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The Effect of Food Label Use on Nutrient Intakes: An Endogenous Switching Regression Analysis

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This study examines the impact of consumers' use of food labels on selected nutrient intakes of Americans. Endogenous switching regression techniques are employed to control for heterogeneity in the label use decision. When the nutrient intakes of label users and the expected nutrient intakes of label users in the absence of labels are compared, food label use decreases individuals' average daily intakes of calories from total fat and saturated fat, cholesterol, and sodium by 6.90%, 2.10%, 67.60 milligrams, and 29.58 milligrams, respectively. In addition, consumer nutrition label use increases average daily fiber intake by 7.51 grams.

Key words: endogenous switching regression, food labels, nutrient intakes

Introduction

Reducing intakes of fat, cholesterol, and sodium, and increasing fiber intake have been reported to help decrease a person's risk of health problems such as cancer and coronary heart disease. Concerns about the effect of diet on health have resulted in the legislation of the Nutrition Labeling and Education Act (NLEA) and its implementation in 1994. As a result, most food products now carry labels that provide information about saturated fat, cholesterol, fiber, sodium, and other nutrients in a format designed to help consumers choose a more healthful and nutritious diet. Zarkin et al. estimated that the potential health benefits from better diet due to these new labels could be as much as 1.2 million life-years gained during the next 20 years. The U.S. Department of Agriculture (USDA) also estimates that improved dietary patterns could save $43 billion in medical care costs (Frazao).

The above estimates, of course, are contingent upon the presumption that consumers' diets are improved by their use of food labels. Previous analyses on the effectiveness of government programs have focused primarily on the Food Stamp, National School Lunch, and Federal Transfer programs (e.g., Akin et al.; Butler and Raymond; Devaney and Fraker). Most of these studies found participation in government programs to have a positive impact on nutrient intakes. Little empirical work, however, has been conducted to determine the impact of the NLEA on consumers' nutrient intakes. With the exception of the study conducted by Kim et al., which reported a positive effect of food label use on the overall quality of consumers' diet represented by the Healthy Eating

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Index (USDA 1995), no other known investigation has evaluated the impact of use of food label nutrition information on consumers' intake of selected nutrients.

The purpose of this study is to assess the impact of food label use on consumers' intake of selected nutrients using the USDA's 1994–96 Continuing Survey of Food Intakes by Individuals (CSFII) and its companion Diet and Health Knowledge Survey (DHKS). In particular, we attempt to determine the characteristics of consumers who use food labels as well as to evaluate the effect of consumer label use on selected nutrient intakes. Key factors such as diet-health knowledge, importance of nutrition when food shopping, smoking, exercise, and food stamp participation also are examined in this study in relation to label use and nutrient intakes. This analysis is particularly timely and important because there is considerable debate and pending legislation to alter regulation of food labels.[1]

The Econometric Model

In evaluating the effect of label use on nutrient intakes, a model that can be employed is the following:

$$N = \beta'\mathbf{X} + \delta I + \varepsilon, \tag{1}$$

where N is the intake of a certain nutrient, $\mathbf{X}$ is a vector of exogenous personal characteristics, and I is a dummy variable ($I = 1$ if the individual uses nutrition information on the food label when shopping, and 0 otherwise). However, this model is subject to misinterpretation because the label use decision is voluntary, thus resulting in the familiar problem of self-selectivity bias (Maddala). If the label use decision is based on individual self-selection, it is likely that label users have systematically different characteristics from nonlabel users. This subsample heterogeneity is econometrically problematic when unobserved characteristics are distributed differently across label users and nonlabel users. Thus, unobserved variables may influence both the label use decision and nutrient intakes, resulting in inconsistent estimates of the effect of label use on nutrient intakes.

A more general model for econometric analysis is the endogenous switching regression model (Gould and Lin; Lee; Maddala; Willis and Rosen). The model consists of nutrient intake equations for label users and nonlabel users and an equation for the label use decision. In this approach, the label use decision is modeled by standard limited dependent variable methods. Equations for nutrient intakes are then estimated separately for each group (label users and nonusers) conditional on label use.

Following Lee, let the label use decision be a dichotomous choice resulting from maximizing an individual's utility, which is a function of the consumption of food, nonfood, and health (Variyam, Blaylock, and Smallwood). The expected utility of label use (I_1^*) is compared to the utility of nonuse (I_0^*); the label is used by consumers if $I_1^* > I_0^*$, and

[1] In September 1998, the Food and Drug Administration (FDA) revised its food labeling regulation to require a warning statement on fruit and vegetable juice products to inform consumers of the risk of foodborne illness to children, the elderly, and persons with weakened immune systems. In addition to the FDA's regulation of food labeling, there are more recent policy changes related to the way that dietary supplements and functional foods are regulated.

nonuse of the label occurs if $I_1^* \le I_0^*$. Define label use of the ith nutrient content on the food products for the jth consumer as follows: $I_{ij} = 1$ if $I_1^* > I_0^*$, and $I_{ij} = 0$ if $I_1^* \le I_0^*$. Then, the decision of whether or not to use the label can be described by

$$I_{ij} = \gamma_i' \mathbf{Z}_j - \mu_{ij}, \tag{2}$$

where $\mathbf{Z}_j$ denotes vector characteristics that affect label use (Nayga 1996; Guthrie et al.), γ_i is a vector of parameters, and μ_{ij} is an error term. Equation (2) is a probit specification for label use.

In terms of demand theory, individuals not using food labels may be different in their food consumption behavior from those using food labels (see Gould and Lin; Variyam, Blaylock, and Smallwood). Assuming fixed weights representing nutrient levels in each food, label use may affect individuals' nutrient intakes. Define N_{ij} as the observed ith nutrient intake for the jth consumer, and define N_{ij1} and N_{ij0} as the ith nutrient intakes of label user j ($I_{ij} = 1$) and nonlabel user j ($I_{ij} = 0$), respectively. Then separate nutrient intake equations are specified for label users and nonusers by (3) and (4):

$$N_{ij1} = \beta_{i1}' \mathbf{X}_j + \varepsilon_{ij1}, \tag{3}$$

$$N_{ij0} = \beta_{i0}' \mathbf{X}_j + \varepsilon_{ij0}, \tag{4}$$

where $\mathbf{X}_j$ is a vector of the jth consumer's observed characteristics that affect nutrient intakes (Capps; Putler and Frazao; Haines, Guilley, and Popkin; Nayga 1994; Variyam, Blaylock, and Smallwood), β_{i1} and β_{i0} are vectors of parameters, and ε_{ij1} and ε_{ij0} are error terms.

