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INCORPORATING SUBSISTENCE INTO A PROBIT ANALYSIS OF HOUSEHOLD NUTRITION LEVELS

Cristanna M. Cook, David B. Eastwood, and Ty Cheng

Abstract

Previous nutrient demand and consumption analyses show that several economic and sociodemographic variables are often associated with intakes. However, most of the literature does not account for differences among individuals within households. This study reviewed possible definitions of nutrient differences with respect to nutritional needs. Nutrient levels defined by the Thrifty Food Plan were used as subsistence levels for households in the 1977-78 Nationwide Food Consumption Survey. Probit analysis showed that the usual variables found related to nutrient intakes did not differentiate among subsistence groups. Household life cycle and working female heads influenced whether the household was under its requirement level.

Key words: characteristics model, demand, food, nutrients, probit regression, subsistence

Starting with Malthus' (1798) iron law of wages, the concept of subsistence has been recognized as a key component of consumer behavior. Traditional demand analysis has explicitly incorporated subsistence into the utility function starting with the work of Klein-Ruben (1947) and the extended linear expenditure system (e.g., Eastwood and Craven 1981) and into the almost ideal demand system (e.g., Blanciforti and Green 1983).

The characteristics model of food consumption, as developed and extended by Eastwood, Brooker, and Terry (1986), Hager (1985), and LaFrance (1985), explicitly introduces food nutrients into the decision-making process. Solution of the model leads to hedonic price equations and nutrient demand equations. The former can be thought of as relating the market price of a food to its nutritional composition. The latter refers to amounts of a nutrient consumed as a function of socioeconomic variables. However, no research using these models has incorporated subsistence.

Surveys of dietary status have consistently found that many households continue to have poor diets even though they are well above poverty levels. Viewed from a dietary perspective, consumers need minimum amounts of nutrients in order to survive, let alone have healthier lives, *ceteris paribus*. This suggests that the arguments of the utility function ought to accommodate subsistence levels of nutrients. To the extent that this is a better approximation of consumer decision-making, three implications follow directly. First, the characteristics model needs to be reassessed. Second, the nutrient demand equations could be using the wrong dependent variable. Third, public policies directed toward enhancing dietary status may need to be re-evaluated in order to reach more households that are at risk.

The initial problem in this study was to define measurable subsistence levels for nutrients. There were several methods for doing this. Each was evaluated in terms of its potential as an empirical measure. One was selected as the best alternative. Based upon these levels, consumer units' nutrition levels were estimated as above or below respective subsistence levels. Then the roles of socioeconomic variables as determinants of the probability of being above or below subsistence were estimated.

MEASURES OF NUTRITIONAL STATUS

Perhaps the best known measure of nutritional adequacy is the recommended dietary allowances (RDA), in which nutritional requirements are determined for persons in specific age-sex categories. These levels are for healthy individuals, and they contain a margin of error to ensure that an individual's nutritional needs are satisfied. As noted by the National Academy of Science (1986), RDAs can overestimate degrees of dietary inadequacy. Other problems, particularly of alternative definitions of adequacy, have been identified by the National Academy of Sciences (1980).

The probability approach attempts to define a subsistence level that matches requirements with actual physiological needs of individuals. Based upon

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these needs, the methodology attempts to approximate the distribution of needs for individuals. Once the requirement distribution is found, the actual intakes can be compared to it, and the probabilities of the actual intakes being less than the requirement level can be stated. A difficulty with the application of this method is that requirement distributions have been found only for a very restricted segment of the population (Battese et al.).

Prato and Bagali develop a definition of subsistence by considering the least cost bundle of foods to obtain a constant level of nutrition received by a household. Their approach does not consider consumer demand for nutrients nor does it incorporate any standard nutrition level, such as the RDA. In addition, the empirical analysis was only for one food group, although consumers can obtain nutrients from a variety of foods.

The concept of the 21-meal nutritionally equivalent person (21-MNEP) could be used to define subsistence. It is based upon a representative consumer eating all meals at home during a week compared to the RDA standard. This method, as developed by Smallwood and Blaylock (1981), can be used to incorporate subsistence. Hama and Chern (1988) used this approach to create an explanatory variable in Engel functions and nutrient demand equations. A problem with this framework is that the use of food to account for the RDAs may not be based upon the consumer's actual purchases. Another problem is that variations in nutritional needs based upon household composition are not included.

A switching regression was used by Akin, Guilkey, and Popkin (1983) to determine basic need levels for 14 nutrients. Family income relative to the poverty level was the switching variable. Unfortunately, this indicator measure did not allow for nutritional needs based upon the age-sex composition of the household.

