The Economics of Health Behavior and Vitamin Consumption

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Abstract

Conventionally, fruits and vegetables have been the major source of micronutrients. However, with the rising availability of nutritional supplements, U.S. consumers no longer need to rely on food alone for their nutritional needs. Time-pressured consumers with limited cooking skills and nutrition knowledge may find it easier to take vitamin supplements. The objective of this paper is to determine the impact of lifestyle, diet behavior including vitamin supplement consumption, and food culture on diet quality outcomes as measured by the Healthy Eating Index-2005 (HEI) and total energy intake. We use the 2003-04 U.S. National Health and Nutrition Examination Survey (NHANES) to examine the relationship between HEI and caloric intake. Further, our specific focus is to determine the role of vitamin supplements in the U.S. diet by developing a profile of supplement consumers. In addition, we consider the caloric implications of diets that substitute vitamin supplements for fruits and vegetables. Selected variables include demographic and socioeconomic factors, as well as a large number of dietary, health indicators, and lifestyle-related information. Findings from our econometric model show that consumers of vitamin supplements display higher HEI scores and consume diets with more calories. Specifically, our empirical results find that dietary supplements are consumed by female, married, college-educated senior respondents. Individuals who might believe they need to eat better also consume vitamin supplements. These are respondents who have been told by a health professional that they have high blood pressure and elevated cholesterol levels. Thus, vitamin supplement consumption seems to be another marker for healthy eating. It also raises concerns since healthy eaters do not need the supplements, and may consume some vitamins and minerals above the upper level.

Keywords: Vitamins, Supplements, Fruits and vegetables, NHANES, Health production, Healthy Eating Index - 2005

JEL codes: I1, H2

1. Introduction

In 2009, the prevalence of U.S. obesity has increased to 27% (Centers for Disease Control and Prevention (CDC), 2010a). At the root of this national health threat have been changes in diet and food choice pattern, along with a reduction in physical activity. The 2010 Dietary Guidelines Advisory Committee states in its final report that on average, Americans consume too few vegetables, fruits, high-fiber whole grains, low-fat milk and milk products, and seafood, and they eat too much added sugars, solid fats, refined grains, and sodium. Approximately 35 percent of the calories in the average US diet consist of SoFAS (added sugars and solid fats). This is true for both males and females of all age groups. It is important to reduce the energy intake by limiting the intake of SoFAS and including more healthful foods (Dietary Guidelines Advisory Committee 2010).

In order to maintain good health, fruits and vegetables (F&V) are an important provider of vitamins, minerals and fiber (Godfrey and Richardson 2002). Epidemiological studies have shown that vitamin deficiencies lead to severe health consequences, such as cancer, allergies, and cardiovascular disease (Lambert 2001; Dietary Guidelines Advisory Committee, 2010). As such, vitamins can be considered a disease-preventative input. The U.S. Council for Responsible Nutrition emphasizes that more than $10 billion annually could be saved if people consumed at least 100 International Units (IU) of vitamins on a regular long-term basis to reduce the risk of heart disease (Dickinson 2002). Still, U.S. F&V consumption, the main source of micronutrients is only at 67% of the recommended intake level by the World Health Organization (Shankar, Srinivasan and Irz 2008). U.S. adults eat only 17% of the fruit and 25% of the vegetable servings recommended by *My Pyramid* (USDA 2010; Wilde and Llobrera 2009).

Conventionally, produce has been the major source of micronutrients. However, with the rising availability of nutritional supplements, U.S. consumers no longer rely exclusively on food for their nutritional needs. Time-pressured consumers with limited cooking skills and nutrition knowledge may find it easier to take vitamins, supplements. The consumption of pharmaceutically-produced vitamin supplements has seen steady growth rates across most developed countries (Gregory 2005). However, the 2010 US Dietary Guidelines Advisory Committee states "a daily multivitamin/mineral supplement does not offer health benefits to healthy Americans." The report does concede that supplements may benefit population sub-groups with know deficiencies in particular nutrients such as calcium or Vitamin D, but there is a health risk from taking too many suplements. Thus, there is a need to determine whether the consumption of vitamin supplements complements or substitutes for a healthy diet.

The objective of this paper is to determine the impact of lifestyle, diet behavior, and food culture on diet quality outcomes as measured by the Healthy Eating Index 2005 (HEI-2005) and total energy intake. We use the 2003-04 U.S. National Health and Nutrition Examination Survey (NHANES) to examine the relationship between HEI and caloric intake. Further, our specific focus is to determine the role of vitamin supplements in the U.S. diet by developing a profile of supplement consumers. Selected variables include demographic and socioeconomic factors, as well as a large number of dietary, health status, and lifestyle-related information. Following the estimation work described above, we also develop a simulation model to further examine the link between vitamin consumption and total caloric intake.

