FOOD EXPENDITURE AND NUTRIENT AVAILABILITY IN ELDERLY HOUSEHOLDS

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INTRODUCTION

The purpose of this paper is to develop a simultaneous equation model for estimating food expenditure and availability of selected nutrients for elderly households in the United States. The model will be used to evaluate the impacts of the exogenous variables, such as the Food Stamp Program, on the nutritional well-being of these elderly.

In recent years, a number of studies have explored the problems of food intakes and of nutrient levels by elderly individuals (Munro; O'Hanlon and Kohrs; Weiner). A few studies have dealt on the topic in terms of elderly households (Rizek and Peterkin; Ingwersen and Hama).

Other studies have explored nutrient consumption and impacts of socioeconomic factors (Adrian and Daniel; Allen and Gadsen; Davis; Basiotis et al.). These studies do not deal specifically with the elderly segment of the population. However, they provide important conceptual and statistical frameworks for analyzing data from large-scale food consumption surveys and relating nutrient levels of food consumed to socioeconomic factors. The results obtained by Davis provide strong evidence suggesting interaction between socioeconomic factors and income-food expenditure relationship, which in turn, affect household nutritional consumption. Allen and Gadsen, as well as Basiotis et al., used data from the 1977-78 supplemental Nationwide Food Consumption Survey of low-income households. This sample consisted of households who were eligible for the Food Stamp Program at the time of the screening.

Allen and Gadsen used multiple regression analysis to estimate the relationships between nutrient levels and household characteristics and to obtain the coefficients for calculating the marginal propensities to consume and the nutrient consumption elasticities. Alternative functional forms were tested and the linear form apparently provided the best statistical fit.

Basiotis et al. used the low-income survey to analyze nutrient consumption patterns by a system of recursive simultaneous equations. Specifically, their model consists of one structural equation for food costs and eight equations for explaining the availability of eight diet components (food energy, protein, calcium, iron, riboflavin, thiamin, vitamin C, and vitamin A). It was a recursive system because in their model food costs affected the nutrient availability but not vise versa. They reported only the estimated parameters in the reduced form equations.

The model developed in this paper represents an extension of the work by Basiotis et al. Specifically, we hypothesize that food expenditure and demand for nutrients are simultaneously determined. This joint decision behavior is particularly appropriate for the elderly households because of their knowledge and, possibly, greater concern about their health and nutritional needs than households in other age groups.

MEASUREMENT OF NUTRIENT LEVEL

In the household phase of the Nationwide Food Consumption Survey 1977-78 and the supplemental surveys, interviews were conducted with the person considered to be most responsible for food planning and preparation in the household. Trained interviewers used an aided-recall questionnaire to obtain the kind (such as ground beef and skim milk), the form (such as fresh, canned, frozen, or dried), the quantity, and the cost, if purchased, of each food and beverage used in the household during the seven days before the interview. Money value for nonpurchased food was imputed after data collection. "Food used" refers to all food that disappeared from household food supplies during the 7-day period including food eaten by household members and guests, as well as the food discarded in the kitchen and at the table and leftovers fed to pets.

In this survey, dietary levels were determined by the amount of food energy and 14 specified nutrients in the food reported by households. The quantities of food were converted to nutritive values of food, and the values for each nutrient in all items were summed. The number of nutrition units was then computed for each household according to the sex, age, and number of meals eaten by the household and guests during the 7-day survey period. For normalization, a nutrition unit is standardized as a male 23-50 years old equivalent. Then, the total amount of nutrients available to the household were divided by the standardized nutrition units. The 1974 Recommended Dietary Allowances (RDA) developed by the National Academy of Sciences were the standards used to assess the dietary level of the household food. Technically, household diets may not have met the RDA because how the food was actually divided among its members is not known. However, if the household did not meet the RDA, at least one member must not have met the recommendations (see Human Nutrition Information Service for details).

Since the number of nutrients is large, it is essential to determine which nutrients are more critical than others in households' decisions on food expenditure. For this purpose, the nutritive value of household food was compared with the recommended amounts of nutrients. Table 1 shows the percentages of households in the sample (to be discussed in detail later) meeting the RDA for food energy and nutrients. Note that RDA are established for 11 of the 14 nutrients studied. These percentages were calculated for all households, and also for the households meeting the RDA for seven selected key nutrients and those not meeting the RDA, separately.

These figures indicate that, for elderly households, the percentages of households meeting RDA are lower for food energy, calcium, magnesium, and vitamin B_6 than other nutrients. For the subgroup of the households not meeting RDA for the seven key nutrients, we found that food energy, calcium, magnesium, and vitamin B_6 have very low percentages. Based on this analysis, we considered food energy, calcium, magnesium, and vitamin B_6 as critical nutrient determinants for total food expenditure. We added iron as another nutrient factor, because iron is perceived as one of the critical nutrients for the elderly.