The Thrifty Food Plan (TFP) has 11 age-sex categories, and its dietary goals are equal to or greater than the RDAs for nine of them. Average food energy levels are used for each age-sex class designation. These averages are based upon activity levels for moderately active individuals within each age-sex category. Average intakes—the midpoints of the RDA ranges by age-sex category—have been used to assess dietary status in the nutrition literature. The TFP specifies nutritional diets at specified cost levels for adults and children by age and sex (Cleveland et al.). These levels are based upon a methodology that attempts to account for consumer preferences, limited income, market prices, and nutritional requirements. Thus, TFP nutrient levels are based on consumer decision making as well as nutrition, so they are more suitable to use in analysis of nutrient demand based upon consumers' food choices. Therefore, for each nutrient, 11 age-sex subsistence levels were generated using the TFP. Then, for a given household, its consumption of a nutrient was compared to the TFPs. Nutrient aggregates chosen for this analysis reflected the trade-offs among several factors: nutrient measures available in the household food consumption data set and in the TFP, dietary/nutritional considerations, and previous research.

Terry and Morgan et al. have shown that estimation of nutrient demand and/or hedonic equations explain more of the variations in the dependent variables when dietary components are aggregated into related groups (e.g. minerals). Other investigations (Federal Trade Commission; Morgan) have found that individuals evaluate foods in terms of key dietary factors or lump nutrients into aggregates. The level of knowledge necessary to understand the function of each nutrient and evaluate its impact and necessary level would require high information access cost. Thus, consumers are trying to reduce the information they need to process by grouping nutrients into broader categories.

The aggregated nutrients used in this study were minerals (calcium, iron, and magnesium), B vitamins (niacin, riboflavin, thiamin, B6, and B12), food energy (a combination of carbohydrates, fats, and protein), vitamin C, and vitamin A. Vitamin A was considered separately because it was measured in International Units and because consumers were assumed to have heard enough about vitamin A to understand its importance in the diet. All other nutrients were measured in milligrams or converted to milligrams except for food energy, which was measured in kilocalories. Vitamin C was left as a category by itself because consumers appear to perceive Vitamin C as separate from other nutrients. All other nutrients were aggregated into minerals, B complex vitamins, and food energy.

Data on household food consumption and composition were from the 1977-78 Nationwide Food Consumption Survey because these were the most recent. The spring quarter of the survey was used to keep the sample size manageable. Use of the household as the unit of analysis was based upon the assumption that dependent members of a consuming unit do not have the resources to make extensive independent purchase and decisions. Information included the kind, form, and quantities of food used during a seven-day period. Data were also gathered on home food production, the number of meals eaten at home and away, and guest meals. Nutritional contents of foods were also part of the data. The 1975

TFP was used to define subsistence because it was developed just prior to the time of the survey.

Only households that purchased at least 20 food items were included. This was to eliminate households that acquired substantial portions of food away from home. The assumption was that those households that did not purchase at least 20 food items did not reflect typical shoppers for food that was to be consumed at home. Consequently, the results presented below pertain to those households that purchased 20 or more food items per week. Missing, incorrect, or inappropriate data further reduced the sample to 2,004 households.

VARIABLES AFFECTING NUTRIENT CONSUMPTION

Empirical work has shown various socioeconomic and demographic variables to be significant determinants of nutrient consumption (e.g., Adrian and Daniel; Akin, Guilkey, and Popkin; Basiotis et al.; Blanciforti, Green, and Lane; Capps and Love; Chavas and Keplinger; Davis et al.; Davis and Neenan; Eastwood, Brooker, and Terry; Pitt; Searce and Jensen; and Shafer and Keith). Income and the composition of the household are significant variables. Household composition includes age, sex, size, and race. Age, sex, and household size were not included explicitly in this study because age and sex variables were used to define nutrient subsistence categories and because an analysis of variance showed no statistical differences between subsistence groups and size of household. Location of the household with respect to urban areas and regions has also been found to be significant. Meal planners' education, stage of the life cycle, and participation in the food stamp program have been found to be significant as well. Employment of the head of the household is another significant variable. Most nutrient demand studies show income and/or expenditure to be positively related to the demand for some nutrients. The number of meals eaten from home food supplies adjusted for number of meals eaten out was also included.