2. Background

Preventative health care and associated consumer behaviors have been well recognized as an important means of mitigating potential public health problems and reducing health care costs to society (Drichoutis et al. 2005). Retiring baby boomers and increasing incidence of obesity are only two of the mounting challenges of managing public health in the U.S. The annual economic burden of treating chronic illnesses in the U.S. is estimated to approach $1.11 trillion. Preventative healthcare measures, such as improved nutritional outcomes from greater adherence to dietary guidelines among U.S. consumers are estimated to save between $21 billion and $43 billion each year in medical care costs and lost productivity resulting from secondary chronic health problems associated with poor diets (Frazão 1999). The preventative potential of avoiding diet-health related disabilities such as coronary heart disease, cancer, stroke, and diabetes is valued at $28 billion, 110,000 premature deaths among individuals aged 55 to 74 years, annually.

The close association between diet quality, health and wellbeing has invigorated public attention on nutritional quality through better information and motivational campaigns such as the Food Guide Pyramid which follows the Dietary Guidelines for Americans 2005 (Britten et al. 2006). Recently, there has been interest in implementing a mandatory "broad-based" generic promotion program that would attempt to enhance the demand for all F&V. Broad-based advertising programs for F&V have featured large-scale media efforts in the United Kingdom (*5 a Day* campaign), Australia (*Go for 2&5*® campaign), and Canada (*5 to 10 a day* campaign). In the United States, broad-based campaigns for F&V have been less visible, and have had much less media exposure than their counterparts in other regions. The *5-A-Day For Better Health* program was introduced by the National Institute of Cancer and the Produce for Better Health Foundation (PBH) in 1991. USDA's 5-A-Day for Better Health Program specifically promoted the daily consumption of F&V of at least five servings a day to ensure regular and sufficient intake of vitamins and minerals important to maintain good health. In 2007, the PBH and the Centers for Disease Control and Prevention unveiled a new program called *Fruit and Veggies—More Matters*. This new program was created in an effort to align the fruit and vegetable marketing campaign with the nutrition recommendations published in the Dietary Guidelines for Americans by the U.S. Departments of Agriculture and Health and Human Services (PBH 2010). While these campaigns have contributed to improving diets for American consumers over time, there is only insufficient knowledge about the true gap between actual and healthful diets across the economic and demographic spectrum in the U.S. population.

Changing socio-demographics, rising demands for convenience foods, growing away-from-home food expenditures and a decline in food preparation skills have contributed to consumers' more favorable attitudes towards nutritional supplements as a perceived healthy, alternative healthy way to improve their diets (Pole 2007). In fact, long term evidence from NHANES data reveals that nutritional supplement use has risen steadily over the last 40 years. Reported dietary supplement intakes have been consistently higher particularly among older consumers. More recent evidence puts overall supplement use at 52% of all adults with a variation of 43 to 63% across age groups and genders. The by far most commonly used nutritional supplement is the multivitamin, consumed by 35% of American adults in 2000 (Dickinson and Shao 2006). Of U.S. adult consumers, 62% occasionally use nutritional supplements, while 46% take supplements regularly (Dickinson and Shao 2006). According to a study by Balluz et al. (2000) about 55% of children in the U.S. receive some sort of vitamin and/or mineral supplement on a regular basis. This trend is one contributing factor to the decline in children's consumption of fresh vegetables by 42% between 1980 and 2005 (Pole, 2007).

The trend towards nutritional supplements intake in most of Western societies has also exacerbated health experts knowledge gap of factors that may slow down future improvements in diet quality. Particularly, influencing adoption rates and consumer choices of healthful food products requires detailed empirical knowledge and understanding of how diet-health information and its effect on dietary choices vary across the population. Knowledge of the substitutive relationships between foods and dietary supplement is valuable information for targeting nutrition programs to promote healthy choices and for forecasting food behavioral trends (Variyam et al. 1999).

3. Methodology

Health status and economic choice are interrelated, such that food intake depends on income, a wide set of socio economic, and other external influencing factors that include personal and exogenous factors. We apply consumption data from the National Health and Nutrition Examination Survey (NHANES) 2003-2004 to estimate the importance of various household characteristics on the individual's diet quality and energy intake (CDC 2010b).

The NHANES measured participants' current physical health and used questionnaires to obtain their food and supplement consumption, lifestyle and demographic characteristics. NHANES data is based on 24 hour-recall of food intake and is one of the most comprehensive data sets on health and nutrition available. The greatest advantage of using NHANES data versus retail data, such as data purchased from *Nielsen*, is the combination of medical data with actual consumption data—that is the foods that individuals actually eat, as opposed to foods that are purchased by a household and may not be eaten.

3.1 Empirical Model

Consumer behavior towards diet quality, health and vitamin intake in the diet production is a function of socio-economic, demographic and personal and exogenous factors which we hypothesize to affect diet and health behavior. We specify three models to address the role of vitamin intake on different diet quality measures, as well as the characteristics of users of nutritional supplements in NHANES.

