Factors Affecting Grain Consumption: Evidence from 1999-2002 NHANES Survey Data

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Abstract: The latest Dietary Guidelines for Americans recommend that half of all daily grain servings be whole grains. Meeting the new guidelines may be a tall order for most Americans. Targeting nutrition messages that educate people on how to comply with these new recommendations requires a solid understanding of who needs to boost their whole grain intake. It also requires a better understanding of the way people consume grain-based foods—which types of foods, eating occasion and locations are more conducive to whole grain intake and which are more conducive to refined grain intake. This analysis makes use of the most recent NHANES data (1999-2002). We use data from the dietary recall and link it to a nutrient database that provides the number of food group servings for each food consumed in the 24 hour period to estimate how individuals' consumption of both total and whole grain correlate with socio-economic factors, specific health indicators, and behaviors related to food choices.

Keywords: Dietary intake, whole grains, Tobit

The views expressed are the authors' and do not necessarily represent policies or views of the Economic Research Service, the Center for Nutrition Policy and Promotion or the USDA

Introduction

The latest *Dietary Guidelines for Americans*, released in January 2005, recommend that at least half of all daily grain servings come from whole grain foods. These recommendations, echoed in the newly released MyPyramid (formerly know as the *Food Guide Pyramid),* mark a significant departure from past recommendations that did not specify an exact quantity of whole grains. Recent figures from the USDA suggest that meeting these guidelines will be a tall order for most of the population. On average, adult Americans age 31-50 will need to triple their current whole grain intake and halve their consumption of refined grains (USDA/USDHHS 2005).

MyPyramid provides tips on how to reach these recommendations. Some, such as choosing whole wheat over white bread, should be relatively easy to implement. Other tips, like adding whole grains to mixed dishes and using whole wheat pancake mixes, require that people have the time and cooking skills to prepare these items from scratch (U.S Department of Agriculture 2005). The extent to which consumers will choose to adopt these new recommendations is hard to determine. Very little is known about the economic and behavioral factors that currently drive both total and whole grain consumption. Using the 1989-1991 and 1994-1996 Continuing Survey of Food Intake by Individuals (CSFII), Kantor et al (2001) found that the average intake of whole grains was positively correlated with education, income, whether a meal was consumed at home, and dietary awareness. Since 1994, however, at least 50 new products featuring a whole grain product claim are introduced into the retail market each year. For example, General Mills has recently reformulated their breakfast cereals to qualify as either a good or excellent source of whole grains. Thus, it is likely that consumers find it easier to purchase whole grain foods today than ten years ago. There is still very little known about how differences in specific behavioral patterns such as snacking, skipping breakfast, and dieting, or health conditions, such as obesity and diabetes affect whole grain intake.

Creating nutrition education programs that encourage all people to comply with these new dietary recommendations requires an understanding of the way people consume grain-based foods—which types of foods, eating occasion, and locations are more conducive to whole grain intake and which are not. It is also important to gauge the impact of certain health considerations, such as bodyweight and diabetes. Thus, the objective of this study is to provide a contemporary analysis of how socio-economic, health, and behavioral factors affect consumption of whole grain foods. We use the most recent dietary data from the National Health and Nutrition Examination Survey (NHANES) and a standard economic model of consumer demand.

Because some individuals do not report consuming whole grains on the day of the recall, we use a censored model of consumer demand. Because some of the health conditions and behaviors included in this study are endogenous, we also employ an instrumental variables (IV) estimator to produce unbiased estimates. The next section describes literature relevant to this project. Following this, we provide a description of the theoretical model that supports our empirical approach, a discussion of the NHANES 1999-2000 and 2001-2002 data, an explanation of our econometric methods, and an account of our results. We conclude with a summary of our findings and a discussion of their relevance.

Background

According to the Dietary Guidelines for Americans 2005, "Whole grains, as well as foods made from them, consist of the entire grain seed, usually called the kernel. The kernel is made of three components—the bran, the germ, and the endosperm. If the kernel has been cracked, crushed or flaked, then it must retain nearly the same relative proportions of bran, germ, and endosperm as the original grain to be called whole grain." (USDA/USDHHS 2005). A refined grain has all of the bran and most of the germ removed. While products made from the bran or germ are good sources of fiber, they are not considered whole grains. Enriched grains are refined grains with vitamins and minerals added back into the grain. Whole grains have significantly more fiber, calcium, magnesium, and potassium than refined grains, even enriched grains. However, fortified refined grains have more folate, and may have more thiamin, riboflavin and iron. While whole grains have these nutrients, they are also available to consumers in other foods, particularly dark green leafy vegetables, milk, watermelon, and meat and beans or whole grains fortified with folic acid (Dietary Guidelines Advisory Committee 2004).

