oatmeal, cooked, quick (1 or 3 minutes), fat added in cooking
56201062	Grits, cooked, corn or hominy, with cheese, NS as to regular, quick, or instant, fat added in cooking	56203060	Oatmeal, cooked, quick (1 or 3 minutes), fat added in cooking
56201070	Grits, cooked, corn or hominy, with cheese, regular, NS as to fat added in cooking	56202980	Oatmeal, cooked, regular, NS as to fat added in cooking
56201071	Grits, cooked, corn or hominy, with cheese, regular, fat not added in cooking	56203010	Oatmeal, cooked, regular, fat not added in cooking
56201072	Grits, cooked, corn or hominy, with cheese, regular, fat added in cooking	56203050	Oatmeal, cooked, regular, fat added in cooking

56201082	Grits, cooked, corn or hominy, with cheese, quick, fat added in cooking	56203060	Oatmeal, cooked, quick (1 or 3 minutes), fat added in cooking
56201092	Grits, cooked, corn or hominy, with cheese, instant, fat added in cooking	56203070	Oatmeal, cooked, instant, fat added in cooking
56201110	Grits, cooked, corn or hominy, quick, fat not added in cooking	56203020	Oatmeal, cooked, quick (1 or 3 minutes), fat not added in cooking
56201120	Grits, cooked, corn or hominy, quick, fat added in cooking	56203060	Oatmeal, cooked, quick (1 or 3 minutes), fat added in cooking
56201130	Grits, cooked, corn or hominy, quick, NS as to fat added in cooking	56202970	Oatmeal, cooked, quick (1 or 3 minutes), NS as to fat added in cooking
56201210	Grits, cooked, corn or hominy, instant, fat not added in cooking	56203030	Oatmeal, cooked, instant, fat not added in cooking
56201220	Grits, cooked, corn or hominy, instant, fat added in cooking	56203070	Oatmeal, cooked, instant, fat added in cooking
56201230	Grits, cooked, corn or hominy, instant, NS as to fat added in cooking	56203230	Oatmeal, NS as to regular, quick, or instant, made with milk, NS as to fat added in cooking
56201510	Cornmeal mush, made with water	56203010	Oatmeal, cooked, regular, fat not added in cooking
56202000	Millet, cooked, fat not added in cooking	56203010	Oatmeal, cooked, regular, fat not added in cooking
56202960	Oatmeal, cooked, NS as to regular, quick or instant; NS as to fat added in cooking	56202960	Oatmeal, cooked, NS as to regular, quick or instant; NS as to fat added in cooking
56202970	Oatmeal, cooked, quick (1 or 3 minutes), NS as to fat added in cooking	56202970	Oatmeal, cooked, quick (1 or 3 minutes), NS as to fat added in cooking
56202980	Oatmeal, cooked, regular, NS as to fat added in cooking	56202980	Oatmeal, cooked, regular, NS as to fat added in cooking
56203000	Oatmeal, cooked, NS as to regular, quick or instant, fat not added in cooking	56203000	Oatmeal, cooked, NS as to regular, quick or instant, fat not added in cooking
56203010	Oatmeal, cooked, regular, fat not added in cooking	56203010	Oatmeal, cooked, regular, fat not added in cooking