THE PROBABILITY OF ADEQUATE NUTRIENT LEVELS

Incorporation of subsistence into the characteristics framework leads to the realization that the appropriate measures of nutrient intakes should be the amounts in excess of subsistence levels. Given the previous research, an important issue is the role of socioeconomic variables in determining the probabilities of households being above or below these subsistence levels. A probit model was used to estimate the probabilities. This approach has the potential of providing better information about households that are more likely to be at dietary risk.

The five nutrient aggregates described above were used. Based on the composition of each household in the sample, TFP subsistence levels were calculated and compared to actual nutrient consumption. A household was placed into one of two categories for each nutrient according to whether it was above or below its subsistence level. The approach assumed that households view these nutrients independently. This is consistent with the aggregation of nutrients into broad groups and with the notion that no tradeoffs among aggregates with respect to dietary needs occur. A similar assumption was also made in the probability approach (outlined above) of defining adequacy. Furthermore, independence conforms to households being more concerned with and/or aware of some nutrients and not others. On the other hand, a household that is concerned only with a specific nutrient within an aggregate could be misclassified. Such households were considered to be a very small part of the sample given the literature on consumer awareness and less concern with specific nutrients in 1977.

Partial support for independence was found through the following procedure. Households were given 0,1 values for each of the five nutrients based on their being above or below subsistence levels. Spearman correlations were calculated. All were less than .5, except for food energy and minerals (.6). High positive (negative) correlations would have suggested that households that were above on one nutrient tended to be above (below) on the other.

RESULTS

Table 1 presents the socioeconomic measures used in the probit regression analysis. They reflect the existing literature and the measures available within the survey. The Appendix presents means and frequencies for these variables by nutrient. Table 2 gives the probit regression results. The chi-square levels led to inferences of significant overall relationships in all equations. Pseudo R^2s were calculated as $1-(L_1/L_2)^{2/n}$, where L_1 is the maximum of the likelihood function for the constant only, L_2 is the maximum with respect to all parameters, and n is sample size (Maddala). These values are reasonably high for cross-section household-level data.

In addition to the estimated coefficients and standard errors, the estimated effects of unit changes in each independent variable on the probabilities are shown. These are provided instead of elasticities due to the presence of dummy variables. The changes in probabilities were calculated given the mean values

Table 1. Variables Included in Probit Regression

Variable	Description
Bonus	value of food stamps received above purchase value of food stamps (1976 dollars);
Urban	1 if city or suburban residence, 0 otherwise;
Noeast	1 if northeastern region, 0 otherwise;
Nocent	1 if northcentral region, 0 otherwise;
South	1 if southern region, 0 otherwise;
Lc1[a]	1 if the female head was present and the average age of the children was less than 6 years, 0 otherwise;
Lc2[a]	1 if the female head was present and the average age of the children was equal to or greater than 6 years but less than 19 years, 0 otherwise;
Lc3[a]	1 if the female head was present and the average age of the children was equal to or greater than 12 years but less than 19 years, 0 otherwise;
Lc4[a]	1 if the female head was absent, 0 otherwise;
Nmeal	the number of meals eaten away from home during the week;
Edmpl	1 if meal planner had at least some college, 0 otherwise;
White	1 if household was white, 0 otherwise;
Income	family disposable income (1976 dollars); and
Fwork	1 if female working head present, 0 otherwise.

[a] Lc1, Lc2, Lc3, and Lc4 taken together define the life cycle stage of the household.

of the continuous independent variables and zero values of the other dummy variables.

Income had a significant impact in determining whether the household acquired a sufficient level of vitamin C, but it was not significant in the other equations. This is consistent with Peterkin, Kerr, and Hama (1982) who found that meeting recommended dietary allowances was not related to levels of food expenditures. The bonus value of food stamps was only significant in the food energy equation, and in this case participants were less likely to be above their household subsistence levels. Taken together, these results were consistent with the notion that food is relatively inexpensive in this country. The availability of food stamps and/or adequate income enables most households to consume minimum nutrition levels. However, income and food stamps do not distinguish between households that consume over or under their defined subsistence levels. More importantly, the results showed that economic variables in and of themselves did not guarantee adequate household nutrient consumption.

An employed female in the household lowered the probability of the household being above subsistence in all equations. This is likely due to two factors. First, single-parent households headed by a female were more likely to be below the poverty level and, therefore, have poorer diets. The second pertains to households with at least two adults. Because income was an insignificant variable in all except one equation, it was inferred that income has a negligible effect on nutritional status. Consequently, the negative effect of the employed female is not through additional income, but rather, through her absence from the household due to working.[1]

This study supports the view that additional family income generated by working women does not necessarily lead to the consumption of nutrients at home that would provide all the requirements for all family members. Since food-at-home was used to analyze household nutrient adequacy, it could be that households with working women acquire a more adequate diet via food-away-from-home purchases (McCracken; Kinsey).