In Model 1, average NHANES healthy eating index scores (HEI) are regressed against key demographic, lifestyle, diet behavior, health indicators, and food culture variables:

(1) HEI = f(Kcal, Vitamins, Age, Education, Income, Marital status, Exercise, Leisure, Smoking, Alcohol, Health Indicators, Ethnicity, HHSize)

In Model 2 the same set of variables is used to estimate the impact on NHANES participants' average total caloric intake (when controlling for HEI scores):

(2) Kcal = f(Kcal, Vitamins, Age, Education, Income, Marital status, Exercise, Leisure, Smoking, Alcohol, Health Indicators, Ethnicity, HHSize))

To further investigate the characteristics of those NHANES participants that frequently take nutritional supplement we specify a probit model, as shown by model 3

(3) Vitamins (>0) = f(HEI, Kcal, Age, Education, Income, Marital status, Exercise, Leisure, Smoking, Alcohol, Health Indicators, Ethnicity, HHSize)

3.2 Variables Affecting Diet Behavior

This study uses data from 7,992 adults who are 20 years and older. We include five types of variables in the empirical analysis: (1) diet behavior; (2) demographics; (3) lifestyle; (4) health indicators; and (5) food culture. Table 1 provides an overview of the variables used in the regression models.

Table 1: Descriptive Statistics of Variables used in the Regressions

Variable	**Definition**	**Mean and Std.deviation**
Diet Behavior		
HEI	Average HEI (Healthy Eating Index) over two days	40.19 (16.48)
Log (Kcal)	Log(Average Total Kilocalorie Intake over two days)	7.56 (0.41)
Vitamins	=1 if intake of any vitamins, minerals, or dietary supplements during the past month	0.53 (0.50)
Demographics		
Young	=1 if age of respondent is between 20 and 39 years	0.32 (0.47)
Mid-age	=1 if age of respondent is between 40 and 59 years (omitted)	0.28 (0.45)
Senior	=1 if age of respondent is ≥60 years	0.37 (0.48)
Male	=1 if male, =0 if female	0.48 (0.50)
College	=1 if graduated college or above	0.19 (0.39)
Low income	=1 if family income of less than $25,000/year	0.32 (0.47)
Medium income	=1 if family income is between $25,00 and $75,000/year (omitted variable)	0.43 (0.50)
High income	=1 if family income is more than $75,000/year	0.19 (0.39)
Married	=1 if individual is married or living as married	0.61 (0.49)

Table 1 cont:

Variable	Definition	Mean and Std.deviation
Lifestyle		
Low Level of Physical Activity	=1 if self-rated usual daily activity is sitting and not about very much or standing/walking about a lot during the day without much carrying/lifting things	0.77 (0.42)
Medium Level of Physical Activity	=1 if self-rated usual daily activity is lifting light load or climbing stairs or hills often	0.15 (0.36)
High Level of Physical Activity	=1 if self-rated usual daily activity is doing heavy work or carrying heavy loads	0.07 (0.25)
TV	Number of hours the respondent watches TV per day	2.50 (1.63)
PC games	Number of hours the respondent plays PC games per day	3.49 (2.69)
Smoker	=1 if respondent has smoked at least 100 cigarettes in entire life and is currently smoking every day or some days	0.16 (0.37)
Alcohol	=1 if female (male) respondents consumed on average 1 (2) alcoholic drinks or more of any type per day during the previous year	0.39 (0.49)
Health Indicators		
Body Mass Index (BMI)	Weight (kg)/ (Height (m))^2	27.79 (5.95)
Blood pressure	=1 if respondent has been told by a doctor or other health professional that blood pressure is high	0.35 (0.48)
Cholesterol	Value is 1 if respondent has been told by a doctor or other health professional that blood cholesterol is high	0.31 (0.46)
Diabetes	Value is 1 if respondent has been told by a doctor or other health professional to have diabetes or sugar diabetes	0.11 (0.41)
Food Culture		
Caucasian	= 1 if respondent is Caucasian (omitted variable)	0.54 (0.50)
Other Race	= 1 if respondent is Pacific Islander or Asian	0.04 (0.20)
Black	= 1 if respondent is non-Hispanic Black	0.19 (0.40)
Hispanic/Latino	= 1 if respondent is Hispanic	0.22 (0.41)
Small household	= 1 if household has 1-2 members	0.50 (0.50)
Medium household	=1 if household has between 3-6 members (omitted variable)	0.46 (0.50)
Large household	=1 if household has more than 7 members	0.04 (0.19)

Regarding food consumption, USDA's Healthy Eating Index-2005 (HEI) is used to assess an individual's overall diet quality. Variations in an individual's diet quality can be caused by a multitude of factors. The revised HEI used in this analysis follows the 2005 Dietary Guidelines for Americans and My Pyramid (Guenther, Reedy, and Krebs-Smith 2008). Index scores on a 100 point scale include My Pyramid food group components for the My Pyramid groups, such as vegetable subgroups and whole fruits. The index also includes sub-scores for saturated fats, sodium, and calories from solid fats, alcoholic beverages and added sugars–SoFAAS. Higher HEI score indicate closer adherence to current dietary guidelines for individual food and nutrient groups (Guenther et al. 2006).

