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Socio-economic and behavioural factors are predictors of food use in the National Food Stamp Program Survey

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The unhealthy dietary patterns in the USA especially among low-income households demand complex strategies for health promotion. The present paper analysed the proximate determinants of 7 d food use by 919 participants in the National Food Stamp Program Survey conducted in 1996. The households' consumption of dietary energy, carbohydrate, protein, fibre, saturated, monounsaturated and polyunsaturated fats, Ca, Fe, β-carotene and vitamin C were explained by background, socio-economic and behavioural factors. Certain methodological issues arising in modelling food use data were addressed. The results showed that the subjects' knowledge of the US Department of Agriculture food pyramid, reading nutrition labels, adopting a low-fat diet, selecting fruits and vegetables, saving money at grocery stores and frequency of shopping trips were often significantly associated ($P < 0.05$) with the densities of nutrient use. The results identified certain aspects of nutrition education programmes that deserve greater emphasis for improving diet quality. The model for energy intake indicated that disbursing half the food stamp benefits on a 2-week basis and better shopping practices can enhance food availability.

Diet: Hunger: Food stamps: Behavioural factors: Poverty

Food shortages and hunger experienced by low-income households in an affluent country such as the USA are embarrassing and are alleviated by households' participation in programmes such as the Food Stamp Program (Basiotis *et al.* 1983; Cohen *et al.* 1999; Rose 1999). The Food Stamp Program provides low-income households with benefits that can be used for purchasing food from authorized retailers. In 1997, for example, this programme provided more than US$22 billion in benefits to 9 million US households. Furthermore, food pantries and the Supplemental Food Program for Women, Infants, and Children (WIC) help buffer households, especially those with young children, against deficiencies of nutrients such as Ca, Fe and vitamin C (Pérez-Escamilla & Haldeman, 2002). Because the body stores of micronutrients are typically low and micronutrients are vital for functioning of the immune system (Scrimshaw & SanGiovanni, 1997), it is important that food stamp and other programmes afford adequate and balanced nutrition over time.

While some low-income households may experience periodic hunger, the recent trends in consumption of energy-dense foods and decline in physical activity contribute to the obesity epidemic in the USA (Bhargava & Guthrie, 2002). Households with low education and income levels are likely to consume worse diets, in part because of their limited understanding of the nutritional requirements and also because of the lack of ability to explore healthy foods and lifestyle choices. While promoting dietary change is a sustainable long-term strategy for improving health outcomes (Contento, 1995; Bhargava & Hays, 2004), there have been few studies exploring such issues in low-income populations. In a previous analysis of the data from the National Food Stamp Program Survey (NFSPS), Hersey *et al.* (2001) reported that subjects 'looking for grocery specials' were significantly more likely to belong to households meeting their RDA for vitamins A, B_6, C and folate.

In addition to the information on looking for grocery specials, the NFSPS compiled variables such as the decision-makers' selection of foods on the basis of information on labels, preference for consuming low-fat foods and fruits and vegetables, and knowledge of the US Department of Agriculture food pyramid. The effects of behavioural and economic factors on food use can provide insights into aspects that could be modified via nutrition education (US Department of Agriculture, 1999). Thus, for example, while the effects of price reductions on food use are important from a budgeting standpoint (Hersey *et al.* 2001), it is perhaps more important to investigate the effects of behavioural factors on food choices. This is because a low-income household may subsequently experience an increase in income that in turn would increase their

Abbreviations: AME, adult male equivalent; ENU, equivalent nutritional unit; NFSPS, National Food Stamp Program Survey; WIC, Supplemental Food Program for Women, Infants and Children.

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food intake. An understanding of what constitutes a healthy diet is essential for reducing the consumption of energy-dense foods that contribute to weight gain and other medical conditions (US Department of Agriculture/Department of Health & Human Services, 2000).