The error terms of the above equations (ε_{ij1}, ε_{ij0}, and μ_{ij}) are assumed to have a trivariate normal distribution with mean vector zero and covariance matrix

$$\operatorname{cov}(\varepsilon_{ij1}, \varepsilon_{ij0}, \mu_{ij}) = \begin{bmatrix} \sigma_{i1}^2 & \sigma_{i1,0} & \sigma_{i1\mu} \\ \sigma_{i1,0} & \sigma_{i0}^2 & \sigma_{i\mu 0} \\ \sigma_{i1\mu} & \sigma_{i0\mu} & 1 \end{bmatrix},$$

where $\operatorname{var}(\varepsilon_{ij1}) = \sigma_{i1}^2$, $\operatorname{var}(\varepsilon_{ij0}) = \sigma_{i0}^2$, $\operatorname{var}(\mu_{ij}) = 1$, $\operatorname{cov}(\varepsilon_{ij1}, \varepsilon_{ij0}) = \sigma_{i1,0}$, $\operatorname{cov}(\varepsilon_{ij1}, \mu_{ij}) = \sigma_{i1\mu}$, and $\operatorname{cov}(\varepsilon_{ij0}, \mu_{ij}) = \sigma_{i0\mu}$.

Since the choice of using labels or not is endogenous, the error terms in equations (3) and (4), conditional on the sample selection criterion, have nonzero expected values:

$$E[\varepsilon_{ij0} \mid I_{ij} = 1] = -\sigma_{i1\mu} \frac{\phi(\gamma_i' \mathbf{Z}_j)}{\Phi(\gamma_i' \mathbf{Z}_j)}, \tag{5}$$

$$E[\varepsilon_{ij0} \mid I_{ij} = 0] = \sigma_{i0\mu} \frac{\phi(\gamma_i' \mathbf{Z}_j)}{1 - \Phi(\gamma_i' \mathbf{Z}_j)}, \tag{6}$$

where ϕ and Φ are the standard normal probability density function and the standard normal cumulative density function, respectively. Thus, nutrient demand relationships (3) and (4) should not be estimated using OLS. In general, a two-step estimation method has been widely used in the estimation of endogenous switching regression models. Full information maximum likelihood (FIML) estimation, as noted by Maddala, is preferred over the two-step estimation procedure since the parameters are consistent and asymptotically efficient assuming proper model specification (Lee and Trost). Also, Monte Carlo experiment studies show that FIML estimation is superior to two-step estimation; in particular, the two-step estimator performs poorly when there is a high degree of multicollinearity between $\gamma_i'\mathbf{Z}_j$ and explanatory variables $\mathbf{X}_j$ (Hartman; Nelson; Nawata).

FIML parameter estimates can be obtained from the following likelihood function:

$$(7)\qquad L_i(\beta_{i1}, \beta_{i0}, \sigma_{i1}, \sigma_{i0}, \rho_{i1\mu}, \rho_{i0\mu}) = \prod_{j=1}^{J}\left[\int_{-\infty}^{\gamma_i'\mathbf{Z}_j} f_1(N_{ij1} - \beta_{i1}'\mathbf{X}_j, \mu_{ij})\, d\mu_{ij}\right]^{I_{ij}} \times \left[\int_{\gamma_i'\mathbf{Z}_j}^{\infty} f_0(N_{ij0} - \beta_{i0}'\mathbf{X}_j, \mu_{ij})\, d\mu_{ij}\right]^{1-I_{ij}},$$

where f_1 and f_0 are the jointly normal density functions for $\{\varepsilon_{j1}, \mu_j\}$ and $\{\varepsilon_{j0}, \mu_j\}$, respectively. The logarithmic likelihood function is

$$(8)\qquad \ln L_i(\beta_{i1}, \beta_{i0}, \sigma_{i1}, \sigma_{i0}, \rho_{i1\mu}, \rho_{i0\mu}) = \sum_{j=1}^{J} I_{ij}\left[\ln\phi\left(\frac{N_{ij1} - \beta_{i1}'\mathbf{X}_j}{\sigma_{i1}}\right) - \ln\sigma_{i1} + \ln\Phi(\eta_{ij1})\right] + (1 - I_{ij})\left[\ln\phi\left(\frac{N_{ij0} - \beta_{i0}'\mathbf{X}_j}{\sigma_{i0}}\right) - \ln\sigma_{i0} + \ln\left(1 - \Phi(\eta_{ij0})\right)\right],$$

where

$$\eta_{ij1} = \frac{\left[\gamma_i'\mathbf{Z}_j - \frac{\rho_{i1\mu}}{\sigma_{i1}}(N_{ij1} - \beta_{i1}'\mathbf{X}_j)\right]}{\sqrt{1 - \rho_{i1\mu}^2}}$$

and

$$\eta_{ij0} = \frac{\left[\gamma_i'\mathbf{Z}_j - \frac{\rho_{i0\mu}}{\sigma_{i0}}(N_{ij0} - \beta_{i0}'\mathbf{X}_j)\right]}{\sqrt{1 - \rho_{i0\mu}^2}},$$

with $\rho_{i1\mu}$ and $\rho_{i0\mu}$ denoting the correlation coefficients of $\{\varepsilon_{ij1}, \mu_{ij}\}$ and $\{\varepsilon_{ij0}, \mu_{ij}\}$, respectively.