In addition to the HEI, food consumption is measured by energy intake. The energy released from carbohydrates, protein and fat in food can be measured in calories. Energy is expressed in 1000-calorie metric units, known as kilocalories (Kcal). Foods that are rich in fats and sugars tend to be high in energy (Whitney, Cataldo, and Rolfes 2002).

In light of declining F&V consumption and rising intake levels of nutritional supplements in the U.S. it remains unclear what role supplements may play in consumers' diet and health behavior. Consumers may take nutritional supplements as a *substitute* for vitamins from F&Vs in order to improve their diet. Or they may take nutritional supplements to *complement* and improve their diet with specific micronutrients. We specify different empirical models to test to what extent vitamin supplement intake patterns explain U.S. NHANES participant's diet quality outcomes. In addition, a profile of vitamin supplement consumers based on individual demographic, lifestyle, diet behavioral and health food cultural factors is constructed.

Several demographic variables may impact the consumption of F&V, such as age, gender, education, income, and marital status (Arnade and Gopinath 2006, Beydoun and Wang 2008, Stewart and Blisard 2008, Variyam et al. 1999). Considering age, the impact of this variable can be separated into two different effects. Thus, we specify two different age variables in order to account for age variations that may impact diet quality, energy intake and vitamin supplement consumption. Younger people may tend to consume more energy-dense food than older people, and thus, the effect on HEI and Kcal should be negative over the lower range of age. With increasing age the effect is becoming negative, since obesity increases the chances of morbidity. Seniors who survive may consume diets of higher quality, given that the benefits of health and good nutrition may become more apparent with increasing age (Frazão and Allshouse 2003). Regarding gender, previous research shows that the consumption of F&V is typically lower among men in comparison to women (CDC 2007). In our study, 48% of all respondents were male.

In addition to age and education, we include three variables classifying the respondents into different income groups. Most economic analyses of diet and health emphasize the impact of income, recognizing the importance of socio-demographic variables, preferences, and nutrition knowledge. Income is a determining factor associated with obesity. Cutler, Glaeser, and Shapiro (2003) suggest that with the labor market developments since the 1970s, more time is spent on market work, while less time and energy are expended for home and leisure activities, such as food preparation or exercise activities. Only a slow growth or decline in real income of certain population groups took place. This has lead to an increase in the demand for inexpensive and convenient food choices, which are typically higher in calorie content, while at the same time decreasing the calories expended via exercise. It is assumed that with increasing income, the prevalence of obesity is decreasing, and thus it is expected that higher income groups show an improved diet quality and less energy intake. Higher income groups may be more likely to afford vitamin supplements.

Regarding endogenous non-food health inputs, we will focus on exercising, sedentary activities such as time spent in front of the TV and PC, smoking, and alcohol consumption. These lifestyle factors have significant influences on individual's health status. Health experts continue to emphasize the importance of regular health-enhancing activities such as the consumption of a well-balanced diet together with physical activity (Dwyer 2001; Dietary Guidelines Advisory Committee 2010.) It is plausible to assume that time spent exercising is positively correlated to eating a healthy diet. In our sample, exercising has been classified into three groups depending on an individual's average daily level of activity. As leisure activities such as watching TV and playing PC games go along with a more sedentary lifestyle, these respondents may consume unhealthier food choices which will be reflected in their diet behavior.

Nicotine is an appetite suppressant. Given the well-known increased risk of developing lung cancer, emphysema and heart conditions, smokers tend to need more immediate satisfaction and place less value on future health (Huston and Finke 2003). Individuals who smoke generally have lower levels of diet quality (Ma et al. 2000). Alcohol intake can increase or decrease the likelihood of developing health-related problems. Thus, it may affect diet behavior positively or negatively. The Dietary Guidelines for Americans 2005 recommends that women consume no more than one alcoholic drink per day, and men no more than two. Red wine in moderation has been linked to good health but drinking more than three alcoholic drinks per day can lead to numerous health problems such as increased likelihood of injuring oneself or others, liver conditions, mental health and others (Klatsky 2010; U.S. Department of Health and Human Services and U. S. Department of Agriculture 2005).

Health indicators are measure of the stock of health that the individual has. Poor diet quality is directly linked to obesity and type 2 diabetes, and increases the risk for high blood pressure; elevated blood cholesterol levels can also be moderated in part by controlling dietary cholesterol intake (Dietary Guidelines Advisory Committee, 2010). Obesity, diabetes, high blood pressure, and elevated blood cholesterol are indicators that the individual has a higher risk of cardio-vascular disease (Expert Panel on Detection, 2001). When available, we choose to use the respondent's own knowledge of the condition, rather than measured results from the NHANES exam. We assumed that if the person was unaware of his or her condition she or he would not change their diet behavior to counter-act the condition. For BMI, we used the measured BMI, because it is a good stock measure of past eating behavior, and since it is physically apparent the individual may be aware of the condition without input from a health care provider.