56203020	Oatmeal, cooked, quick (1 or 3 minutes), fat not added in cooking	56203020	Oatmeal, cooked, quick (1 or 3 minutes), fat not added in cooking
56203030	Oatmeal, cooked, instant, fat not added in cooking	56203030	Oatmeal, cooked, instant, fat not added in cooking
56203050	Oatmeal, cooked, regular, fat added in cooking	56203050	Oatmeal, cooked, regular, fat added in cooking
56203060	Oatmeal, cooked, quick (1 or 3 minutes), fat added in cooking	56203060	Oatmeal, cooked, quick (1 or 3 minutes), fat added in cooking
56203070	Oatmeal, cooked, instant, fat added in cooking	56203070	Oatmeal, cooked, instant, fat added in cooking
56203110	Oatmeal with maple flavor, cooked	56203110	Oatmeal with maple flavor, cooked
56203210	Oatmeal, NS as to regular, quick, or instant, made with milk, fat not added in cooking	56203210	Oatmeal, NS as to regular, quick, or instant, made with milk, fat not added in cooking
56203230	Oatmeal, NS as to regular, quick, or instant, made with milk, NS as to fat added in cooking	56203230	Oatmeal, NS as to regular, quick, or instant, made with milk, NS as to fat added in cooking
56203610	Oatmeal, multigrain, cooked, fat not added in cooking	56203010	Oatmeal, cooked, regular, fat not added in cooking
56204980	Rice, white, cooked, converted, NS as to fat added in cooking	56205120	Rice, brown, cooked, regular, NS as to fat added in cooking
56204990	Rice, white, cooked, regular, NS as to fat added in cooking	56205120	Rice, brown, cooked, regular, NS as to fat added in cooking
56205000	Rice, cooked, NFS	56205120	Rice, brown, cooked, regular, NS as to fat added in cooking
56205010	Rice, white, cooked, regular, fat not added in cooking	56205110	Rice, brown, cooked, regular, fat not added in cooking
56205020	Rice, white, cooked, instant, NS as to fat added in cooking	56205120	Rice, brown, cooked, regular, NS as to fat added in cooking
56205030	Rice, white, cooked, instant, fat not added in cooking	56205110	Rice, brown, cooked, regular, fat not added in cooking
56205040	Rice, white, cooked, converted, fat not added in cooking	56205110	Rice, brown, cooked, regular, fat not added in cooking

56205060	Rice, cooked, with milk	56205120	Rice, brown, cooked, regular, NS as to fat added in cooking
56205070	Rice, sweet (rice, cooked, with honey)	56205120	Rice, brown, cooked, regular, NS as to fat added in cooking
56205080	Rice, creamed, made with milk and sugar, Puerto Rican style	56205120	Rice, brown, cooked, regular, NS as to fat added in cooking
56205110	Rice, brown, cooked, regular, fat not added in cooking	56205110	Rice, brown, cooked, regular, fat not added in cooking
56205120	Rice, brown, cooked, regular, NS as to fat added in cooking	56205120	Rice, brown, cooked, regular, NS as to fat added in cooking
56205130	Yellow rice, cooked, regular, NS as to fat added in cooking	56205120	Rice, brown, cooked, regular, NS as to fat added in cooking
56205150	Yellow rice, cooked, regular, fat not added in cooking	56205110	Rice, brown, cooked, regular, fat not added in cooking
56205170	Yellow rice, cooked, regular, fat added in cooking	56205120	Rice, brown, cooked, regular, NS as to fat added in cooking
56205190	Rice, white, cooked, glutinous	56205110	Rice, brown, cooked, regular, fat not added in cooking
56205210	Rice, wild, 100%, cooked, fat not added in cooking	56205210	Rice, wild, 100%, cooked, fat not added in cooking
56205300	Rice, white and wild, cooked, fat not added in cooking	56205210	Rice, wild, 100%, cooked, fat not added in cooking
56205310	Rice, brown and wild, cooked, fat not added in cooking	56205210	Rice, wild, 100%, cooked, fat not added in cooking
56205320	Rice, white and wild, cooked, fat added in cooking	56205510	Rice, brown, cooked, regular, fat added in cooking
56205330	Rice, white and wild, cooked, NS as to fat added in cooking	56205510	Rice, brown, cooked, regular, fat added in cooking
56205400	Rice, cooked, NS as to type, fat added in cooking	56205510	Rice, brown, cooked, regular, fat added in cooking
56205410	Rice, white, cooked with (fat) oil, Puerto Rican style (Arroz blanco)	56205510	Rice, brown, cooked, regular, fat added in cooking