The estimates of β_{i1} and β_{i0} measure the marginal effect of an explanatory variable on the nutrient intake, unconditional on label use. Suppose there is a variable that appears both in $\mathbf{X}_j$ and $\mathbf{Z}_j$, say the kth element of these vectors. The conditional effect on those who actually use the label is given by

$$(9)\qquad \frac{\partial E(N_{ij1} \mid I_{ij} = 1)}{\partial X_{jk}} = \beta_{i1k} + \gamma_k \sigma_{i1\mu} \frac{\phi(\gamma_i'\mathbf{Z}_j)}{\Phi(\gamma_i'\mathbf{Z}_j)}\left[\gamma_i'\mathbf{Z}_j + \frac{\phi(\gamma_i'\mathbf{Z}_j)}{\Phi(\gamma_i'\mathbf{Z}_j)}\right].$$

Similarly, the conditional effect on those who do not use the label is specified by

$$(10)\qquad \frac{\partial E(N_{ij0}\,|\,I_{ij}=0)}{\partial X_{jk}} = \beta_{i1k} - \gamma_k \sigma_{i0\mu} \frac{\phi(\gamma_i' \mathbf{Z}_j)}{1-\Phi(\gamma_i'\mathbf{Z}_j)} \left[\gamma_i'\mathbf{Z}_j - \frac{\phi(\gamma_i'\mathbf{Z}_j)}{1-\Phi(\gamma_i'\mathbf{Z}_j)} \right].$$

Equations (9) and (10) decompose the effect of a change in X_{jk} into two parts. The first part is the direct effect on N_{ij1} (N_{ij0}). The second part captures an indirect effect that appears as a result of correlation between the unobservable components of N_{ij1} (N_{ij0}) and I_{ij} (Poirier and Ruud; Maddala).

Data

Survey data from the USDA's 1994–96 Continuing Survey of Food Intake by Individuals and the companion Diet and Health Knowledge Survey are used in this study. The CSFII contains data on nutrient intakes by individuals, while the DHKS includes detailed information about the individual's socioeconomic background, health/diet related information, and questions on label usage. The empirical work uses DHKS respondents who completed the survey of both day-1 and day-2 intakes. Incomplete data for some of the variables resulted in a total of 5,203 observations for this analysis.

The names, definitions, and means for the variables used in the analysis are presented in table 1. The dependent variables include the binary label use variables for each nutrient as well as average daily percentage of calories from total and saturated fat, average daily cholesterol intake, average daily fiber intake, and average daily sodium intake. These nutrients are selected for this study due to the importance and attention they have received from health professionals, the media, and the public in recent years. Further, these are also the major nutrients presented with nutrient content information on food labels. Binary variables (1 = use, 0 = nonuse) are employed to capture the decision to use the nutrient content information for these nutrients on food labels.[2] About 75.8% of the sample indicated they used nutrition information on total fat, 73.4% used information on saturated fat, 73.3% used information on cholesterol, 70.8% used information on fiber, and 73.6% used information on sodium.

Explanatory variables (table 1) consist of personal or household characteristics, demographic factors, participation in the Food Stamp Program, and knowledge about linkage between diet and health problems. Personal or household characteristics include body mass index, age, gender, education, race, employment status, special diet status, smoking, exercise, and vegetarian/nonvegetarian.[3] Other demographic factors include region, urbanization, household size, and income.

The *Diet-Heath Knowledge* variable is constructed to reflect consumers' awareness about the linkage between diet and health problems. Questions in the DHKS used to

[2] The respondents were asked questions concerning the use of labels. The general question format was: "When you look for nutrition information on the food label, would you say you often, sometimes, rarely, or never look for information about total fat?" ("about saturated fat?" "about cholesterol?" "about fiber?" "about sodium?") Responses of "often," "sometimes," or "rarely" were given a value of 1; responses of "never" received a value of 0.

[3] Some of these variables (e.g., exercise and smoking) may be endogenous in the nutrient intake equations. However, there are no good instrumental variables in the data that can be used for these variables. Nakamura and Nakamura oppose an "always instrumentation" policy for endogenous explanatory variables, because (*a*) there is usually little real evidence that instruments which are used are exogenous themselves, and (*b*) it encourages applied researchers to limit the variables they include in their models so as to avoid difficult instrumentation problems. The authors also showed that estimates from the use of instrument variables can be suspect because of generally large standard errors and erratic parameter estimates.

Table 1. Definitions of Variables, Means, and Standard Deviations

Dependent Variables	Binary Nutrition Label Use Means	Means of Nutrient Intakes: Total Sample	Label User	Label Nonuser
Calories from Total Fat (%)	0.7578	36.57	36.05	38.20
Calories from Saturated Fat (%)	0.7338	12.16	11.85	13.01
Cholesterol (milligrams)	0.7328	267.05	253.63	304.48
Fiber (grams	0.7080	15.53	15.77	14.99
Sodium (milligrams)	0.7355	3,233.72	3,176.17	3,400.98

Explanatory Variables	Description	Mean	Standard Deviation
Income	Household income ($10,000s)	3.5211	2.6386
Household Size	Number of household members	2.5813	1.4493
Age	Age of respondent (in years)	50.8388	17.1452
Male	Respondent is male (1 = yes, 0 = no)	0.5025	—
Black	Respondent is Black (1 = yes, 0 = no)	0.1125	—
Others	Respondent is other non-White race (1 = yes, 0 = no)	0.0630	—
Employed	Respondent is employed (1 = yes, 0 = no)	0.5822	—
City	Respondent resides in the central city (1 = yes, 0 = no)	0.2941	—
Nonmetro	Respondent resides in nonmetropolitan area (1 = yes, 0 = no)	0.2643	—
Education	Schooling (in years)	12.6610	3.0824
Northeast	Respondent resides in the Northeast (1 = yes, 0 = no)	0.1911	—
West	Respondent resides in the West (1 = yes, 0 = no)	0.3542	—
Midwest	Respondent resides in the Midwest (1 = yes, 0 = no)	0.2528	—
Food Stamps	Respondent participates in Food Stamp Program (1 = yes, 0 = no)	0.0761	—
Exercise	Respondent exercises regularly (1 = yes, 0 = no)	0.6043	—
BMI_SP	Body mass index of respondent	27.9662	11.5336
Smoker	Respondent is a smoker (1 = yes, 0 = no)	0.2564	—
Nutrition	Nutrition is important when buying food (1 = yes, 0 = no)	0.6949	—
Vegetarian	Respondent is a vegetarian (1 = yes, 0 = no)	0.0302	—
Meal Planner	Respondent is a household meal planner (1 = yes, 0 = no)	0.6706	—
NHSP	Respondent is non-Hispanic (1 = yes, 0 = no)	0.9232	—
Diet-Health Knowledge	Knowledge about diet-disease linkage (1 = yes, 0 = no):		
	▸ Health problems caused by eating too much fat	0.8703	—
	▸ Health problems caused by not eating enough fiber	0.6638	—
	▸ Health problems caused by eating too much sodium	0.8807	—
	▸ Health problems caused by eating too much cholesterol	0.8746	—
Special Diet	Special diet status (1 = yes, 0 = no):		
	▸ Respondent is on a low-fat or low-cholesterol diet	0.0918	—
	▸ Respondent is on a low-sodium diet	0.0501	—
	▸ Respondent is on a high-fiber diet	0.0150	—