The net meals variable was used to capture the effects of reduced-at-home nutrient consumption by household members who consumed meals away from home. It was not significant in any nutrient equation. This suggests that the probability of being above or below subsistence is not affected by the number of meals at home.

Region and urban location had little effect on whether a household met it subsistence level. Southern, Northeastern, and North Central households had a higher probability of being under their defined subsistence levels for food energy. These location variables were not significant in any other equation.

[1] This interpretation was suggested by a reviewer.

Table 2. Maximum Likelihood Estimates of the Probit Regressions[a] (Standard Errors in Parentheses)

	Minerals		Food Energy		Vitamin C		Vitamin B		Vitamin A	
Variable	Coefficient	Change[b]	Coefficient	Change[b]	Coefficient	Change[b]	Coefficient	Change[b]	Coefficient	Change[b]
Intercept	+.179916 (.1296)		+.987185* (.130800)		+.771382* (.127600)		-.260822 (.146500)		+.593707* (.121900)	
Income	-.000003 (.000004)	-.000002	-.000000 (.000004)	-.000000	+.000016* (.000004)	+.000001	-.000002 (.00004)	-.000001	+.000002 (.000003)	+.000001
Bonus	-.001369 (.001577)	-.000694	-.004257* (.001570)	-.002396	-.001379 (.013930)	-.000693	-.000040 (.001836)	-.081804	-.000987 (.001405)	-.000557
F Work	-.141826** (.063500)	-.069007	-.225951* (.063880)	-.127283	-.266636* (.06342)	-.142439	-.399864* (.076420)	-.095909	-.292810* (.060570)	-.162153
N Meal	-.001713 (.002034)	-.000867	+.000354 (.002028)	+.000199	-.000188 (.001977)	-.000095	-.000529 (.002369)	-.000166	-.001728 (.001908)	-.000943
No. East	-.093150 (.092080)	-.291734	-.239004** (.093050)	-.134825	-.059905 (.091430)	-.030574	-.176111 (.108400)	-.005532	-.029563 (.087560)	-.016674
No. Central	-.123850 (.092550)	-.067267	-.201266** (.093230)	-.113394	+.034686 (.091510)	+.016872	-.020197 (.106400)	-.006318	-.039736 (.087390)	-.022405
South	-.145951 (.091030)	-.078769	-.237656** (.092130)	-.134065	-.0815658 (.089460)	-.041984	-.027595 (.105000)	-.008563	-.051301 (.086100)	-.028911
Urban	+.057108 (.066890)	+.029170	-.057465 (.067650)	-.032376	-.070887 (.066480)	-.036028	-.045846 (.077490)	-.014147	-.046382 (.063600)	-.022908
EdMPL	+.037883 (.069450)	+.019415	-.189382** (.069350)	-.106660	+.115397 (.069360)	+.0556695	-.128346 (.084380)	-.036430	+.144995** (.066040)	+.081597
White	+.304021* (.093570)	+.156981	+.001742 (.091550)	+.000980	-.063277 (.087720)	-.0319526	-.154833 (.105700)	-.047396	-.200624** (.085920)	-.113003
Lc1	-1.65737* (.113100)	-.260345	-1.73700* (.104000)	-.506632	-1.116870* (.088350)	-.587435	-1.269930* (.159100)	-.110377	-1.116470* (.092950)	-.447540
Lc2	-1.30968* (.10130)	-.337687	-1.29594* (.093650)	-.569287*	-.541054* (.088730)	-.299138	-1.064480* (.141200)	-.134786	-.695555* (.087880)	-.361396
Lc3	-.464793* (.083570)	-.241431	-.373986* (.084470)	-.206200	-.101681 (.089680)	-.046725	-.382553* (.101800)	-.124791	-.275679* (.082690)	-.155520
Lc4	-.739929** (.230400)	-.330907	-.720534** (.222500)	-.402989	-.168280 (.239600)	-.080521	-.904620** (.348900)	-.1490870	-.466277** (.224800)	-.258998
Chi Square	453.55*		521.32*		205.3*		212.02*		208.45*	
Pseudo R^2	.26 upper limit = .72		.30 upper limit = .72		.13 upper limit = .69		.16 upper limit = .57		.13 upper limit = .75	

*Statistically significant at 1 percent level.
**Statistically significant at 5 percent level.