The health benefits of whole grains are covered in a very extensive literature review recently carried out by the 2005 Dietary Guidelines Advisory Committee and summarized in their report to the Secretaries of the US Departments of Health and Human Services and Agriculture (Dietary Guidelines Advisory Committee 2004). Whole grain intake can reduce the risk of coronary heart disease, and Type II diabetes; this protection is unique to cereal fiber. Along with fruits and vegetables, whole grains are high in fiber. Diets rich in fiber have been shown to reduce the risk of stroke and certain cancers, while improve laxation, and help with weight management. The World Cancer Research Fund (1997) literature review finds a "possible decreased risk" of pancreatic, colon, rectal, and breast cancers with higher fiber intake. Finally, switching to more whole grain products may help with weight maintenance if the consumer also chooses grain products with little added sugar. This switch will allow consumers to get the health benefits of whole grains while limiting caloric intake (USDA/USDHHS 2005).

Previous research on grain consumption finds that health behaviors and beliefs, attributes of the grains and characteristics of the household and individual all contribute to grain consumption. As will be seen in the next section, we will incorporate this information into our model. The health behaviors and beliefs as well as the characteristics of the individual will be incorporated into our model of health, while the attributes of the grain itself contribute to the utility one derives from the food itself.

Bhargava and Hays (2004) emphasize the importance of behaviors and characteristics of the individual in designing nutrition education programs. They implement an intensive one year nutrition education intervention among 548 minority women. They find that those who had health concerns, such as a friend or relative with cancer or heart disease, had more reasons to participate in the classes and the study, those who already consumed a low-fat diet had a higher fiber intake at the end of the intervention than women who did not have these characteristics. Among the control group, those with health concerns actually consumed less fiber. Using multivariate analysis of the 1987-88 Nationwide Food Consumption Survey (NFCS), Nayga et al (1996) find that those on a special diet consume more fiber. In an analysis of the USDA's Continuing Survey of Food Intake by Individuals 1994-96 (CSFII), Ma et al (2000) find that those who choose to smoke cigarettes and consume alcohol above moderation (more than one drink per day for women, and two drinks for men) have lower grain consumption. Former smokers consume more grains than smokers, but individuals who never smoked consumed the most, regardless of alcohol consumption. Unfortunately this study does not distinguish between whole and refined grain consumption. These articles suggest that the health behaviors and characteristics to put in our model include whether an individual has a health condition such as cancer or heart disease, whether the individual is on a special diet, and smoking, and alcohol consumption.

Other studies also examine how the characteristics of the grain products available affect household consumption. In the study of the 1987-88 National Food Consumption Survey (NFCS), Nayga (1996) finds that at home sources contained more fiber than from other sources (2.62 g/1000 kcals versus 1.93 g/1000 g/kcals). A 1995 mail survey of household purchase decisions of certain grain products (whole wheat versus white bread, and bagels versus donuts) conducted by Mautou et al (1998) finds that households with children purchase more white bread. Shi and Price (1998) use 1987-88 NFCS data in a Lancaster model to examine the impact of nutrient and non-nutrient attributes on the price of breakfast cereal. They find that cereals with higher levels of fiber or fat lowered the price of cereal, but bran increased the price. This seemingly contradictory finding may be reflective of the population's nutrition understanding at the time, and the focus on bran rather than fiber. Cereals with rice were the highest price, followed by multigrain and bran. For hot cereals, convenience was also valued. These studies suggest we should include the availability of grain products, the source of the food, and the individual's knowledge of nutrition in our model.

Finally, we turn to the impact of characteristics of the individual and household on whole grain consumption. Individuals with higher levels of education consume more whole grains (Bhargava and Hays 2004;Moutou, Brester, and Fox 1998), as do those who live in higher income households, urban areas and are older (Moutou, Brester, and Fox 1998). Women are more likely than men to consume whole grains (Moutou, Brester, and Fox 1998). Although not separated by whole and refined grains, Gao (1994) finds that younger consumers as well as Hispanics and Asians consume more rice. Nayga (1996) finds that Hispanics consume more fiber than whites. This finding could be linked to the fact that many corn tortillas are whole grain products.

The literature indicates that consuming whole grain foods is important to good health. However, why some choose to consume whole grains and others do not is not well understood. The more recent studies published in the nutrition literature cover a specific population involving an intervention. These studies are useful in contributing to our understanding of grain consumption, but are not necessarily applicable to the US population as a whole. Other studies use older national data that do not allow the incorporation of health beliefs and characteristics to the extent newer data do. In this study we use recent data, combined with appropriate economic and econometric modeling to address the policy question, how can we motivate individuals to consume more whole grains?