Another important issue is the disbursement of food stamps and subsidies from supplemental programmes (Wilde & Ranney, 2000). Because of coexistence of obesity and hunger in some low-income households (Townsend *et al.* 2001), it would be counter-productive to encourage binge-eating in periods following the receipt of benefits. Furthermore, food shortages are likely to entail lower intakes of fresh fruits and vegetables that are relatively difficult to store and relatively expensive. If, for example, households face hunger after exhausting the monthly food stamp benefits, then it may be more effective to disburse half the benefits on a 2-week basis.

At a conceptual level, food consumption decisions are influenced by factors such as the ethnicity, education and income levels of the decision-makers. Behavioural variables such as reading nutrition labels and the knowledge of what constitutes a healthy diet are likely to play an important role in determining food intake. The effects of socio-economic and behavioural factors on nutrient availability among food stamp programme participants should therefore be analysed in a multidisciplinary framework. The purpose of the present paper was to analyse the proximate determinants of the quantity and dietary quality of food used by households in the NFSPS, with the aim of identifying behaviours that could be changed via nutrition education. We estimated models for the use of carbohydrate, fibre, protein, saturated, monounsaturated and polyunsaturated fats, Ca, Fe, vitamin C and β-carotene, which were expressed as ratios to the energy use. These densities of nutrients were explained by background, behavioural and socio-economic variables to provide insights into the proximate determinants of vital nutrient use that were likely to affect health outcomes. Certain methodological issues were also addressed in the analysis. A model was estimated for energy use to provide further insights into factors affecting the overall food situation in the households.

Methods

Subjects

The data were from the NFSPS conducted in 1996 with the sponsorship of the US Department of Agriculture (Cohen *et al.* 1999). From the national sample of 2142 food stamp participants, a random sample of 937 households was selected to complete 7 d food use diaries. The food used was converted into nutrient and energy used by using a food composition database. The data on households' dietary energy and selected nutrient densities were analysed for the present paper.

Experimental methods

One week before the completion of food use diaries, the households were interviewed through a computer-assisted personal interview; a second interview took place 1 week after the completion of the diaries. Background, socio-economic, behavioural and nutritional variables of the households were measured. Ethnicity, age, education levels, occupation of the head of the household, and household size in terms of adult male equivalents (AME) were recorded. In addition, equivalent nutritional units (ENU) were computed from AME by taking into account meals consumed by the members outside the home. The presence of guests was also incorporated in an alternative version of the ENU. Income from various sources, such as that earned or received from Aid to Families with Dependent Children, was recorded. Participation of the household in the WIC and the period for which the household had been receiving food stamp benefits were recorded. The presence of guests at meals, number of meals consumed outside the home and meals skipped were recorded. The time between receipt of food stamp benefits and the end of the 7 d period of food use was recorded. Demographic features of the metropolitan area were included in the data set.

The constructions of behavioural and dietary indices

In the diet and behaviour module of the questionnaire, the subjects were asked several questions relating to their dietary knowledge, seeking nutrition information, eating preferences and shopping practices. Because the questions covered different dimensions of household characteristics and behaviour, five indices were created to quantify the effects of behavioural and socio-economic factors on food use (Steptoe *et al.* 1999; Bhargava & Hays, 2004); sensitivity analyses were performed in modelling the food data to check the robustness of the conclusions.

The first index was based on answers to six questions relating to the US Department of Agriculture food pyramid. The subjects were asked if they were familiar with the food pyramid and, if so, they were asked to identify the five broad food groups. Correct answers were assigned the score 1 and then were summed; the 'food pyramid' index thus ranged from 0 to 6. The 'nutrition labels' index was based on the answers to five questions on a scale of 1 to 6 (1, not important; …; 5, important; 6, very important), relating to subjects' reading of labels on foods purchased; the score 1 was assigned if the subjects reported 5 or 6 as the answers. The first three questions related to shopping for food: how important was product safety, nutrition, and how well the food will keep. The fourth question asked if the subjects had changed their decision to buy a product in the previous 2 weeks because of information on the label. The fifth question asked if the subjects had ever changed their mind because of nutrition labels. The affirmative answers to these questions were assigned the score 1; the scores on the five questions were summed to form the 'nutrition labels' index ranging from 0 to 5.