Note: The base group includes *White*, *Female*, *Unemployed*, *Suburban*, and *South*.

construct the variable take the general form: "Have you heard about any health problems caused by eating too much fat?" ("eating too much cholesterol?" "eating too much sodium?" "not eating enough fiber?") Each answer of "yes" is given a value of one, while each "no" response is given a value of zero. A *Diet-Health Knowledge* binary variable is constructed for each nutrient examined in this study. Another binary dummy variable, *Nutrition*, is included in the probit label use model, following Nayga (1996). This variable indicates whether the individual considers nutrition as an important factor when buying foods.

Since the analysis is limited to DHKS respondents, only adults are included in the sample. About 67% of the sample are main meal planners. DHKS participants, however, can use food labels either while grocery shopping in the store or when at home (Nayga, Lipinski, and Savur).

Model Specification Test

The joint normality assumption plays a key role in the estimation of an endogenous switching regression model. The normal selection-bias adjustment has been known to be quite sensitive to departures from normality (Pagan and Vella; Goldberger). A simple test for the joint normality assumption is to add the variables to the second-stage estimator in the two-step estimation procedure of equations (2), (3), and (4), and test if these are jointly zero (Pagan and Vella):

$$(\hat{\gamma}_i'\mathbf{Z}_j)^t \cdot W \quad (t = 1, 2, 3),$$

where

$$W = \begin{cases} \dfrac{\phi(\hat{\gamma}_i'\mathbf{Z}_j)}{\Phi(\hat{\gamma}_i'\mathbf{Z}_j)} & \text{for label users,} \\[2ex] \dfrac{\phi(\hat{\gamma}_i'\mathbf{Z}_j)}{1 - \Phi(\hat{\gamma}_i'\mathbf{Z}_j)} & \text{for nonusers.} \end{cases}$$

This is the situation tantamount to the Regression Specification Error Test (RESET). The test results are reported in table 2. Columns (1), (2), and (3) contain the absolute values of the t-statistics for the null hypothesis that the coefficient is equal to zero. Column (4) shows the significance level of the χ^2 value for the null hypothesis that the parameters corresponding to columns (1), (2), and (3) are jointly zero. The results generally reflect the fact that model misspecification due to nonnormality is not consequential.

Results

Nutrition Label Use Equations

Parameter estimates of the nutrition label use model for each of the nutrients (five types of nutrient content information presented on food labels) are reported in table 3. The estimation results are generally consistent across the equations. The probability of using nutrition information on food labels increases with income, while the probability of label use decreases with age in all equations except for dietary fiber. Consistent with Nayga's

Table 2. Results of the Joint Normality Test

Type of Nutrition Information	Group	Pred × W (1)	Pred^2 × W (2)	Pred^3 × W (3)	P-Value (4)
Calories from Total Fat	User:	2.394	2.509	1.173	0.024
	Nonuser:	0.821	0.754	0.862	0.458
Calories from Saturated Fat	User:	2.021	1.811	0.717	0.075
	Nonuser:	0.384	0.397	0.323	0.442
Cholesterol	User:	1.071	0.469	0.004	0.672
	Nonuser:	0.044	0.171	0.423	0.836
Dietary Fiber	User:	0.038	0.815	1.084	0.587
	Nonuser:	1.310	1.286	1.020	0.232
Sodium	User:	0.258	0.146	0.473	0.259
	Nonuser:	0.660	0.927	0.771	0.133

Notes: Pred indicates the predicted value of $\gamma_i'\mathbf{Z}_j$. For label users, W is equal to $\phi(\gamma_i'\mathbf{Z}_j)/\Phi(\gamma_i'\mathbf{Z}_j)$, while for nonusers, W is equal to $\phi(\gamma_i'\mathbf{Z}_j)/[1 - \Phi(\gamma_i'\mathbf{Z}_j)]$. Columns (1), (2), and (3) contain the absolute values of the t-statistics for the null hypothesis that the coefficient is equal to zero. Column (4) shows the significance level of the χ^2 value for the null hypothesis that the parameters corresponding to columns (1), (2), and (3) are jointly zero.

(1996) finding, males are less likely to use nutrient content information on labels than females. Results also indicate that education is positively related to the probability of using nutrient content information for these five nutrients available on food labels. This finding is consistent with the results of Guthrie et al. Urbanization differences also are evident in that individuals who reside in nonmetro areas are less likely to use nutrient content information on the five nutrients than those who reside in suburban areas.

As expected, individuals who are on a special diet are more likely to use nutrient content information on the five nutrients than individuals who are not on a special diet. Individuals who are more informed about the linkage between diet and health problems also are more likely to use nutrient content information on all five nutrients. This result is consistent with Nayga's (2000) finding and the argument that poorly informed consumers tend to underestimate the marginal benefit of label use. Nonsmokers and those who exercise regularly are positively related to the probability of using nutrient content information on labels.

Non-Hispanics are less likely to use nutrient content information on dietary fiber and sodium than Hispanics. Individuals who are meal planners are more likely than others to use nutrient content information on the five nutrients examined. In addition, those who place more importance on nutrition when food shopping are more likely to use nutrient content information on the five nutrients than others.

Nutrient Intake Equations

The parameter estimates for the nutrient intake equations are provided in table 4a (calories from total fat and calories from saturated fat) and table 4b (cholesterol, dietary fiber, and sodium).[4] Tables 4a and 4b also contain the estimated standard deviation of

[4] We obtained similar results when we reestimated the models using a different categorization of label use—that is, responses of "often" and "sometimes" were given a value of 1, and responses of "rarely" and "never" were assigned a value of 0.