Theoretical Model and Econometric Implications

We begin with a standard model influenced by Becker (1965), Lancaster (1966) and Grossman (1972) of consumer demand that assumes individuals gain utility from the foods they eat (F), their health (H), and a composite non food item (N). In our model, health status is assumed to be determined by behaviors (α) like diet, exercise, cigarette smoking, and alcohol consumption. It is also influenced by exogenous factors (ϕ), which include genetics, age, gender, cultural background, and physical environment. If and how much people choose to modify their behaviors to manage their health is assumed to be a function of dietary and health awareness (η) and whether or not an individual has any known pre-existing medical conditions (λ). Additionally, we assume that individual's choices are constrained by prices (P) and income (Y). As such, we assume that an individual (i) maximizes utility subject to a budget constraint and health production function. From this, we obtain the following derived demand for specific foods:

(1) $F_i = f(P, Y_i, \phi_i, \alpha_i(\eta_i, \lambda_i))$.

In this case, the demand for grains and whole grain foods is a function of prices, income, other demand shifters, such as age, gender, cultural preferences, and one's behaviors, which are determined by diet and health knowledge, and the presence of health problems.

This specification illuminates the simultaneous nature of food choices, behaviors, and health. For simplicity (and data availability) we use a static framework. In reality, these decisions are more dynamic; past food and behavioral choices influence our current health status, which in turn influence our future food and behavioral choices. We can rewrite (1) as:

(2) $F_i = \beta' X_i + \delta\alpha_i + e_i$

(3) $\alpha_i = \xi Z_i + \varepsilon_i$

Where X_i is a vector of exogenous explanatory variables containing (P, Y_i, ϕ_i) that relate to individual food choice, Z_i is a vector of exogenous explanatory variables relating to behavioral choices, and e_i, ε_i are random disturbance terms. This implies that an estimation approach that does not explicitly address this simultaneous process will bias the estimated relationship between whole grain intake and the explanatory variables. An instrumental variable (IV) estimator may circumvent this problem if the dataset contains additional variables that are theoretically correlated with the endogenous explanatory variables but not correlated with the error terms. For example, a blood relative's health is most arguably an exogenous variable; we have very little control over whether or not a grandparent had a heart condition. It may also be highly correlated with our own health and level of health information; our family's health history is a strong predictor of our own health and watching a family member struggle with ill health may provide motivation to adopt healthier practices.

Beyond these variables, however, it is usually difficult to find other variables that are both theoretically correlated with endogenous variables, and uncorrelated with the error term. Thus, there are usually too few exogenous variables unique to (Z), which means the system cannot be properly identified (Park and Davis 2001b;Greene 1990). One way to handle this situation, adopted by both Park and Davis (2001b) and Abdulai and Aubert (2004), is to follow the method developed by Lewbel (1997), where the second and third moments of the endogenous variables are used as additional instruments in the IV estimation. As a simple example, suppose that only a single behavioral factor (α_i) is endogenous to our model. Lewbel shows that

(4a) $v_{1i} = (F_i - \overline{F})(\alpha_i - \overline{\alpha})$ and

(4b) $v_{ji} = (X_{ji} - \overline{X}_j)(\alpha_i - \overline{\alpha})$

are legitimate instruments to use in an IV regression, where X_j is an element of the matrix X, and $\overline{X}_j, \overline{F}, \overline{\alpha}$ denote the sample means for the explanatory, dependent, and endogenous variable. As indicated in equations (2) and (3), we use an IV estimator, where a relative's health condition and the moments of the variables are used as to instrument each specific behavior (α_{ik}). As pointed out by Park and Davis, however, if the correlation among these variables and the endogenous variables is still low, the IV estimators may be more biased and inefficient than the original estimator. For that reason, this study provides estimates with and without the IV estimator. We report the results of both Hausman and overidentification tests to evaluate the relative strengths of the models.

As will be described in detail below, the dietary data used in this study come from a cross-sectional survey of the US population. Most cross-sectional data sets select who to survey in stages. In NHANES, the first stage is based on their primary sampling unit (PSU), a small geographic area within a single census track. The second is based on sociodemographic characteristics such as age, sex and income. Such stratified samples give way to another statistical hurdle because households within a given stratum tend to be more similar to one another in terms of their sociodemographic characteristics, as well as geographic location (Deaton 1997). Not accounting for the survey design will likely lead to errors in estimating the variance and standard errors.

A similar issue relates to the fact that most cross-sectional data sets do not sample the entire population, and thus requires the use of sampling weights to compensate for an individual's probability of being selected for the survey, and the probability of nonresponse. This study uses STATA's survey estimators (STATA 8.2) and specifies the survey's primary sampling unit, the level of stratification, and sampling weight. This yields estimates that will be more efficient than simply using either OLS or IV estimators.