Food culture is a relatively new construct, and describes the measurable factors that describe taste, lifestyle and familiarity of foods (Carlson et al. 2010). In this paper, we include race and ethnicity as approximate measure of foods that may be more familiar from the upbringing of the respondents. For individuals who live in, and especially grew up in multi-racial settings, race and ethnicity may not likely to be a good measure of taste or familiarity of foods. Thus, as the American population becomes more diverse, race and ethnicity may play a less important measure in diet quality. The one exception that is found in recent literature is Hispanics who typically eat a diet of higher quality than Caucasians (Aldrich and Variyam 2000). We also include household size to capture the food culture at home. Larger households likely need to cook more often than medium or small size households. Small households of one or two individuals can prepare a meal to last several days, but may be less inclined to cook for themselves. However, typically small households may be married couples who may eat foods of higher diet quality than larger households.

4. Results

4.1 Impacts on Diet Quality and Energy Intake

Table 2 shows the results from the first two models, which estimate the impact of (1) diet behavior; (2) demographics; (3) lifestyle; (4) health indicators; and (5) food culture, on HEI and Kcal. With regard to diet behavior, increasing the energy intake significantly decreases the HEI. Thus, increasing the HEI by consuming a balanced diet would lower the energy intake, as indicated by the negative and significant HEI in model 2. Respondents who consume vitamin supplements have significantly higher HEIs. This is an interesting result, as it suggests that consumers of a well-balanced diet truly care about their well-being as they also take vitamin supplements. Thus, vitamin consumption seems to be another marker for healthy eating. It also raises concerns since healthy eaters do not need the supplements, and may consume some vitamins and minerals above the upper level (Dietary Guidelines Advisory Committee 2010).

The two age groups show the expected signs and the data supports the significance of both. Young is negative, whereas Senior is positive, underlining the fact that people tend to eat a diet of higher quality with less energy, as they get older. With growing age, the metabolic rate slows down and therefore the body does not require as many calories to maintain its weight (Myers, 2003). Males typically have lower levels of diet quality than females (Arnade and Gopinath 2006, Beydoun and Wang 2008, Stewart and Blisard 2008, Todd et al. 2010, Variyam et al. 1999). Researchers typically find that females are more likely to be concerned about body size and thus, more familiar with health issues. Alternatively, it has been shown that females are cultured from a young age to think of themselves as gate-keepers for current or future families and pay more attention to nutrition information when presented. Education has strong positive impact on HEI but no effect on kcal. Education is a strong proxy for information and awareness leading to overall higher diet quality for the higher educated. In addition, education represents the discount rate- the willingness to put off immediate pleasure for long-term health benefits (Huston and Finke 2003). While income is commonly found to be a barrier to healthy eating, we find that income is not significant in the HEI model, but low-income respondents reported fewer calories consumed.

Respondents who are more active consume more calories than those who are sedentary. Our results also show that individuals who log more screen time hours have poorer diet quality. As expected, smokers have a significantly lower HEI score, but do not display any difference with regard in the number of calories consumed. Those who consume alcohol at the recommended or above level do not have a lower HEI score, but do consume more calories. It is plausible that our results would find a lower HEI score if our alcohol indicator included only those who drink excessively (more than 3 (4) drinks per day for females (males) on a regular basis.

With regard to the outcomes of the health indicator variables, the results are largely as expected. Individuals who have been told that they have elevated cholesterol or diabetes have higher HEI scores, while those with high blood pressure consume fewer calories. Blood pressure or hypertension is a condition that can develop from obesity, so lowering weight by consuming fewer calories may be part of the education around individuals with hypertension. Those who have higher BMIs have lower quality diets and consume more calories. Larger individuals do need to consume more calories to support daily activities. More research is needed to determine if BMI should be included as a categorical variable, rather than a continuous one.

Hispanics and Latino/as have higher diet quality so our results are not surprising. It appears that smaller households have advantages over medium size households in terms of diet quality, indicating either more care for each individual, more time to prepare nutritious meals, or more income per capita to spend on food.

Table 2: Results from Regression Models 1 (HEI) and 2 (Kcal)

	HEI		Log (Kcal)	
Diet Behavior	Coefficient	St.Err.	Coefficient	St.Err.
HEI			-0.001***	0.000
Log (Kcal)	-1.958***	0.496		
Vitamins	2.096***	0.386	0.058***	0.009
Demographics				
Young	-0.945**	0.458	0.113***	0.011
Senior	2.349***	0.518	-0.167***	0.012
Male	-1.347** *	0.401	0.281***	0.009
College	3.432***	0.532	0.005	0.011
Low income	-0.692	0.425	-0.031**	0.010
High income	-0.653	0.520	0.011	0.011
Married	0.714 *	0.391	-0.005	0.009
Lifestyle				
Low Level of Physical Activity	-0.476	0.506	-0.031**	0.011
High Level of Physical Activity	-1.284	0.810	0.057***	0.020
TV	-0.474***	0.117	0.003	0.003
PC games	-0.143*	0.073	-0.006***	0.002
Smoker	-3.417***	0.463	0.010	0.012
Alcohol	-0.599	0.383	0.053***	0.009
Health Indicators				
BMI	-0.069 *	0.031	0.003***	0.001
Blood pressure	-0.284	0.436	-0.036***	0.010
Cholesterol	1.134**	0.430	0.006	0.009
Diabetes	1.659*	0.660	-0.018	0.014
Food Culture				
Other race	2.375*	1.010	-0.015	0.020
Black	-0.701	0.491	-0.066***	0.012
Hispanic/Latino	3.378***	0.493	-0.045***	0.011
Small household	0.694*	0.418	-0.015	0.010
Large household	0.404	0.942	0.034	0.024
R-square	0.06		0.25	

Significance indicated by *, **, and *** at the 90%, 95%, and 99% confidence levels.