The 'low-fat diet' index was created by assigning the score 1 to affirmative answers to six questions regarding choices of low-fat foods. The questions were: if the subjects' diet was low in fat and cholesterol; if eating habits had changed to reduce fat; if they were currently limiting the amount of fat; if they had limited fat in the diet in the past; if they were currently eating a low-fat diet; if in the past 1 month they had thought about changes that could decrease fat in the diet. The answers to these six questions were summed to create the 'low-fat diet' index ranging from 0 to 6.

The 'fruits and vegetables' index was based on answers to five questions investigating the extent to which the diets consisted of fruits and vegetables. The questions were: if fruits and vegetables were a regular part of the diet; if the subjects had ever changed their eating habits to increase consumption of fruits and vegetables; if they were eating more fruits and vegetables than previously; if they had been eating more fruits and vegetables in the last year; if they chose five or more servings of fruits and vegetables. The affirmative answers were assigned the score 1 and summed for the five questions; the 'fruits and vegetables' index ranged from 0 to 5.

The 'save money' index was based on subjects' answers to six questions on their shopping practices: how often the subjects looked in newspapers for grocery specials; used cents-off or store discount coupons; stocked up on items when there were bargains; compared prices at different supermarkets; visited other food stores for advertised specials; used a shopping list. Affirmative answers were scored as 1 and the 'save money' index ranged from 0 to 6.

Overall, because of missing observations on eighteen of the participating households, complete data on 919 households were used in the analysis.

A framework for modelling the proximate determinants of food use in the National Food Stamp Program Survey

Food use among NFSPS households was likely to depend on factors such as ethnicity, income, household size, education, and on behavioural variables such as the subjects' knowledge and perceptions of the likely effects of various foods on health. Moreover, participation by the eligible households in the WIC could have enhanced dietary knowledge of the decision-makers. There were two sets of issues addressed in the empirical analysis. First, a model for dietary energy use was likely to reveal the effects of socio-economic and behavioural variables and of factors such as the time elapsed since receipt of food stamp benefits on households' overall food situation. Second, because the energy expenditures of subjects were not available in the NFSPS (James & Schofield, 1990; Goldberg *et al.* 1991), the proximate determinants of diet quality were investigated by modelling nutrient use expressed as the ratios to energy intake (Bhargava & Reeds, 1995), i.e. as nutrient densities.

In developing a model for the households' energy use, it was essential to take into account meals consumed outside the home and those skipped for other reasons. The NFSPS constructed ENU from AME by accounting for meals eaten outside the home by each member and also by taking into account the food used by guests. The ENU were derived separately for energy and for nutrients such as Ca and Fe by assuming that the nutrient intake corresponded to the RDA (Cohen *et al.* 1999). The latter assumption, however, may be invalid if the subjects had a poor understanding of RDA. The choice between AME and ENU in the models for food use can be based on statistical criteria such as those discussed later. One might expect ENU to be preferable in the model for energy use because ENU incorporated the expected quantity of food consumed by each person. By contrast, AME may be preferable for explaining nutrient densities that may be less influenced by RDA than the actual nutrient composition of meals.

Last, the empirical relationship between energy use and the explanatory variables was likely to be a multiplicative one. Moreover, certain non-linearities, such as those between household size reflected in AME (or ENU) and energy use, could arise due to 'economies in scale' in food intake. Thus, use of logarithmic transformation was helpful for the precise estimation of model parameters, especially for variables exhibiting a high degree of internal variation.