A final econometric impediment stems from that fact that consumption of whole grain foods is low. Research by Kantor et al (2001) using 2 days of dietary recall found that, on average, over 60 percent of all Americans ate less than a single serving of grain a day. The data on dietary intake used in this study was collected over a single 24 hour period. Thus, we expect that for a single day of intake, many respondents will report zero consumption of whole grain foods. Estimating demand for whole grain products without accounting for the high prevalence of zero observations will yield inconsistent parameter estimates (Greene 1990); in this case, it is not possible to distinguish true non-consumers from consumers who just did not consume whole grain foods on the recall day.

This creates a statistical problem that can be handled by a variety of estimators, such as censored regression, maximum likelihood, or two-step procedures (Lin et al. 2003). Because we also want our estimates to control for endogeneity, we use a censored, or Tobit, regression model (Tobin). We can express the tobit model as:

$$\text{(5)} \quad \begin{array}{ll} F_i = \beta' X_i + \delta\alpha_i + e_i & \text{if } \beta' X_i + \delta\alpha_i + e_i > 0 \\ F_i = 0 & \text{if } \beta' X_i + \delta\alpha_i + e_i \leq 0 \end{array}$$

We use a Tobit/IV Tobit estimator when estimating the demand for whole grains. We use an OLS/IV estimator when estimating demand for total grains.

Data and Results

Data for this analysis comes from the 1999-2000 and 2001-2002 National Health and Nutrition Examination Survey (NHANES). For simplicity, we will refer to the two combined datasets as NHANES 1999-2002. Details of the study are published elsewhere (Centers for Disease Control and Prevention 2003). Since 1999, these data have been collected annually through the Centers for Disease Control and Prevention (CDC) via the National Center for Health Statistics (NCHS). Each year 5,000 civilian, noninstitutionalized persons in the U.S receive a thorough medical examination, provide a 24-hour dietary recall, and answer questions related to health behaviors, such as dieting, physical activity, alcohol consumption and cigarette smoking. This survey is designed to be nationally representative and over-samples African Americans, Mexican Americans and individuals with low-income (Centers for Disease Control and Prevention 2003). The dietary recall data are further enhanced by USDA's Agricultural Research Service's Food Guide Pyramid servings database. This database gives the number of servings for each pyramid food group--including whole grains, refined grains, and total grains—for every food reported consumed by participants in the NHANES 1999-2002 sample (Cook and Friday 2004). We use this database to calculate the number of grain servings consumed by each individual. Thus, the combined dataset is well suited to analyze the relationship between food choice, health status, and socio-economic factors. For this study, we limit our analysis to adults, aged twenty and older[1]. We exclude pregnant and lactating women since their dietary needs differ from the rest of the population. This gives us a total of 9217 observations.

The variables used in our econometric estimation are described and summarized in Table 1. The overall goal of this project is to identify factors that influence whole grain intake and determine how they compare to those that influence total grain intake. Thus, we define two dependent variables; one for total grain intake the other for whole grain intake. To control for factors that

[1] Since most children do not have complete control over the foods purchased in the store and brought into the home, the choices available to them are not the same as those for adults. Children and adults also have different dietary needs, and behaviors of children may be easier to change than those of adults. This required two separate models-

may lead to heteroskedasticity, we use the number of whole (total) grain servings an individual consumes in a day relative to his or her recommended intake. The recommended levels for whole and total grain intake are based on the USDA Food Guide found in the *Dietary Guidelines for Americans* 2005 (USDA/USDHHS 2005). Using the Institute of Medicine gender-based equations for Estimated Energy Requirement (EER) (2002a;2002b) with the measured weight and height and self reported level of physical activity and age, we assign individuals to a caloric level for the USDA Food Guide.

There are very few economic variables in NHANES 1999-2002 data. Similar to other national surveys on dietary intake, there is no information on the food prices or expenditures. Typically, researchers have circumvented this problem by including geographic indicators, such as state, region or whether an individual lives in an urban or rural setting (Variyam, Blaylock, and Smallwood 1996). Due to confidentiality concerns, this information is not released to the public. Also missing is information on household size, and whether or not an individual has children living in the household.

To persevere with this project, our analysis subsists on the available economic proxies. To gauge income effects, we include a household's poverty income ratio. We also control for an individual's level of education (less than high school, high school alone or more than high school) because this variable is highly predictive of income and health knowledge. We include whether the household has participated in food assistance programs, such as Food Stamps (FSP) or an individual in the household participated in the Special Supplemental Nutrition Program for

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one for children, one for adults. Due to the page and time limitations for this presentation, we choose to present our analysis of adults only.