MODEL SPECIFICATION

One of the most important purposes of food consumption is to satisfy the nutritional requirement. In fact, one may view that the household derives utility from the nutritional content of food. For studying demand for food, one often assumes a separable household utility function and a two-stage budgeting process (Deaton and Muelbauer). With such an assumption, the household in the first stage determines the portion of its income for food, and then, in the second stage, determines the quantities of various food items to purchase. These decision-making processes are usually assumed in a recursive

Table 1. Percentages of Households Meeting the RDA[a]

Nutrient	All Households (%)	Portion of Households[b]: Meeting RDA for Seven Key Nutrients[c] (%)	Portion of Households[b]: Not Meeting RDA for Seven Key Nutrients[d] (%)
Food Energy	74	94	47
Protein	94	100	87
Calcium	65	100	19
Iron	92	100	82
Magnesium	72	93	43
Phosphorus	95	100	89
Vitamin A	83	100	61
Thiamin	86	100	66
Riboflavin	94	100	86
Vitamin B_6	57	79	26
Vitamin B_{12}	77	92	56
Ascorbic Acid	93	100	83

[a] Sample size is 1,454 for all households.

[b] Seven key nutrients are protein, calcium, iron, vitamin A, thiamin, riboflavin and ascorbic acid.

[c] Sample size is 829.

[d] Sample size is 625.

fashion that the decisions on what food items to purchase would not affect the first-stage budget allocation for food.

For the purpose of this study, it is assumed that the objective in the second-stage utility maximization is to determine the quantities of various nutrients, which are derived, of course, from the various food items consumed. Furthermore, the quantities of nutrients affect the budget allocation in the first stage. This assumption may appear to be inconsistent with the two-stage budgeting hypotheses in the demand theory. However, in our view, it is appropriate to expect that the household, especially the elderly household, takes into consideration the nutritional needs in allocating the food budget. In fact, this assumption does not violate the basic economic theory. We may incorporate the energy and nutrient requirements as endogenous factors for the first-stage utility maximization. Consequently, the resulting structural equations from both stages of budgeting process can be considered appropriately in a simultaneous equation framework.

The present model consists of a total food expenditure equation and a set of five nutrient demand equations. Since this is a simultaneous equation system, the identification conditions need to be satisfied. The order condition for identification requires that the number of exogenous variables excluded from the equation must at least equal the number of endogenous variables included in the right-hand side of the equation less one. There is no identification problem for all the nutrient equations, because the income variable (exogenous) is present only in the food expenditure equation and there is only one endogenous variable included in the right-hand side of the nutrient equations. For the total food expenditure equation, the identification requires that at least four exogenous variables have to be excluded. The candidate variables for exclusion are the socioeconomic and demographic variables.

Theoretically, all social and demographic variables may affect both food expenditure and nutrient demands. In order to satisfy the identification conditions, we conducted a wide range of preliminary estimation using different combination of exogenous variables. These results show that the race, tenancy, and household head characteristic variables are consistently not significant in the food expenditure equation. Furthermore, the estimates of the coefficients of other structural variables (especially the income variable) are not sensitive to the inclusion or exclusion of these variables. Therefore, the exclusion of these variables in the food expenditure equation should not be subject to any significant pretest bias.

Specifically, the finally selected structural equations for the aggregate demand for food and its energy and nutrient components are expressed as:

$$M = f\,(Q_1, Q_2, Q_3, Q_4, Q_5, Y, S, FS, U, R) \qquad (1)$$

$$Q_i = g_i\,(M, S, FS, U, R, RC, T, H) \qquad (2)$$

$$i = 1, \ldots, 5$$

where

Q = Nutritive value per standard nutrition unit for specified nutrients; and

Q_1 = Food energy (Calories),

Q_2 = Calcium (milligrams),

Q_3 = Iron (milligrams),

Q_4 = Magnesium (milligrams),

Q_5 = Vitamin B_6 (milligrams)

M = Money value of food at home per person in a week equivalent to total food expenditure (dollars),

S = Household size in 21-meal-at-home equivalent person,

Y = Per-capita income before taxes for the previous year (dollars),

U = Dummy variables for urbanization (U_1 = central city, U_2 = suburban, U_3 = nometropolitan),

R = Dummy variables for region (R_1 = Northeast, R_2 = North Central, R_3 = South, R_4 = West),

FS = Dummy variable for Food Stamp Program (1 = participants, 0 = nonparticipants),

RC = Dummy variable for race (1 = white, 0 = nonwhite),

T = Dummy variable for tenancy (1 = owned home, 0 = not owned home),

H = Dummy variables for type of household head (H_1 = male and female head, H_2 = female head only, H_3 = male head only).