4.2 Profile of Vitamin Supplement Consumers

As shown in the Table 3, we use the results from models 1 and 2 to develop a profile of supplement users. In general, we find that the users are not making a trade-off between a healthy diet and vitamin supplement intake. In fact, our results indicate that vitamin supplements are consumed by respondents who display a higher diet quality as way to complement these good health practices. However, we also find that individuals who tend to consume more calories are taking vitamin supplements.

With regard to demographics, the typical consumer of vitamin supplements tends to be a female, college-educated, married and a senior. Respondents between 20 and 39 years show a significant negative likelihood to take vitamin supplements. It is interesting to note that both income classes significantly decrease the likelihood to consume vitamin supplements.

Individuals who might believe they need to eat better also consume vitamin supplements. These are respondents who lead a sedentary lifestyle, and have been told by a health professional that they have high blood pressure and elevated cholesterol levels. They are overwhelmingly of Caucasian descent and live in small households. Although their HEI-2005 score is slightly higher, these smaller households may perceive they are not eating a healthy diet since they may not put the effort into multiple dish meals where vegetables are really obvious. Given the results from models 1 and 2, our profile of vitamin supplement consumers reveals that those who may need these added vitamins are not necessarily consuming them.

Table 3: Results from the Probit Model

	Vitamins	
Diet Behavior	Coefficient	St.Err.
HEI	0.005***	0.001
Log (Kcal)	0.279***	0.041
Demographics		
Young	-0.146***	0.039
Senior	0.364***	0.043
Male	-0.451***	0.033
College	0.231***	0.044
Low income	-0.100**	0.035
High income	-0.147***	0.043
Married	0.116***	0.032
Lifestyle		
Low Level of Physical Activity	-0.075*	0.075
High Level of Physical Activity	-0.127*	0.069
TV	-0.011	0.010
PC games	-0.016**	0.006
Smoker	-0.331***	0.042
Alcohol	-0.059*	0.032
Health Indicators		
BMI	-0.015***	0.003
Blood pressure	0.076**	0.036
Cholesterol	0.177***	0.035
Diabetes	-0.117**	0.052
Food Culture		
Other race	-0.211**	0.080
Black	-0.391***	0.042
Hispanic/Latino	-0.289***	0.039
Small household	0.348***	0.034
Large household	-0.257**	0.084
Log Likelihood	1369.09	
Correct Prediction	73.0%	
Naïve Prediction	26.8%	

Significance indicated by *, **, and *** at the 90%, 95%, and 99% confidence levels.

4.3 Links Between Vitamin Supplement Consumption and Energy Intake

One of the most striking results in Table 3 is the positive and statistically significant relationship between vitamin consumption and energy intake. We expected to find that healthier individuals consumed vitamin supplements and that an increase in vitamin consumption would lead to a decrease in energy intake; our econometric results support the first idea, but not the second. However, the finding related to energy consumption suggests that vitamin supplement consumption may have an important impact on the consumption mix of food, and that this effect will influence total energy intake. For example, it may be the case that some individuals consume vitamin supplements instead of F&V, and that the reduction in F&V in their diet is replaced with other foods.

Most diet recommendations advocate increased consumption of F&V for two reasons. First, F&V contain relatively high levels of many important vitamins and minerals, and many of these micronutrients are not available in a wide range of foods. Second, F&V are low in fat and much less energy-dense than foods in other food groups. As a result, diets that include the recommended amount of F&V provide many of the necessary micronutrients and they displace other foods that may be higher in fat and less nutritious. Substitution between vitamin supplements and F&V may not greatly impact the required level of micronutrient consumption, but it may have a non-trivial influence on the mix of food that is consumed, and this may impact macronutrient intake and total caloric consumption.

Here we develop a framework to examine this subtle, but potentially important, substitution effect between vitamin supplements and F&V. Our analysis includes three steps to assess such substitution effects on caloric consumption patterns. First, we compile data collected by the U.S. Department of Labor, Bureau of Labor Statistics (BLS) that describes at-home food expenditures and food prices to calculate per capita consumption quantities of nineteen food products. The nineteen food products represent the per capita at-home portion of food purchases. Second, information about the caloric composition of food is used to determine energy levels for the food products. The third step combines expenditure data with potential changes in fruit and vegetable consumption in a simulation model to understand the effect of a change in vitamin supplement consumption on food prices, consumption quantities, and caloric intake levels.