Women, Infants, and Children (WIC), because these may proxy additional economic factors. WIC participation signals that either young children or a pregnant woman are present in the household. Also, this program contains a nutrition education component, so participation may correlate with higher levels of nutrition knowledge. Finally, we would like to know the number of adults relative to the number of children in a specific household; single parents have different time constraints compared to married parents or single adults without children. Currently, we can only assess whether an individual is married or living with an adult partner, or single.

From the literature, we know that some characteristics correlate with shifts in food demand. For example, an individual's energy requirements differ because of age, gender and level of physical activity. Cultural norms and level of acculturation also have an influence on our diet (Aldrich and Variyam 2000). We attempt to capture these through an individual's reported ethnicity and whether a language other than English is considered to be one's primary language. The location, time, and type of an eating occasion may also influence our food options and intake. We may find it easier to find whole grain foods at a grocery store compared to a vending machine. We may be more likely to choose oatmeal for breakfast than for lunch. We may be more likely to view steak as a viable choice for a meal compared to a snack. Thus, we control for these three factors by calculating the share of an individual's daily calories consumed at home, at breakfast, and as a snack. We include whether the dietary recall occurred on a weekend, as people may change their food away from home and food at home habits from weekend to weekday. We include a dummy variable for the survey round to control for trends, such as the waxing or waning popularity of low carbohydrate diets.

From the literature, we also know that health concerns may drive our food choices. As proxies for health status, we include whether an individual has any preexisting medical conditions that could impact his or her food choices. We limited these conditions to those that have been linked to lack of whole grain or fiber consumption—heart disease, obesity, strokes, diabetes and certain cancers (Dietary Guidelines Advisory Committee 2004). As a measure of obesity, we use an individual's measured waist circumference to the gender specific measurement that relates to obesity—88 centimeters for women and 102 centimeters for men (National Institute of Diabetes and Digestive and Kidney Diseases 2004).

Finally, if and how much one chooses to smoke, drink alcohol or diet are likely correlated with one's beliefs and awareness about links between diet and health. In this study, smoking is measured as the average number of cigarettes smoked a day. Alcohol is measured as the average number of alcoholic beverages consumed on days when a person drinks (having 7 glasses of wine in one night is a different behavior from having one glass of wine a day (Dietary Guidelines Advisory Committee 2004)). Dieting behavior is measured as a dummy variable, where a value of one indicates that an individual has taken any steps in the past year to maintain or lose weight.

As described earlier, this study employs Lewbel's (1997) method of moments by using the second and third moments of the endogenous variables as additional instruments in the IV estimation. Given our model and data, we have three continuous variables that are possibly endogenous: smoking, drinking, and relative waist circumference. We also have five continuous exogenous variables: income, age, share of calories consumed at home, share of calories consumed at breakfast and share of calories consumed as a snack. Referring back to equations 4a and 4b, we have 3 instruments of the v_1 variety and 15 of the v_j variety. We also have two discrete endogenous variables: whether one has been diagnosed with any health condition and whether one actively manages body weight. As additional instrument, we use whether an individual reported having a blood relative with any of the following health conditions: angina, diabetes, hypertension or osteoporosis.

Results

The auxiliary R^2 values from regressing each possible endogenous variable on the appropriate instruments, the test statistic for over-identification, and the Hausman test statistic comparing the IV/IV-Tobit results to the OLS/Tobit are reported in table 2a. The value of the test for overidentification is high. Thus, it is likely that our model is misspecified or our instruments are suspect. In either case, it is likely that these IV estimates are of little value. For this reason, we estimate an alternative model where only one's diet behavior and health status are considered endogenous[2]. The auxiliary R^2 values, test statistics for over-identification, and Hausman test statistics are reported in table 2b. The auxiliary R^2 values are still relatively high, which suggests the relevancy condition is met for both the IV and IV-Tobit models (Park and Davis 2001a). Due to the low value of test statistic for overidentification, we do not reject the null hypothesis that our model is properly specified. The low Hausman statistic suggests that the difference between the OLS (Tobit) and IV (IV-Tobit) estimates are not systematic and that the former is more efficient. However, the likelihood of not rejecting the null hypothesis of the Hausman test when it is false increases as the instruments become weaker. Weaker instruments increase the

[2] We also estimated a model where an individual's relative waist circumference was a third endogenous variable (in addition to health status and diet behavior). We did not present the results because the models were also overidentified for both total and whole grain intakes.

variance of the IV estimates, which increases the denominator of the Hausman test statistic, and thus decrease the overall test statistic (Park and Davis 2001a).