Table 3. Parameter Estimates of Nutrition Label Use Equations

Variables	Total Fat	Saturated Fat	Cholesterol	Dietary Fiber	Sodium
Constant	-0.8786***	-1.0242***	-0.9666***	-0.4494***	-0.8907***
	(-4.190)	(-4.904)	(-4.644)	(-2.842)	(-4.403)
Income	0.0032***	0.0024**	0.0019*	0.0013*	0.0017*
	(3.058)	(2.398)	(1.912)	(1.729)	(1.725)
Household Size	-0.0625***	-0.0614***	-0.0485***	-0.0167	-0.0408**
	(-3.756)	(-3.770)	(-2.981)	(-1.246)	(-2.524)
Age	-0.0044***	-0.0033***	-0.0025**	-0.0004	-0.0020**
	(-2.846)	(-2.132)	(-1.593)	(-0.355)	(-1.333)
Male	-0.4962***	-0.4067***	-0.3897***	-0.1069**	-0.4251***
	(-9.576)	(-8.086)	(-7.755)	(-2.502)	(-8.449)
Black	-0.0061	-0.0026	0.8332	0.0546	0.0584
	(-0.089)	(-0.037)	(1.201)	(0.918)	(0.846)
Others	-0.0344	-0.0343	0.0197	-0.0127	-0.0713
	(-0.350)	(-0.369)	(0.210)	(-0.180)	(-0.759)
Employed	0.0027	-0.0072	-0.0430	-0.0362	-0.0374
	(0.049)	(-0.137)	(-0.809)	(-0.835)	(-0.732)
City	-0.0369	-0.0549	-0.1145**	-0.0491	-0.0594
	(-0.688)	(-1.068)	(-2.218)	(-1.147)	(-1.173)
Nonmetro	-0.2135***	-0.1847***	-0.2491***	-0.1689***	-0.2661***
	(-4.150)	(-3.708)	(-5.005)	(-4.156)	(-5.332)
Education	0.0639***	0.0573***	0.0459***	0.0518***	0.0577***
	(8.063)	(7.346)	(5.866)	(8.360)	(7.475)
NHSP	-0.1573	-0.0770	-0.0822	-0.8984*	-0.1892**
	(-1.729)	(-0.905)	(-0.942)	(-1.290)	(-2.102)
Food Stamps	-0.1335*	-0.1943**	-0.2078**	-0.0496*	-0.1653**
	(-1.655)	(-2.460)	(-2.562)	(-0.722)	(-2.130)
Diet-Health Knowledge	0.5593***	0.5060***	0.5845***	0.3703***	0.4742***
	(9.646)	(8.853)	(9.882)	(10.124)	(8.173)
Special Diet	0.3662***	0.3539***	0.3907***	0.5997***	0.5100***
	(4.157)	(4.261)	(4.721)	(4.137)	(4.528)
Smoker	-0.2852***	-0.2467***	-0.2905***	-0.2051***	-0.2664***
	(-5.944)	(-5.283)	(-6.223)	(-5.220)	(-5.727)
Exercise	0.2875***	0.2890***	0.2711***	0.1735***	0.2490***
	(6.373)	(6.648)	(6.224)	(4.820)	(5.748)
Meal Planner	0.1733***	0.1577*	0.1667**	0.1478***	0.1194**
	(3.238)	(2.989)	(3.182)	(3.487)	(2.264)
Vegetarian	0.0133	0.0378	0.0137	0.0630	0.0210
	(0.098)	(0.287)	(0.110)	(0.687)	(0.165)
Nutrition	0.9624***	0.9756***	0.9890***	0.1881***	0.9661***
	(12.388)	(12.557)	(12.609)	(5.078)	(12.334)
McFadden R^2	0.172	0.148	0.136	0.156	0.101

Notes: Single, double, and triple asterisks (*) denote significance at the 10%, 5%, and 1% levels, respectively. Numbers in parentheses are t-statistics.

Table 4a. Parameter Estimates of the Nutrient Intake Equations for Calories from Total Fat and Calories from Saturated Fat

	Calories from Total Fat (%)		Calories from Saturated Fat (%)	
Variables	User	Nonuser	User	Nonuser
Constant	34.6900*** (13.753)	35.4250*** (10.150)	13.5710*** (12.279)	10.7940*** (6.921)
Income	0.0205 (0.768)	0.0499 (1.079)	0.0032 (0.285)	0.0176 (0.912)
Income^2	-0.0003 (-1.041)	-0.0004 (-0.944)	-0.76×10^{-4} (-0.725)	-0.0002 (-1.076)
Household Size	-0.1004 (-0.667)	-0.2809 (-1.225)	-0.0165 (-0.253)	-0.0198 (-0.213)
Age	0.1568** (2.338)	0.2075** (2.095)	0.0070 (0.253)	0.0928** (2.088)
Age^2	-0.0018*** (-2.666)	-0.0021** (-2.232)	-0.0003 (-0.890)	-0.0010** (-2.322)
Male	0.9109* (1.676)	-1.6135* (-1.817)	0.3545 (1.607)	-0.2252 (-0.612)
Black	1.0018* (1.734)	0.6846 (0.659)	0.0300 (0.114)	-0.6511 (-1.470)
Others	-3.1857** (-3.897)	-4.7694*** (-3.211)	-1.6000*** (-4.535)	-2.0809*** (-3.162)
Employed	0.6998 (1.621)	1.4722* (1.857)	0.3044 (1.633)	-0.0046 (-0.014)
City	-0.1690 (-0.401)	-1.6471** (-1.973)	-0.1922 (-1.038)	-0.5712 (-1.601)
Nonmetro	1.6086*** (3.539)	-0.4297 (-0.566)	0.6183*** (3.311)	-0.1326 (-0.420)
Education	-0.1239 (-1.453)	0.1056 (0.919)	-0.0820** (-2.323)	0.1061** (2.081)
Northeast	-0.2324 (-0.428)	-0.6263 (-0.596)	0.2044 (0.899)	0.5726 (1.286)
West	0.3176 (0.654)	2.0518** (2.385)	-0.1628 (-0.779)	0.5018 (1.275)
Midwest	0.9610* (1.849)	1.1179 (1.204)	0.3584 (1.591)	0.7887* (1.915)
Food Stamps	1.2976 (1.545)	-0.4011 (-0.352)	0.6796** (2.091)	-0.1628 (-0.337)
NHSP	0.1637 (0.212)	-0.3413 (-0.244)	0.1351 (0.415)	-0.0551 (-0.090)
Diet-Health Knowledge	-0.4636 (-0.609)	1.2232 (1.490)	-0.5941* (-1.905)	-0.1134 (-0.309)
Special Diet	-4.6889*** (-8.034)	-1.8155 (-1.173)	-2.1499*** (-8.059)	-1.5291** (-2.113)
Smoker	1.3226*** (2.899)	-0.0174 (-0.024)	0.5623*** (2.924)	0.3184 (1.055)
Exercise	-1.3525** (-3.181)	2.2034** (3.142)	-0.4670** (-2.594)	0.5621* (1.875)