The selection of explanatory variables follows closely the rationale used by Basiotis et al. Specifically, the food expenditure is determined by such typical exogenous factors as household income and household size. The dummy variables for urbanization and region are used to capture the impacts of food and nonfood prices on food demand. We did not have data for number of family members in various age-sex groups used by Basiotis et al. In our elderly household sample, 42 and 43 percent of the households contained one and two members, respectively. For the nutrient demand equations, the dummy variables for race, tenancy, and household head are included as additional exogenous variables. (Household income is not an explanatory variable for nutrient demand). Note also that the Food Stamp Program participation is assumed to have impacts on both food expenditure and demand for nutrients.

Note that in this study, food expenditure refers to the money value of food used by the household food supply during the 7-day interview period; that is, it is the sum of the expenditures of purchased food and the imputed value of nonpurchased food. The nutritive value for various nutrients is measured in terms of the amount of nutrients available per adult male equivalent person.

DATA SOURCE

The data for this study were obtained from the elderly supplemental survey to the USDA Nationwide Food Consumption Survey 1977-78. Information was from 2,066 households that contained one or more persons 65 years and older during spring and summer of 1977. However, only 1,454 households were usable for this study because the remaining households had missing values--primarily income data. Information from the elderly sample of the Nationwide Food Consumption Survey 1977-78 indicates that 57 percent of those households met the Recommended Dietary Allowances for all seven specified key nutrients (protein, calcium, iron, vitamin A, riboflavin, thiamin, ascorbic acid) and 43 percent did not meet the RDA for at least one of the seven.

One concern in using only a subset of survey data is that it may represent a biased sample, because 612 households with missing values were eliminated. Therefore, we examined carefully the means and distributions of many variables before and after the elimination. We found that these descriptive statistics are generally similar, with some difference occurring in the money value of food at home per person and the household size. Specifically, the money values of food at home per person are $16.85 for the total sample of 2,066 and $17.48 for the subsample of 1,454; the household size per person was 1.84 for the total sample and 1.77 for the subsample. No other apparent difference was evident from the partitioning out of those households with missing values.

REGRESSION RESULTS

The structural parameters for the six-equation system expressed in Eqs. (1) and (2) are estimated by two-stage least squares (2SLS) and three-stage least squares (3SLS). The coefficient estimates are very similar between these two estimation methods. The estimated standard errors are generally smaller with 3SLS because it is a more efficient estimator. Table 2 shows the coefficients and asymptotic t-ratios estimated by 3SLS. (R^2 was obtained from 2SLS).

The regression results are generally supportive of the underlying model specification. R^2's are low but they are typical for this type of cross-sectional study (the weighted R^2 for the system is 0.11). More attention should be paid to the significance of the estimated coefficients. The major statistical results are summarized as follow.

The regression results for the food expenditure equation show that iron and magnesium are the two nutrients which have significant positive impacts on total food expenditure for elderly households. Food energy, calcium, and vitamin B_6 are shown to have negative impacts on food expenditure, but their estimates are not statistically significant. We noted that the correlation coefficients among the food energy and nutrient variables are relatively high (0.6 to 0.8). There may be a more appropriate alternative functional form for expressing the relationship between food expenditure and nutrient availability in the model. We explored one possibility: to adopt an alternative measure of nutritive value per 1,000 Calories and use the ratios of nutrients to food energy in the expenditure equation, but the results were not better than those presented in Table 2. The statistical significance of the nutrient variables in the food expenditure equation strongly support the simultaneity specification.

Table 2. Regression Results Using the Three-Stage Least Squares Estimators[a]