Consequently, we take the same pragmatic approach as Park and Davis (2001b) and report the results of all estimation methods. The results for total grain intake are summarized in table 3a. The results for whole grain intake are summarized in table 3b. The pseudo R^2 values are the squared correlation between the predicted and observed dependent variable. For ease of interpretation, we highlight estimated relationships that are similar in terms of both significance and direction of correlation. We use blue to indicate this similarity holds across all three models. We use yellow to indicate that this similarity exists in two of the three models.

One interesting finding is that the majority of variables used as economic proxies have a significant impact on individuals' whole grain intake but not their total grain intake. Household income and an individual's level of education are positively correlated with greater whole grain intake. Whether or not a household member participates in a food assistance program also significantly correlates with whole grain intake. While receiving food stamps is correlated with lower whole grain consumption, WIC participation is correlated with higher intake. The positive correlation between WIC participation and whole grain intake may reflect both the fact that the WIC program gives coupons for specific nutrient dense foods, and the education component of the program, as well as the targeted nature of the program. To qualify for WIC, an individual must typically meet income requirements, be nutritionally at risk and also be either pregnant, postpartum up to six months, breastfeeding up to one year, or a child below the age of five.

Since we did not include pregnant and lactating women in our analysis, the WIC participants in our data set are living in households with young children.

In keeping with past research, we find that women tend to eat more grains and whole grains. Our results also suggest that physical activity is negatively correlated with total grain consumption, but has no significant relationship with whole grain consumption. We find that individuals who are Black, non-Hispanic tend to eat fewer total and whole grain foods. Acculturation also seems to have a significant impact on diet choices; individuals who consider English to their primary language consume fewer whole grains than individuals who consider Spanish to be their primary language.

Another interesting finding is that certain eating patterns do significantly correlate with whole grain, but not total grain consumption. Individuals who report eating more of their meals at home, at breakfast, or as snacks are significantly more likely to consume more whole grain foods. These eating patterns have no significant impact on their total grain intake. For both whole grains and total grains, weekends are correlated with less grain consumption. The significance of the variable for survey round implies that either the popularity of low carbohydrate diets has waned, or alternatively, reflects that the methods used to collect and record dietary information changed between the two survey rounds[3].

Contrary to our initial hypothesis, the estimated effect of current health is ambiguous. The results of the overidentification and Hausman tests imply the OLS/Tobit results are unbiased and more

[3] In 2002, NHANES adopted the same 'double-pass' method that was employed by USDA-ARS when collecting dietary information for the former CSFII survey.

efficient. If this is the case, then our findings imply that heavier individuals report less total and whole grain consumption than thinner individuals. Individuals with a health concern, however, report consuming significantly more whole grain foods. Among the three different estimators, the general consensus is that greater consumption of cigarettes and alcohol correlate with both lower total and whole grain intake.

Conclusion

This study presents an economic model of consumer choice to determine how socio-economic, health, and behavioral factors influence both whole and total grain intake. We find that certain eating patterns significantly correlate with whole grain intake, but not total grain intake. Individuals who eat more substantial breakfasts, more of their meals at home and more of their calories as snacks also eat significantly more servings of whole grains. A fairly simple policy recommendation from this is to focus nutrition education on the importance of eating breakfast and snacking wisely. It also suggests opportunities for food manufacturers outside the breakfast cereal market. It is likely that nutrition savvy consumers who are pressed for time would welcome more ready-to-eat /low prep food options containing whole grains, such as canned soup made with brown instead of white rice, or pasta salads and rice pilafs made with whole grains.

Behaviors such as smoking and consuming more alcohol than recommended by the Dietary Guidelines for Americans 2005 correlate with less whole grain intake. These behaviors may all point to an underlying belief about the links between current actions and future health. For these individuals, a more effective message may be one that emphasizes the links between today's choices and tomorrow's outcomes. Alternatively, these individuals may find that their future health is not as strong of a motivator as other concepts, such as setting a good example for children or loved ones.

We find a significant association between at least one individual in the household participating in WIC and increased whole grain intake. This correlation may be due to increased nutritional concerns, it may reflect the efficacy of the nutritional education component, or it may be due to the WIC package itself[4]. More detailed data on household composition and an individual's level of nutrition information could help to illuminate more details about this correlation. Because of the time involved in applying for WIC benefits and the effort to receive the nutrition education, the choice to participate should be considered endogenous. Future research will require finding good instruments within NHANES for this variable.

Finally, as found by Aldrich and Variyam, this study suggests that acculturation is significantly linked to diet quality. Individuals who consider Spanish to be their primary language are more likely to consume significantly more whole grain foods. This suggests that nutrition education programs targeted at Hispanic populations should emphasize the importance of maintaining traditional diets and provide tips on how to do so as time and budget constraints change with assimilation.