Table 4a. Continued

	Calories from Total Fat (%)		Calories from Saturated Fat (%)	
Variables	User	Nonuser	User	Nonuser
BMI_SP	0.0051	0.0086	0.0074	-0.0064
	(0.329)	(0.351)	(1.222)	(-0.511)
Meal Planner	-0.3972	0.8354	-0.1269	0.1731
	(-0.799)	(1.092)	(-0.598)	(0.533)
Vegetarian	-2.9102***	-3.0407	-1.8152***	-0.4691
	(-3.371)	(-1.449)	(-4.452)	(-0.578)
σ_{i1}, σ_{i0} [a]	10.558***	10.8110***	4.4406***	4.6591***
	(88.925)	(28.883)	(93.915)	(43.720)
$\rho_{i1\mu}$, $\rho_{i0\mu}$ [b]	-0.0490	0.4241***	-0.0313	0.2053*
	(-0.307)	(4.479)	(-0.200)	(1.825)
N [c]	3,944	1,259	3,819	1,384

Notes: Single, double, and triple asterisks (*) denote significance at the 10%, 5%, and 1% levels, respectively. Numbers in parentheses are *t*-statistics.

[a] The terms σ_{i1}, σ_{i0} denote the standard deviations of error terms of conditional nutrient intake equations for label users and nonlabel users, respectively.

[b] The terms $\rho_{i1\mu}$, $\rho_{i0\mu}$ denote the correlation coefficients between probit label use and conditional nutrient intake equations for label users and nonlabel users, respectively.

[c] N indicates the number of observations in the label user and nonlabel user groups.

conditional nutrient intake equation error terms and the correlation coefficients between probit label use and conditional nutrient intake equations for label users and nonlabel users. For all nutrient intake equations except sodium, the estimated correlation coefficients are significant for nonlabel users. Conversely, these correlation coefficients are not significant for label users. For fiber intake, self-selectivity occurs in both label users and nonlabel users because the correlation coefficients are significant in nutrient intake equations for both label users and nonlabel users.

Based on the conditional marginal effects from equations (9) and (10), the impacts of independent variables on nutrient intakes are as follows. Results indicate that age of label users and nonlabel users is related nonlinearly to intake of calories from total fat, and that age of nonlabel users is related nonlinearly to intake of calories from saturated fat. Specifically, the percentage of caloric intake from these two nutrients increases initially before declining with age. Among label users, males consume about 1% more calories from total fat, 98 milligrams more cholesterol, about 2 grams more fiber, and about 1,103 milligrams more sodium per day than females. Male nonlabel users also consume roughly 1.7% more calories from total fat, 127 milligrams more cholesterol, 2 grams more fiber, and 1,217 milligrams more sodium per day than female nonlabel users.

Among label users, Blacks consume about 1% more calories from total fat, and 42 milligrams more cholesterol per day than Whites. Black nonlabel users consume 294 milligrams less sodium a day than their White counterparts. Individuals of other races consume less total fat and saturated fat than Whites, regardless of whether they are label users or not. Label users who are non-Hispanics consume about 250 milligrams more sodium per day than label users who are Hispanics. Employed nonlabel users

Table 4b. Parameter Estimates of the Nutrient Intake Equations for Cholesterol, Dietary Fiber, and Sodium