[a] All equations were significant at the .001 level when using:
Chi Square = -2 log (L2/L1),
L2 = likelihood obtained from the model in which the coefficients are hypothesized = 0,
L1 = likelihood from the estimated equations, and
Deg. of freedom = number of coefficients.

[b] Parameter estimate times the value of the variability density function.

As the education of the meal planner increased, there was a greater probability for the household to be less likely to consume food energy and more likely to consume foods containing vitamin A. This variable was not significant in over and under subsistence equations for minerals, B vitamins, or vitamin C. It supports the view, presented in the nutrition literature, that education *per se* has inconsistent effects on nutritional well-being (Lerner and Kivett; Popkin). However, this result is also supportive of the view that better education is related to reduced caloric intake and increased consumption of more nutritious foods and foods with vitamin A.

Being white did not seem to affect the chance that a household would be above defined subsistence levels except for minerals and vitamin A. Being white significantly decreased the probability of having the defined subsistence level for vitamin A.

Household life cycle stages (Lc1 — Lc4) were significant in influencing whether the household was

over or under its defined subsistence level. The particular life cycle stages were selected to reflect the categories used by Blanciforti, Green, and Lane. They found that households with children tended to consume less nutritious foods. As the age of children in the household increased, they found a tendency to spend more on less nutritious foods. Older households without children spent proportionally more income on more nutritious foods.

The present analysis showed a different result. As the age of the child increased (>12-19), there was a lower probability (where significant) of the household being under the defined subsistence levels. This may reflect a lack of time for at-home food preparation in households that have young children. It may also indicate that the responsible female in the household may be neglecting her own nutritional well-being. This is possible because being under the household subsistence level means that at least one member of the household has not met his/her defined subsistence level. The specific member(s) of the household who is(are) consuming below appropriate levels(s) cannot be identified in the present analysis.

CONCLUSIONS

This study incorporated subsistence into the analysis of household diets. An empirical measure of subsistence was obtained via the TFP. Actual household nutrient levels were compared to subsistence levels based on purchasing at least 20 food items for at-home consumption. Socioeconomic variables were used to estimate the probabilities of households' being above or below subsistence levels. Probit regressions were used to estimate the probabilities that household characteristics affected the likelihood of households' purchasing at least 20 food items being above or below subsistence. Given the use of household-level data, the overall fits were reasonably high and led to inferences of significant overall fits. The significant coefficients indicated those household characteristics that affected dietary status. Of the variables that have been shown to influence nutrient demands, after incorporating subsistence levels, the two most important variables were family life cycle and having a working female head of household. Households with younger children (under 12 years of age) and households with a female head working were less likely to meet household nutrient requirements.

The results suggest that socioeconomic characteristics affect the probability of households that purchased 20 food items or more per week being above or below subsistence. An important implication is that nutrition education efforts should be intensified for families with younger children and in families with working female household heads. These households are also more likely to be affected positively by food transfer programs. In addition, nutrition labeling that clearly points out the relationship between good nutrition and consumption should be encouraged.

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Appendix A: Means and Frequencies of Socioeconomic Variables by Nutrient and by Nutritional Status Relative to the Subsistence Level

	Nutrient									
	Minerals		Food Energy		Vitamin C		Vitamin B		Vitamin A	
Variable	Below	Above	Below	Above	Below	Above	Below	Above	Below	Above
Bonus	6.35	3.13	7.22	3.01	6.83	4.06	5.08	4.35	5.74	4.15
Urban[a]	727	561	609	679	425	863	1,086	210	658	630
Noeast[a]	254	206	216	244	152	308	384	70	228	232
Nocent[a]	310	223	250	283	162	371	484	92	275	258
South[a]	378	270	308	340	219	429	534	108	333	315
Lc1	24	11	20	15	10	25	33	2	21	14
Lc2[a]	268	25	256	37	185	108	284	9	230	63
Lc3[a]	246	43	219	70	118	171	275	14	190	99
Lc4[a]	192	136	141	187	83	245	284	44	163	165
Nmeal	6.81	6.73	6.63	6.91	6.93	6.70	6.75	6.94	7.09	6.45
Edmpl[a]	387	260	324	291	188	434	534	76	316	847
White[a]	945	785	783	947	556	1,179	1,446	284	884	846
Income	12,109	11,253	12,162	11,375	10,899	12,141	12,049	10,186	11,939	11,532
Fwork[a]	518	364	433	449	306	576	779	103	488	394
n	1,138	866	927	1,077	649	1,355	1,670	334	1,019	985

[a] Variable value represents the number of households in this category.