[4] This sample excludes pregnant and breastfeeding women. Thus, if there is a significant impact due to the WIC package itself, it would likely be due to the post-partum, non-breastfeeding women that are still included in this sample.

Table 1: Variables, Definitions and Summary Statistics [a]

Variable	Variable	Definition and units	Mean Standard Deviation
Dependent Variables	Relative grain	Ratio of total to recommended daily grain consumption	0.90 0.01
	Relative whole grain	Ratio of total to recommended daily whole grain consumption	0.26 0.01
Economic Proxies	PIR	Poverty Index Ratio	2.97 0.06
	Less than high school	1 if individual did not complete high school; zero otherwise	0.22
	More than high school	1 if individual went to school beyond high school; zero otherwise	0.52
	HH FSP	Someone in household authorized FSP; zero otherwise	0.08
	HH WIC	Someone in household receives WIC; zero otherwise	0.06
	Single	1 if unmarried; zero otherwise	0.35
Metabolic Demand Shifters	Age	Age in years	46.55 0.33
	Female	1 if female; zero otherwise	0.51
	Physical activity	Physical activity coefficient for Women(Men)-1(1) if sedentary; 1.12 (1.11) if low active; 1.27(1.25) if active; 1.45(1.48) if very active	1.07 0.71
Cultural Demand Shifters	Black, Non-Hispanic	1 if black, non-Hispanic; 0 otherwise	0.11
	Hispanic	1 if Hispanic; 0 otherwise	0.14
	Other Ethnicity	1 if other ethnicity; 0 otherwise	0.04
	Spanish	1 if Spanish is the primary language spoken at home; zero otherwise	0.07
	Other language	1 if neither English or Spanish are the primary languages spoken at home; zero otherwise	0.04
Other Demand Shifters	Home	Share of daily calories consumed at home	64.66 0.47
	Breakfast	Share of daily calories consumed at breakfast	17.17 0.21
	Snack	Share of daily calories reported as a snack	23.52 0.20
	Weekend	1 if recall took place on a weekend; zero otherwise	0.36
	2001-2002	1 if 2001-2002; 0 if 1999-2000	0.53
Proxies for Health Status	Waist	Ratio of waist circumference (in centimeters) to gender specific overweight classification (88cm for women, 102 cm for men)	1.01 0.00
	Health Condition	1 if individual was told about medical condition (angina, diabetes, chronic heart disease, heart attack, heart failure, or cancer); zero otherwise	0.18
Behaviors	Cigarettes	Number of cigarettes per day; zero if non-smoker	3.72 0.19
	Alcoholic beverages	Number of alcoholic beverages consumed when drinking; zero if non-drinker	1.88 0.05
	Diet	1 if individual indicated he or she was on a special diet; zero otherwise	0.31

[a] A variable's standard deviation is listed below it's mean for all continuous variables. The sample size is 13,904 with 9217 observations on adults 20 and older.

Table 2a: Specification Tests of Model with 5 Endogenous Variables (Waist, Health Condition, Cigarettes, Alcohol, Diet)

	First Stage R^2		SarganTest Statistic for Overidentification		Hausman Test: IV v Non-IV	
	Total Grains	Whole Grains	Total Grains	Whole Grains	Total Grains	Whole Grains
			107.80**	238.51**	9.29	10.02
Waist	0.290	0.299				
Health Condition	0.166	0.166				
Cigarettes	0.370	0.499				
Alcohol	0.644	0.652				
Diet	0.077	0.077				

**The null hypothesis that model is properly specified is rejected at the 1% level.

Table 2b: Specification Tests of Model with 2 Endogenous Variables (Diet, Health Condition)

	First Stage R^2		SarganTest Statistic for Overidentification		Hausman Test: IV v Non-IV	
	Total Grains	Whole Grains	Total Grains	Whole Grains	Total Grains	Whole Grains
			0.605	1.128	0.15	3.72
Diet	0.116	0.116				
Health Condition	0.166	0.166				