	Cholesterol (mg)		Dietary Fiber (g)		Sodium (mg)	
Variables	User	Nonuser	User	Nonuser	User	Nonuser
Constant	249.2300***	265.5100***	1.2249	6.1318**	2970.0000***	2902.7000***
	(4.693)	(3.315)	(0.673)	(2.130)	(7.984)	(4.948)
Income	-0.0839	0.4254	0.0361*	-0.0023	2.3057	10.5140
	(-0.151)	(0.389)	(1.848)	(-0.083)	(0.549)	(1.367)
Income^2	-0.0015	-0.0063	-0.0001	-0.3665×10^{-4}	-0.0034	-0.1153
	(-0.287)	(-0.595)	(-0.762)	(-0.154)	(-0.088)	(-1.546)
Household Size	-1.5183	-4.4865	-0.3088**	0.0460	-55.9490**	-34.5250
	(-0.467)	(-0.891)	(-2.239)	(0.196)	(-2.424)	(-0.932)
Age	1.4740	0.5935	-0.0119	-0.0168	-14.4560	-30.9470
	(1.041)	(0.244)	(-0.290)	(-0.307)	(-1.395)	(-1.850)
Age^2	-0.0238*	-0.0104	0.0003	0.0004	-0.0359	0.1367
	(-1.654)	(-0.434)	(0.665)	(0.695)	(-0.336)	(0.855)
Male	98.3530***	99.0290***	1.4366***	3.0561***	1070.0000***	1242.3000***
	(9.496)	(4.520)	(3.292)	(4.082)	(12.836)	(8.779)
Black	42.0340***	22.5580	-0.7242	-1.4627	-114.9600	-296.3400*
	(3.411)	(0.998)	(-1.184)	(-1.380)	(-1.285)	(-1.702)
Others	19.5720	-42.3130	0.1826	-0.1993	-132.3700	-155.6200
	(1.048)	(-1.188)	(0.249)	(-0.161)	(-1.102)	(-0.665)
Employed	11.6630	23.8900	-0.2680	0.1671	61.1240	239.1000*
	(1.176)	(1.233)	(-0.592)	(0.218)	(0.797)	(1.842)
City	-7.0432	1.7702	-0.3850	1.2474*	-20.5750	-3.2650
	(-0.763)	(0.091)	(-0.883)	(1.651)	(-0.312)	(-0.025)
Nonmetro	17.1520*	-1.0376	-1.3301***	2.5788***	65.9500	13.4080
	(1.747)	(-0.060)	(-3.105)	(2.035)	(0.913)	(0.106)
Education	-3.6772**	1.4604	0.5669**	-0.6525***	15.5550	3.0513
	(-2.045)	(0.560)	(8.748)	(-6.104)	(1.196)	(0.151)
Northeast	2.4708	-8.6088	-0.7894**	-0.1394	34.9690	54.6060
	(0.201)	(-0.364)	(-2.247)	(-0.255)	(0.411)	(0.317)
West	-2.6893	-14.2310	-1.0969***	-0.3316	-81.3270	-21.6391
	(-0.250)	(-0.720)	(-3.214)	(-0.664)	(-1.068)	(-0.149)
Midwest	13.8700	9.5119	-0.5398	0.2205	276.5900***	399.4500**
	(1.231)	(0.447)	(-1.536)	(0.462)	(3.395)	(2.530)
Food Stamps	29.5340**	28.2130	-0.6606	-0.5614	176.8900	444.1600**
	(2.085)	(1.144)	(-0.890)	(-0.474)	(1.546)	(2.351)
NHSP	17.3280	-32.8910	-0.7671	-0.1116	236.9700*	87.7750
	(1.007)	(-1.263)	(-1.041)	(-0.093)	(1.833)	(0.404)
Diet-Health Knowledge	-2.1089	4.9357	4.0994***	-4.4262***	148.0700	89.5300
	(-0.131)	(0.246)	(10.668)	(-6.790)	(1.355)	(0.614)
Special Diet	-50.4610***	-94.1190	5.0390***	-11.6060***	-166.0600	-141.1700
	(-3.298)	(-1.620)	(4.285)	(-4.077)	(-1.349)	(-0.426)
Smoker	15.4250*	14.6170	-3.2892***	1.4856***	33.7130	-0.0407
	(1.679)	(0.913)	(-7.842)	(3.068)	(0.472)	(-0.001)
Exercise	-19.2220**	33.5060**	1.7873***	-1.7605***	-77.7210	253.5900
	(-2.042)	(2.117)	(4.768)	(-2.762)	(-1.115)	(2.247)
BMI_SP	0.0389	0.6110	-0.0273**	0.0225	1.2644	2.7657
	(0.103)	(1.023)	(-2.060)	(1.467)	(0.531)	(0.650)

Table 4b. Continued

	Cholesterol (mg)		Dietary Fiber (g)		Sodium (mg)	
Variables	User	Nonuser	User	Nonuser	User	Nonuser
Meal Planner	-8.6601	5.4950	0.8542*	-2.5393***	-88.8740	202.3000
	(-0.900)	(0.320)	(1.933)	(-3.397)	(-1.267)	(0.951)
Vegetarian	-82.1720***	-49.5860	0.9663	3.5368**	-380.2500**	248.9100
	(-3.021)	(-0.839)	(1.071)	(2.159)	(-2.354)	(0.744)
σ_{i1}, σ_{i0} [a]	212.7300***	244.8900***	11.5470***	16.7420***	1599.9000***	1812.4000***
	(155.603)	(44.977)	(93.363)	(52.219)	(106.906)	(70.058)
$\rho_{i1\mu}$, $\rho_{i0\mu}$ [b]	0.0153	0.2108**	-0.9818***	-0.9933***	-0.1056	-0.0219
	(0.110)	(2.059)	(-354.338)	(-654.706)	(-0.645)	(-0.168)
N [c]	3,814	1,389	3,685	1,518	3,828	1,375

Notes: Single, double, and triple asterisks (*) denote significance at the 10%, 5%, and 1% levels, respectively. Numbers in parentheses are t-statistics.

[a] The terms σ_{i1}, σ_{i0} denote the standard deviations of error terms of conditional nutrient intake equations for label users and nonlabel users, respectively.

[b] The terms $\rho_{i1\mu}$, $\rho_{i0\mu}$ denote the correlation coefficients between probit label use and conditional nutrient intake equations for label users and nonlabel users, respectively.

[c] N indicates the number of observations in the label user and nonlabel user groups.

consume about 0.7% more calories from total fat and 232 milligrams more sodium per day than unemployed nonlabel users.

Some differences are evident in terms of urbanization. For instance, nonlabel users who reside in central cities consume about 1.4% less calories from total fat and 0.06 grams more fiber per day than nonlabel users who reside in suburban areas. On the other hand, label users from nonmetro areas consume about 1.7% more calories from total fat, 0.63% more calories from saturated fat, and about 16.6 milligrams more cholesterol per day than label users from suburban areas. Regional differences also are evident in the results. Label users from the South have greater fiber intakes than those from other regions, while label users from the Midwest have more calories from total fat and sodium intakes than those from the South.

Interestingly, results indicate that for label users, the higher the education level, the lower the intake of saturated fat and cholesterol and the higher the intake of fiber. The effect of education may operate through several vehicles. First, it may improve the efficiency of the production process directly. For example, well-educated consumers may better understand the information contained on the label, and the effect of the nutrient on health. Consequently, they will be better able to adapt their diet behavior in a positive direction. Second, education may provide better access to information. Well-educated consumers may be more aware of effective methods to improve their diets, or they may face lower costs of gathering information. Third, education may be associated with a preference for healthier diets. However, for nonlabel users, education is positively related to saturated fat intake and negatively related to fiber intake.

Diet-health knowledge is negatively related to label users' intake of saturated fat but positively related to label users' intake of fiber. As expected, label users who are on a special diet consume less total fat, saturated fat, cholesterol, and sodium, but more fiber than label users who are not on a special diet. Nonlabel users who are on a special diet also consume less saturated fat than nonlabel users who are not on a special diet, but the magnitude of the effects for saturated fat is smaller than in the equations for label users. Another interesting finding is related to smoking. Label users who are smokers consume about 1.4% more calories from total fat, 0.58% more calories from saturated fat, 15 milligrams more cholesterol, and about 2 grams less fiber per day than label users who are not smokers.