Variables	Food Expenditure (M)	Value Per Nutrition Unit: Food Energy (Q_1)	Calcium (Q_2)	Iron (Q_3)	Magnesium (Q_4)	Vitamin B_6 (Q_5)
Endogenous						
M		57.78 (2.67)	12.77 (1.69)	0.59 (5.91)	12.57 (4.91)	0.07 (6.08)
Q_1	-0.0011 (-1.25)					
Q_2	-0.003 (-1.53)					
Q_3	1.05 (3.70)					
Q_4	0.03 (3.20)					
Q_5	-4.53 (-1.40)					
Exogenous						
Y	0.00023 (4.69)					
S	0.64 (2.01)	-128.23 (-2.94)	-39.86 (-2.62)	-1.03 (-5.19)	-9.49 (-1.85)	-0.02 (-0.67)
FS	-1.49 (-2.66)	354.26 (3.23)	142.37 (3.73)	2.34 (4.63)	30.74 (2.36)	0.14 (2.27)
U_1	-0.23 (-0.60)	36.18 (0.37)	13.02 (0.39)	0.69 (1.55)	5.29 (0.46)	0.08 (1.49)
U_3	-1.87 (-3.43)	139.93 (1.44)	23.89 (0.70)	1.00 (2.22)	22.96 (1.97)	-0.0002 (-0.004)
R_1	2.24 (3.80)	-100.55 (-0.74)	42.85 (0.91)	-1.91 (-3.05)	-11.35 (-0.70)	-0.29 (-3.75)
R_3	-0.92 (-1.64)	293.64 (2.94)	141.22 (4.06)	0.76 (1.63)	30.91 (2.59)	-0.01 (-0.17)
R_4	-0.01 (-0.01)	-43.70 (-0.35)	134.87 (3.11)	-0.57 (-0.98)	22.23 (1.49)	-0.08 (-1.11)
RC		-242.40 (-2.32)	45.99 (1.26)	-1.52 (-3.27)	16.15 (1.35)	-0.16 (-2.69)
T		160.68 (1.89)	45.17 (1.53)	0.71 (1.98)	8.42 (0.91)	0.14 (2.86)
H_1		-379.09 (-4.22)	-8.00 (-0.26)	0.70 (1.75)	-34.55 (-3.35)	-0.06 (-1.17)
H_3		-275.26 (-1.81)	199.88 (3.77)	3.30 (4.74)	-35.58 (-1.98)	0.13 (1.51)
Constant	-2.85 (-1.25)	3203.09 (7.76)	708.79 (4.93)	11.26 (5.99)	246.17 (5.09)	1.15 (4.97)
R^2	0.21	0.09	0.07	0.18	0.07	0.10

[a] The figures in parentheses are estimated asymptotic t-ratio.

As expected, income is shown to be a significant determinant for the total food expenditure. However, the estimated income elasticity is only 0.05, which is lower than that estimated by Basiotis et al. for low-income households.

The food expenditure variable is found to be significant in all the food energy and nutrients equations. The food expenditure elasticities computed at the sample means are 0.26 for food energy, 0.21 for calcium, 0.50 for iron, 0.45 for magnesium, and 0.52 for vitamin B_6. The results indicate that a higher food expenditure would result in higher food energy and nutritional values. These results also reinforce the appropriateness of the simultaneous equations model specification.

One of the most significant results is that the estimated coefficients for the food stamp participation are all statistically significant. The results indicate that the Food Stamp Program contributed significantly to the increases in nutritional values of food consumption for the elderly households. Furthermore, food stamp participation has a negative impact on food expenditures, holding the nutrients levels constant. In fact, the impact of the Food Stamp Program can only be appropriately evaluated in the reduced form equations which can be derived easily from the structural equations. In the reduced form equation, the Food Stamp Program has a strong positive impact on total food expenditure. Specifically, the computed coefficient of food stamp in the reduced form food expenditure equation is 0.64. This indicates that the elderly households on food stamps spent 64 cents more per person in a week for food than the nonparticipant households--with the average value per person for the total sample at $17.48.

The estimates of other regional and demographic variables also offer interesting insights into the aggregate food demand and nutrient demands for elderly households. For example, the household size is shown to have positive impact on total food expenditure and negative impacts on demand for nutrients. The results also show that households owning their homes had higher nutrient consumption. It is not clear why the white households had lower nutrient level for food energy, iron, and vitamin B_6, as the estimated coefficients for race indicate. These results may reflect the consumpton patterns of the Blacks, who tend to eat more iron-rich foods as dark-green leafy vegetables. On the other hand, it is possible that there are interaction effects among these exogenous social and demographic variables in the model. A further investigation of these interactions would be useful in order to improve the specification of the model.

CONCLUSION

Basic to improving health and well-being of the elderly is to provide better measurements on the variation in food expenditure and nutrient availability and their relationship to socioeconomic and demographic factors. Impacts of socioeconomic characteristics of elderly households are evident on the food expenditure and nutrient levels. The per-capita food expenditure at home is greatly influenced by income. In turn, the food expenditure at home has significant impacts on consumption of food energy and selected important nutrients--calcium, iron, magnesium, and vitamin B_6. That is, an increased money allocation for food by elderly households contributes to a more nutritious food consumption. The simultaneous equation model is shown to be an appropriate framework for analyzing food expenditure and nutrient availability.

The results also suggest that the Food Stamp Program has a significant impact on nutrient levels of elderly households. For those elderly households participating in the Food Stamp Program, the nutrient levels of the key nutrients are also higher than the levels for nonparticipants.

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