Annual expenditures for selected food products, and prices for these foods, have been collected by the BLS since 1984. Furthermore, expenditure data are available for many different subpopulations based on sociodemographic characteristics such as education, income, occupation, region, and race. In Table 4 we list the annual expenditures for nineteen food products for the average income group from 2006 (BLS 2008). We used the total food expenditures for a family unit reported by BLS to calculate per-capita expenditures. Table 4 summarizes the annual per capita food expenditures and average prices for the nineteen food products; we organized the food products into six food groups (Grains, Meats and Eggs, Dairy, F&V, Fats and Oils, and Other). Table 4 also outlines the per capita consumption levels of the nineteen food products that were calculated using the expenditure and price data. The penultimate column shows the per unit energy levels for the selected food products that were used to calculate the quantity of calories consumed (shown in the last column in Table 4).

Table 4: Food expenditures, prices, and consumption (Average income in 2006)

Food group Food product	Annual Expenditures[a] ($ per capita)	Average Price [b] ($/100 g)	Per capita Consumption (100 g)	Energy per unit (kcal/100 g)	Energy Consumed (thousand kcal)
Grains					
Cereal	57.20	0.13	447.74	229	94.5
Bakery products	121.60	0.39	308.42	313	85.9
Meats/Eggs					
Beef	94.40	0.68	138.70	240	30.6
Pork	62.80	0.63	99.00	222	20.4
Other meats	42.00	0.50	83.27	272	19.6
Poultry	56.40	0.30	185.55	197	33.0
Fish and seafood	48.80	1.02	47.80	127	4.9
Eggs	14.80	0.19	51.29	190	9.6
Dairy					
Fresh milk	56.00	0.08	82.55	56	4.4
Other dairy	91.20	0.70	129.80	387	43.3
Fruits/ Vegetables					
Fresh fruit	78.00	0.31	252.94	51	11.6
Fresh vegetables	77.20	0.24	327.56	31	8.7
Processed fruit	43.60	0.42	100.48	45	4.1
Processed vegetables	38.00	0.18	210.39	33	6.2
Fats/Oils					
Sugar and sweets	50.00	0.11	463.27	381	147.6
Fats and oils	34.40	0.27	128.01	577	68.3
Other					
Miscellaneous	250.80	0.76	328.14	198	54.2
Nonalcoholic beverages	132.80	0.38	346.50	24	7.5
Travel food	17.20	0.76	22.50	198	2.5
Total	1367.20				657.0

[a] Source: Bureau of Labor Statistics, 2006. Available at http://www.bls.gov/cex/csxstnd.htm
[b] Average prices reported by BLS (http://www.bls.gov/ro3/apmw.htm) were $ per pound and were converted here to $ per 100 grams
[c] Prices for fish and seafood were not provided by BLS and were specified as 50% above average beef prices.

Next, we employ a partial equilibrium model to characterize supply, demand, and market clearing conditions for the six food groups (Alston, Norton, and Pardey 1995). Agricultural economists have adapted this type of model to study a wide range of research topics, most notably in studies that examine the potential effects of relatively small changes in supply and demand conditions. The term *QS* is used to denote quantity supplied, *QD* denotes quantity demanded, *P* denotes a price, and the subscript *g* is used to denote a food group.

Equation (4) describes the supply of food group g; it depends on the price of food group g and exogenous supply shifters, denoted as $\boldsymbol{B_g}$. Equation (5) describes the demand for food group g and shows that it is a function of the price of food group g, prices of all other food groups, denoted as $\boldsymbol{P_h}$, and exogenous demand shifters, denoted as $\boldsymbol{A_g}$.

(4) $QS_g = \mathrm{f}_g(P_g; \boldsymbol{B_g})$

(5) $QD_g = \mathrm{k}_g(P_g, \boldsymbol{P_h}; \boldsymbol{A_g})$

Totally differentiating these equations and converting them to elasticity form yields a system of linear approximations, or a linear elasticity model. The equations are solved for proportional changes in quantity and prices as functions of various elasticity parameters; values for elasticity parameters are held constant as exogenous changes are applied. Note that levels for prices and quantities are not required in the simulation model; the purpose of the model is to simulate changes in prices and quantities for a given set of parameters for some shock that influences on eo r more of the markets included in the model.

The linear elasticity model is outlined in Equations (6) and (7), and is used to simulate how prices and quantities would respond to changes in market conditions for the selected food groups. A vertical shift downward in the gth supply function (an increase in supply) is denoted β_g in Equation (6), and a vertical shift upwards in the gth demand function (an increase in demand) is denoted α_g in Equation (7). The own-price elasticity of supply for food group g is represented by ε_g in Equation (6). Equation (7) includes own-price elasticities of demand for food groups, denoted as η_{gg}, and cross-price elasticities of demand for food groups, denoted as η_{gh}. The model can be used to examine the economic effects of changes in demand conditions driven by changes in fruit and vegetable consumption given changes in vitamin supplement consumption. Adding a market clearing condition replaces QS_g and QD_g with Q_g, and the fully specified model for the six food groups yields a system of twelve equations. In Equations (6) and (7), for any variable X, E(X) represents the relative change in X, that is, E(X) represents dX/X where d refers to a total differential.