Among label users, those who exercise regularly consume less total fat, saturated fat, and cholesterol than those who do not exercise regularly. However, this result does not hold for nonlabel users. In fact, among nonlabel users, those who exercise regularly consume more total fat, saturated fat, cholesterol, and less fiber than those who do not exercise regularly. These findings on diet-health knowledge, smoking, special diet, and exercise may suggest that these factors, when combined with label use, can have a positive influence on intakes—but not without label use.

Label users who are food stamp participants consume about 0.8% more calories from saturated fat and about 29 milligrams more cholesterol per day than label users who are not food stamp recipients. Nonlabel users who are food stamp participants consume about 434 milligrams more sodium per day than nonlabel users who are not food stamp participants. These findings suggest that despite use of food labels, food stamp participants, on average, still eat foods that are higher in saturated fats and cholesterol than non-food stamp recipients. This finding is consistent with that of Butler and Raymond.

Body mass index is negatively related to fiber intake for label users. Label users who are meal planners consume more fiber than label users who are not meal planners, while meal planners consume less fiber than those who are not meal planners among nonlabel users. As expected, label users who are vegetarians consume less calories from total and saturated fat, and less cholesterol and sodium than label users who are not vegetarian.

Changes in Nutrient Intakes

We can calculate the total effect of label use for label users by comparing the nutrient intakes of the label user $[E(N_{ij1} | I_{ij} = 1)]$ and the expected nutrient intakes of the label user in the absence of labels $[E(N_{ij0} | I_{ij} = 1)]$. Note that under self-selection, those individuals who have a comparative advantage with label use will exploit label information, and therefore will benefit more from it than would a randomly selected individual with the same characteristics (Maddala, p. 261). Thus, for a label user with characteristics $\mathbf{X}_j$ and $\mathbf{Z}_j$, the expected effect in terms of nutrient intakes due to label use is given by

$$E(N_{ij1} | I_{ij} = 1) - E(N_{ij0} | I_{ij} = 1) = (\beta_{i1} - \beta_{i0})'\mathbf{X}_j + (\sigma_{i0\mu} - \sigma_{i1\mu}) \frac{\phi(\hat{\gamma}_i'\mathbf{Z}_j)}{\Phi(\hat{\gamma}_i'\mathbf{Z}_j)}. \tag{11}$$

The means of the expected nutrient intakes before label use and after label use, and their distributions in terms of dietary guidelines are reported in table 5. Based on equation (11), food label use decreases the average daily calories from total fat by 6.90 percentage points, the average daily calories from saturated fat by 2.10 percentage points, the average daily cholesterol intake by 67.60 milligrams, and the average daily sodium intake by 29.58 milligrams. Conversely, food label use increases the average daily fiber intake by 7.51 grams.

Table 5. The Effect of Consumer Label Use on Selected Nutrient Intakes

Description	Before Using Nutrition Label	After Using Nutrition Label	Net Change
Average Nutrient Intakes:			
Calories from Total Fat (%)	42.95	36.05	-6.90
Calories from Saturated Fat (%)	13.95	11.85	-2.10
Cholesterol (milligrams)	321.27	253.67	-67.60
Dietary Fiber (grams)	8.62	16.13	7.51
Sodium (milligrams)	3,205.41	3,175.83	-29.58
Individuals Meeting the Dietary Guidelines for Americans (%):			
Calories from Total Fat:			
30% or less	0.15	2.31	2.16
30–45%	70.56	97.69	27.13
45% or more	29.28	0.00	-29.28
Calories from Saturated Fat:			
10% or less	0.29	8.82	8.53
10–15%	83.21	91.13	7.92
15% or more	16.50	0.05	-16.45
Cholesterol:			
300 milligrams or less	38.54	72.44	33.90
300–450 milligrams	61.01	27.56	-33.45
450 milligrams or more	0.45	0.00	-0.45
Dietary Fiber:			
15 grams or less	95.47	32.54	-62.93
15–25 grams	4.34	67.46	63.12
25 grams or more	0.19	0.00	-0.19
Sodium:			
2,400 milligrams or less	18.05	13.64	-4.41
2,400–4,800 milligrams	80.72	86.36	5.64
4,800 milligrams or more	1.23	0.00	-1.23

The effect of food label use was analyzed in light of the recommendations of the *Dietary Guidelines for Americans* (published cooperatively by the USDA and the U.S. Department of Health and Human Services) for each nutrient intake.[5] The percentage of consumers who meet the guideline of 30% or less calories from total fat is 0.15% before use of the nutrition label. The percentage of consumers who meet the guideline for calories from total fat increases to 2.31% after they use the nutrition label. Label use increases the percentage of consumers meeting the dietary guideline of calories from saturated fat from 0.29% to 8.82%. Food label use has the largest effect on cholesterol intakes, where the percentage of consumers whose cholesterol intakes are 300 milligrams or less increases from 38.54% to 72.44%. Label use increases the percentage of

[5] The dietary guidelines recommend the following: (*a*) choose a diet that provides no more than 30% of calories from fat, (*b*) reduce saturated fat to less than 10% of calories, (*c*) the daily value of diet for cholesterol is 300 milligrams or less, (*d*) the daily value of diet for sodium is 2,400 milligrams or less, and (*e*) the daily value of diet for dietary fiber is 25 grams or more.

consumers whose fiber intakes are between 15–25 grams from 4.34% to 67.46%. In contrast, label use does not have a significant effect on sodium intakes in light of the dietary guidelines.

Concluding Remarks

An endogenous switching regression technique is employed to control for heterogeneity in the label use decision. The results generally indicate that nutritional label use, indeed, improves the intakes by consumers of the selected nutrients examined in this study. In particular, label use tends to reduce individuals' intakes of calories from total and saturated fat, as well as intakes of cholesterol and sodium, and tends to increase intakes of dietary fiber. These findings provide evidence of the benefits of label use and are of great importance in terms of public policy because improved diets can provide society with dramatic health benefits resulting in life-year gains and medical care cost savings (Zarkin et al.; Frazao).

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