Table 3a: Results-Total Grain Consumption

	Estimator								
Dependent Variable:	OLS			IV: Instrumented Waist, Health, Cigs, Alc and Diet			IV: Instrumented Health and Diet		
Relative total grain	Parameter Estimate	Z statistic		Parameter Estimate	Z statistic		Parameter Estimate	Z statistic	
PIR	0.003	0.42		0.024	1.06		-0.004	-0.24	
Less than high school	0.007	0.36		-0.007	-0.28		0.016	0.98	
More than high school	0.048	2.39	**	0.061	1.61		0.032	1.23	
HH FSP	-0.007	-0.19		-0.001	-0.01		0.006	0.14	
HH WIC	0.054	1.45		0.031	0.63		0.055	1.61	
Single	0.038	1.93	*	0.036	1.61		0.041	1.94	*
Age	0.000	0.11		-0.005	-1.46		0.000	-0.08	
Female	0.059	3.07	**	0.087	1.91	*	0.033	0.86	
Physical activity	-0.001	-2.88	**	0.000	0.00		-0.001	-1.92	*
Black, Non-Hispanic	-0.138	-5.56	**	-0.136	-5.42	**	-0.133	-5.04	**
Hispanic	0.021	0.68		0.063	1.06		-0.008	-0.16	
Other Ethnicity	0.006	0.11		0.028	0.46		0.038	0.61	
Spanish	0.006	0.14		-0.011	-0.22		0.042	1.00	
Other language	0.134	3.52	**	0.148	3.50	**	0.150	3.48	**
Home	0.000	1.09		0.000	0.52		0.000	1.08	
Breakfast	0.000	0.36		0.000	-0.43		0.000	-0.05	
Snack	0.000	0.43		0.000	0.49		0.000	0.27	
Weekend	-0.046	-2.85	**	-0.039	-2.16	**	-0.042	-2.10	**
2001-2002	0.060	2.77	**	0.045	1.30		0.086	3.42	**
Waist	-0.303	-5.38	**	0.302	0.71		-0.550	-2.82	**
Health Condition	0.016	0.75		0.326	1.16		0.114	0.52	
Cigarettes	-0.004	-5.23	**	-0.010	-4.34	**	-0.004	-4.42	**
Alcoholic beverages	-0.009	-2.18	**	-0.014	-2.47	**	-0.010	-2.97	**
Diet	-0.082	-5.21	**	-0.614	-1.27		0.240	0.80	
Constant	1.192	11.32	**	0.726	1.71	*	1.445	5.71	**
Pseudo R^2	0.051			0.014			0.015		

** Parameter estimated to be significant at the 5% level.

* Parameter estimated to be significant at the 10% level.

Table 3b: Results-Whole Grain Consumption

	Estimator								
Dependent Variable:	Tobit			IV-Tobit: Instrumented-Waist, Health, Cigs, Alc and Diet			IV-Tobit: Instrumented-Health and Diet		
Relative whole grain	Parameter Estimate	Z statistic		Parameter Estimate	Z statistic		Parameter Estimate	Z statistic	
PIR	0.029	3.72	**	0.061	4.4	**	0.016	0.98	
Less than high school	-0.006	-0.25		-0.047	-1.42		-0.014	-0.48	
More than high school	0.071	3.38	**	0.159	4.4	**	0.040	1.11	
HH FSP	-0.094	-1.96	*	-0.182	-4.1	**	-0.121	-3.24	**
HH WIC	0.120	2.72	**	0.083	1.79	*	0.145	3.56	**
Single	0.058	2.62	**	-0.004	-0.14		0.034	1.50	
Age	0.001	0.89		-0.002	-0.88		0.001	0.20	
Female	0.054	2.88	**	0.079	1.78	*	0.028	0.64	
Physical activity	0.000	0.39		0.002	3.09	**	0.000	-0.53	
Black, Non-Hispanic	-0.224	-6.88	**	-0.191	-5.74	**	-0.265	-9.23	**
Hispanic	0.008	0.25		0.192	4.17	**	0.024	0.50	
Other Ethnicity	-0.119	-2.14	**	-0.139	-1.74	*	-0.156	-2.29	**
Spanish	0.220	3.20	**	0.357	7.69	**	0.377	8.96	**
Other language	-0.053	-0.80		0.025	0.35		-0.042	-0.71	
Home	0.001	4.52	**	0.001	3.52	**	0.002	4.92	**
Breakfast	0.004	8.18	**	0.004	5.11	**	0.004	5.69	**
Snack	0.002	4.32	**	0.000	0.13		0.002	2.93	**
Weekend	-0.047	-2.56	**	-0.062	-2.69	**	-0.045	-2.31	**
2001-2002	0.079	2.98	**	0.073	2.82	**	0.122	4.64	**
Waist	-0.193	-4.04	**	1.050	2.55	**	-0.469	-1.57	
Health Condition	0.074	3.16	**	0.103	0.47		0.143	0.58	
Cigarettes	-0.009	-7.98	**	0.016	5.65	**	-0.010	-6.52	**
Alcoholic beverages	-0.011	-2.32	**	-0.020	-2.7	**	-0.014	-3.25	**
Diet	-0.016	-0.87		-1.060	-2.98	**	0.243	0.52	
Constant	-0.170	-2.35	**	-1.444	-3.81	**	0.160	0.60	
Pseudo R^2	0.076			0.013			0.07745089		

** Parameter estimated to be significant at the 5% level.

* Parameter estimated to be significant at the 10% level.

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