(6) $\mathrm{E}(Q_g) = \varepsilon_g[\mathrm{E}(P_g) + \beta_g]$

(7) $\mathrm{E}(Q_g) = \eta_{gg}[\mathrm{E}(P_g) - \alpha_g] + \sum_h \eta_{gh}[\mathrm{E}(P_h) - \alpha_g]$

The changes in quantities that can be simulated in the model describe the marginal changes in consumption patterns for the food groups. These marginal changes are combined with the initial consumption patterns (from Table 4) to calculate changes in total energy intake for the nineteen food products. The marginal change in consumption for a food group is used as a proxy to characterize the changes in consumption for individual food products (following the classification of products into food groups in Table 4).

We conducted some preliminary analysis of the caloric implications of possible substitution between vitamin supplements and F&V. Rather than estimate elasticities here, we calculated elasticities following an Armington-type specification (Armington 1969) and these are shown in the top portion of Table 5. We simulate the caloric effects of a 1% reduction in the consumption of F&V due to increased consumption of vitamin supplements. Such results can be used to highlight changes in caloric consumption patterns for individual food products, food groups, and all food consumed at home. Preliminary results shown in the bottom portion of Table 5 suggest that a 1% decrease in fruit and vegetable consumption (due to increased vitamin supplement consumption) leads to shift in the total mix of foods from the six groups, and that this shift increases per capita intake by 55 calories annually. This finding indicates that there may be important trade-offs associated with increased consumption of vitamin supplements, including increased total caloric if individuals replace calories from F&V with foods from other food groups. This is an issue that needs to be considered in subsequent research.

Table 5: Armington Elasticities and Simulation Results

Food group	**Demand elasticity with respect to the price of:**						**Supply elasticity**
	Grains	Meats/ eggs	Dairy	Fruits/ Veg.	Fats/ Oils	Other	
Grains	–0.85	0.15	0.15	0.15	0.15	0.15	1.0
Meats/eggs	0.08	–0.93	0.08	0.08	0.08	0.08	1.0
Dairy	0.05	0.05	–0.95	0.05	0.05	0.05	1.0
Fruits/ vegetables	0.10	0.10	0.10	–0.90	0.10	0.10	1.0
Fats/oils	0.10	0.10	0.10	0.10	–0.90	0.10	1.0
Other	0.03	0.03	0.03	0.03	0.03	–0.98	1.0
	Change in food price (%)		Change in food quantity (%)			Change in total energy (kcal)	
Grains	-0.02		0.18			13.4	
Meats/eggs	-0.01		0.24			8.9	
Fruits/ vegetables	0.05		-0.31			-12.2	
Dairy	-0.01		0.33			13.4	
Fats/ oils	-0.01		0.43			14.5	
Other	-0.02		0.45			16.7	
Total						54.7	

5. Summary, Conclusions and Outlook

This project focuses on dietary supplements, a major area of industry growth and competition for the Northern American -food sector. In addition, this topic has received little attention in applied economics research to date. Population ageing, retiring baby boomers and rising awareness of diet-health related disease, for example obesity and diabetes pose challenges to food marketers and the public health system. The so called "diet-health mega-trend" is expected to push the future demand for food products with clear health benefits and create market pressure for convenience product innovations from the food sector. Yet, an ageing population's focus on health and wellbeing will also create unique opportunities for marketing food products for domestic consumers as well as consumer in foreign markets. Higher incomes and willingness to pay for health and convenience food products is a market opportunity that needs to be examined carefully.

We use the 2003-04 U.S. National Health and Nutrition Examination Survey (NHANES) to examine the relationship between HEI and caloric intake. Further, our specific focus is to determine the role of vitamin supplements in the U.S. diet by developing a profile of supplement consumers. In addition, we consider the caloric implications of diets that substitute vitamin supplements for fruits and vegetables. Selected variables include demographic and socioeconomic factors, as well as a large number of dietary, health indicators, and lifestyle-related information. Findings from our econometric model show that consumers of vitamin supplements display higher HEI scores and consume diets with more calories. Specifically, our empirical results find that dietary supplements are consumed by female, married, college-educated senior respondents. Individuals who might believe they need to eat better also consume vitamin supplements. These are respondents who have been told by a health professional that they have high blood pressure and elevated cholesterol levels. Thus, vitamin supplement consumption seems to be another marker for healthy eating. It also raises concerns since healthy eaters do not need the supplements, and may consume some vitamins and minerals above the upper level.

Given the recent economic downturn in the economy, growth opportunities related to diet-health trends should be of great importance to the F&V industry. In this context, knowledge of the determinants of demand for vitamin supplements, especially from competing food supplements, is essential. Findings here will be particularly helpful to identify potential niche markets for small and medium-sized producers in the Northern American F&V sector.

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