56205420	Rice, white, cooked, regular, fat added in cooking	56205510	Rice, brown, cooked, regular, fat added in cooking
56205430	Rice, white, cooked, instant, fat added in cooking	56205550	Rice, brown, cooked, instant, fat added in cooking
56205440	Rice, white, cooked, converted, fat added in cooking	56205510	Rice, brown, cooked, regular, fat added in cooking
56205510	Rice, brown, cooked, regular, fat added in cooking	56205510	Rice, brown, cooked, regular, fat added in cooking
56205540	Rice, brown, cooked, instant, fat not added in cooking	56205540	Rice, brown, cooked, instant, fat not added in cooking
56205550	Rice, brown, cooked, instant, fat added in cooking	56205550	Rice, brown, cooked, instant, fat added in cooking
56207010	Wheat, cream of, cooked, regular, fat not added in cooking	56207200	Whole wheat cereal, cooked, fat not added in cooking
56207020	Wheat, cream of, cooked, quick, fat not added in cooking	56207200	Whole wheat cereal, cooked, fat not added in cooking
56207030	Wheat, cream of, cooked, instant, fat not added in cooking	56207200	Whole wheat cereal, cooked, fat not added in cooking
56207040	Wheat, cream of, cooked, made with milk	56207330	Whole wheat cereal, wheat and barley, cooked, fat added in cooking
56207060	Wheat, cream of, cooked, instant, fat added in cooking	56207330	Whole wheat cereal, wheat and barley, cooked, fat added in cooking
56207080	Wheat, cream of, cooked, NS as to regular, quick, or instant, fat added in cooking	56207330	Whole wheat cereal, wheat and barley, cooked, fat added in cooking
56207110	Bulgur, cooked or canned, fat not added in cooking	56207110	Bulgur, cooked or canned, fat not added in cooking
56207150	Couscous, plain, cooked, fat not added in cooking	56207110	Bulgur, cooked or canned, fat not added in cooking
56207180	Couscous, plain, cooked, fat added in cooking	56207110	Bulgur, cooked or canned, fat not added in cooking
56207200	Whole wheat cereal, cooked, fat not added in cooking	56207200	Whole wheat cereal, cooked, fat not added in cooking

56207220	Wheat, cream of, cooked, regular, fat added in cooking	56207330	Whole wheat cereal, wheat and barley, cooked, fat added in cooking
56207230	Wheat, cream of, cooked, quick, fat added in cooking	56207330	Whole wheat cereal, wheat and barley, cooked, fat added in cooking
56207300	Whole wheat cereal, wheat and barley, cooked, fat not added in cooking	56207300	Whole wheat cereal, wheat and barley, cooked, fat not added in cooking
56207330	Whole wheat cereal, wheat and barley, cooked, fat added in cooking	56207330	Whole wheat cereal, wheat and barley, cooked, fat added in cooking
56207360	Wheat cereal, chocolate flavored, cooked, fat not added in cooking	56207360	Wheat cereal, chocolate flavored, cooked, fat not added in cooking
56207370	Wheat cereal, chocolate flavored, cooked, NS as to fat added in cooking	56207370	Wheat cereal, chocolate flavored, cooked, NS as to fat added in cooking
56208500	Oat bran cereal, cooked, fat not added in cooking	56207200	Whole wheat cereal, cooked, fat not added in cooking
57000000	Cereal, NFS		WG cold cereal average
57000050	Kashi cereal, NS as to ready to eat or cooked		WG cold cereal average
57000100	Oat cereal, NFS		WG cold cereal average
57100100	Cereal, ready-to-eat, NFS		WG cold cereal average
57100400	Character cereals, TV or movie, General Mills		WG cold cereal average
57100500	Character cereals, TV or movie, Kelloggs		WG cold cereal average
57101000	All-Bran		WG cold cereal average
57101020	All-Bran with Extra Fiber		WG cold cereal average
57103000	Alpha-Bits		WG cold cereal average
57103100	Apple Cinnamon Cheerios		WG cold cereal average
57103500	Apple Cinnamon Squares Mini-Wheats, Kellogg's (formerly Apple Cinnamon Squares)		WG cold cereal average
57104000	Apple Jacks		WG cold cereal average
57106050	Banana Nut Crunch Cereal (Post)		WG cold cereal average
57106100	Basic 4		WG cold cereal average
57106250	Berry Berry Kix		WG cold cereal average
57106260	Berry Burst Cheerios		WG cold cereal average

57107000	Booberry	WG cold cereal average
57110000	All-Bran Bran Buds, Kellogg's (formerly Bran Buds)	WG cold cereal average
57111000	Bran Chex	WG cold cereal average
57117000	Cap'n Crunch	WG cold cereal average
57119000	Cap'n Crunch's Crunch Berries	WG cold cereal average
57120000	Cap'n Crunch's Peanut Butter Crunch	WG cold cereal average
57123000	Cheerios	WG cold cereal average
57124000	Chex cereal, NFS	WG cold cereal average
57124200	Chocolate flavored frosted puffed corn cereal	WG cold cereal average
57125000	Cinnamon Toast Crunch	WG cold cereal average
57125900	Honey Nut Clusters (formerly called Clusters)	WG cold cereal average
57126000	Cocoa Krispies	WG cold cereal average
57127000	Cocoa Pebbles	WG cold cereal average
57128000	Cocoa Puffs	WG cold cereal average
57130000	Cookie-Crisp	WG cold cereal average
57131000	Crunchy Corn Bran, Quaker	WG cold cereal average
57132000	Corn Chex	WG cold cereal average
57134000	Corn flakes, NFS	WG cold cereal average
57135000	Corn flakes, Kellogg	WG cold cereal average
57137000	Corn Puffs	WG cold cereal average
57138000	Total Corn Flakes	WG cold cereal average
57139000	Count Chocula	WG cold cereal average
57143000	Cracklin' Oat Bran	WG cold cereal average
57144000	Crisp Crunch	WG cold cereal average
57148000	Crispix	WG cold cereal average
57151000	Crispy Rice	WG cold cereal average
57152000	Crispy Wheats'n Raisins	WG cold cereal average
57201800	Disney cereals, Kellogg's	WG cold cereal average
57206000	Familia	WG cold cereal average
57206700	Fiber One	WG cold cereal average
57207000	Bran Flakes, NFS (formerly 40% Bran Flakes, NFS)	WG cold cereal average
57208000	Complete Wheat Bran Flakes, Kellogg's (formerly 40% Bran Flakes)	WG cold cereal average

57209000	Natural Bran Flakes, Post (formerly called 40% Bran Flakes, Post)	WG cold cereal average
57211000	Frankenberry	WG cold cereal average
57213000	Froot Loops	WG cold cereal average
57213850	Frosted Cheerios	WG cold cereal average
57214000	Frosted Mini-Wheats	WG cold cereal average
57214100	Frosted Wheat Bites	WG cold cereal average
57215000	Frosty O's	WG cold cereal average
57218000	Frosted Rice Krispies	WG cold cereal average
57221000	Fruit & Fibre (fiber) with dates, raisins, and walnuts	WG cold cereal average
57221650	Fruit Harvest cereal, Kellogg's	WG cold cereal average
57221700	Fruit Rings, NFS	WG cold cereal average
57223000	Fruity Pebbles	WG cold cereal average
57224000	Golden Grahams	WG cold cereal average
57227000	Granola, NFS	WG cold cereal average
57228000	Granola, homemade	WG cold cereal average
57229000	Granola, lowfat, Kellogg's	WG cold cereal average
57229500	Granola with Raisins, lowfat, Kellogg's	WG cold cereal average
57230000	Grape-Nuts	WG cold cereal average
57231000	Grape-Nut Flakes	WG cold cereal average
57231200	Great Grains, Raisin, Date, and Pecan Whole Grain Cereal, Post	WG cold cereal average
57231250	Great Grains Double Pecan Whole Grain Cereal, Post	WG cold cereal average
57232100	Healthy Choice Almond Crunch with raisins, Kellogg's	WG cold cereal average
57237100	Honey Bunches of Oats	WG cold cereal average
57237300	Honey Bunches of Oats with Almonds, Post	WG cold cereal average
57238000	Honeycomb, plain	WG cold cereal average
57239000	Honeycomb, strawberry	WG cold cereal average
57239100	Honey Crunch Corn Flakes, Kellogg's	WG cold cereal average
57240100	Honey Nut Chex	WG cold cereal average
57241000	Honey Nut Cheerios	WG cold cereal average
57241200	Honey Nut Shredded Wheat, Post	WG cold cereal average
57243000	Smacks, Kellogg's (formerly Honey Smacks)	WG cold cereal average
57301100	Kaboom	WG cold cereal average

57301500	Kashi, Puffed	WG cold cereal average
57302100	King Vitaman	WG cold cereal average
57303100	Kix	WG cold cereal average
57304100	Life (plain and cinnamon)	WG cold cereal average
57305100	Lucky Charms	WG cold cereal average
57305150	Frosted oat cereal with marshmallows	WG cold cereal average
57305170	Malt-O-Meal Coco-Roos	WG cold cereal average
57305180	Malt-O-Meal Corn Bursts	WG cold cereal average
57305500	Malt-O-Meal Honey and Nut Toasty O's	WG cold cereal average
57305600	Malt-O-Meal Marshmallow Mateys	WG cold cereal average
57306120	Malt-O-Meal Puffed Wheat	WG cold cereal average
57306500	Malt-O-Meal Golden Puffs (formerly Sugar Puffs)	WG cold cereal average
57306700	Malt-O-Meal Toasted Oat Cereal	WG cold cereal average
57306800	Malt-O-meal Tootie Fruities	WG cold cereal average
57307150	Marshmallow Safari, Quaker	WG cold cereal average
57307500	Millet, puffed	WG cold cereal average
57308150	Mueslix cereal, NFS	WG cold cereal average
57308190	Muesli with raisins, dates, and almonds	WG cold cereal average
57308300	Multi Bran Chex	WG cold cereal average
57308400	Multi Grain Cheerios	WG cold cereal average
57309100	Nature Valley Granola, with fruit and nuts	WG cold cereal average
57316200	Nutty Nuggets, Ralston Purina	WG cold cereal average
57316300	Oat Bran Flakes, Health Valley	WG cold cereal average
57316410	Apple Cinnamon Oatmeal Crisp (formerly Oatmeal Crisp with Apples)	WG cold cereal average
57316450	Oatmeal Crisp with Almonds	WG cold cereal average
57316500	Oatmeal Raisin Crisp	WG cold cereal average
57316710	Oh's, Honey Graham	WG cold cereal average
57316750	Oh's, Fruitangy, Quaker	WG cold cereal average
57318000	100% Bran	WG cold cereal average

57319500	Sun Country 100% Natural Granola, with Almonds	WG cold cereal average
57320500	100 % Natural Cereal, with oats, honey and raisins, Quaker	WG cold cereal average
57321700	Optimum, Nature's Path	WG cold cereal average
57322500	Oreo O's cereal, Post	WG cold cereal average
57323000	Sweet Crunch, Quaker (formerly called Popeye)	WG cold cereal average
57323050	Sweet Puffs, Quaker	WG cold cereal average
57327450	Quaker Oat Bran Cereal	WG cold cereal average
57327500	Quaker Oatmeal Squares (formerly Quaker Oat Squares)	WG cold cereal average
57329000	Raisin bran, NFS	WG cold cereal average
57330000	Raisin Bran, Kellogg	WG cold cereal average
57331000	Raisin Bran, Post	WG cold cereal average
57332050	Raisin Bran, Total	WG cold cereal average
57332100	Raisin Nut Bran	WG cold cereal average
57335550	Reese's Peanut Butter Puffs cereal	WG cold cereal average
57336000	Rice Chex	WG cold cereal average
57339000	Rice Krispies	WG cold cereal average
57339500	Rice Krispies Treats Cereal (Kellogg's)	WG cold cereal average
57340000	Rice, puffed	WG cold cereal average
57340700	Scooby Doo Cinnamon Marshmallow Cereal, Kellogg's	WG cold cereal average
57341000	Shredded Wheat'N Bran	WG cold cereal average
57341200	Smart Start, Kellogg's	WG cold cereal average
57344000	Special K	WG cold cereal average
57346500	Toasted Oatmeal, Honey Nut (Quaker)	WG cold cereal average
57347000	Corn Pops	WG cold cereal average
57348000	Frosted corn flakes, NFS	WG cold cereal average
57349000	Frosted Flakes, Kellogg	WG cold cereal average
57355000	Golden Crisp (Formerly called Super Golden Crisp)	WG cold cereal average
57401100	Toasted oat cereal	WG cold cereal average
57403100	Toasties, Post	WG cold cereal average
57404100	Malt-O-Meal Toasty O's	WG cold cereal average
57404200	Malt-O-Meal Apple and Cinnamon Toasty O's	WG cold cereal average
57406100	Total	WG cold cereal average

57407100	Trix	WG cold cereal average
57408100	Uncle Sam's Hi Fiber Cereal	WG cold cereal average
57409100	Waffle Crisp, Post	WG cold cereal average
57410000	Weetabix Whole Wheat Cereal	WG cold cereal average
57411000	Wheat Chex	WG cold cereal average
57412000	Wheat germ, plain	WG cold cereal average
57416000	Wheat, puffed, plain	WG cold cereal average
57416010	Wheat, puffed, presweetened with sugar	WG cold cereal average
57417000	Shredded Wheat, 100%	WG cold cereal average
57418000	Wheaties	WG cold cereal average
57601100	Wheat bran, unprocessed	WG cold cereal average
57602500	Oat bran, uncooked	WG cold cereal average

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