The model for energy use

The model for the households' energy use (model 1) was given by equation (1) ($i = 1, \ldots, n$):

$$
\begin{aligned}
&\ln(\text{energy intake})_i \\
&= a_0 + a_1\,(\text{black})_i + a_2\,(\text{Hispanic})_i + a_3\,(\text{college degree})_i \\
&+ a_4 \ln(\text{income} + \text{food stamp benefits})_i + a_5 \ln(\text{AME})_i \\
&+ a_6\,(\ln(\text{AME})_i)^2 + a_7 \ln(\text{proportion meals away})_i \\
&+ a_8\,(\text{guests})_i + a_9\,(\text{members} > 60 \text{ years old})_i \\
&+ a_{10}\,(\text{members} < 18 \text{ years old})_i + a_{11}\,(\text{WIC participant})_i \\
&+ a_{12} \ln(\text{food pyramid})_i + a_{13} \ln(\text{nutrition labels})_i \\
&+ a_{14} \ln(\text{low-fat diet})_i + a_{15} \ln(\text{fruits and vegetables})_i \\
&+ a_{16} \ln(\text{save money})_i + a_{17}\,(\text{number of shopping trips})_i \\
&+ a_{18} \ln(\text{days from food stamp receipt})_i \\
&+ a_{19} \ln(\text{proportion skipped meals})_i + u_i. \qquad (1)
\end{aligned}
$$

Model 1 embodied salient features of energy use by the NFSPS households. The indicator variables for ethnicity, college education, guests present during meals, presence of elderly people and/or children and participation in the WIC reflected background information. Socio-economic variables were household income, shopping practices and the number of days since receipts of monthly food stamp benefits. Behavioural variables covered the subjects' understanding of the US Department of Agriculture food pyramid, reading nutrition information on labels, consumption of a low-fat diet and fruits and vegetables, and the number of shopping trips to grocery stores. Because the variable measuring the number of monthly shopping trips ranged from 1 to 4, it was not transformed into logarithms. Random error terms u were assumed to be normally distributed with zero mean and constant variance.

In addition to these variables, model 1 included AME, AME^2 and the proportion of meals consumed outside the home. In order to incorporate the effects of household size and presence of guests on food use, it was important to estimate an alternative version (model 2) that replaced these three variables by ENU and ENU^2. Because the proportion of meals consumed outside the home was the household average, for households with a single member, model 2 was a special case of model 1 in the linear case where the square of AME variable was excluded from the explanatory variables. A likelihood ratio test for nested formulations could be applied to discriminate between these two versions (Cox & Hinkley, 1974). In practice, however, most households had more than one member so that models 1 and 2 were non-nested even in the linear variables case. Because a quadratic formulation in AME was likely to be useful, one would need to use complex statistical procedures to discriminate between non-nested models that are also non-linear in variables. Thus, to simplify the methodology, we estimated both models 1 and 2 and compared the maximum values of the log-likelihood functions for model selection. In view of the differences in the number of model parameters, the Akaike information criterion (Akaike, 1973) was also used to discriminate between the alternative model formulations.

The models for the nutrient densities

Behavioural factors such as subjects' nutritional knowledge were likely to be more strongly associated with diet quality than energy use. The models (model 3) for nutrient densities for use of carbohydrate, fibre, protein, saturated, monounsaturated and polyunsaturated fats, Ca, Fe, β-carotene and vitamin C were as follows:

$$
\begin{aligned}
&\ln(\text{nutrient/energy use})_i \\
&= b_0 + b_1\ (\text{black})_i + b_2\ (\text{Hispanic})_i \\
&\quad + b_3\ (\text{college degree})_i + b_4\ \ln(\text{income} \\
&\quad + \text{food stamp benefits})_i + b_5\ \ln(\text{AME})_i \\
&\quad + b_6\ \ln(\text{proportion meals away})_i \\
&\quad + b_7\ (\text{members} > 60\ \text{years old})_i \\
&\quad + b_8\ (\text{members} < 18\ \text{years old})_i \\
&\quad + b_9\ (\text{WIC participant})_i + b_{10}\ \ln(\text{food pyramid})_i \\
&\quad + b_{11}\ \ln(\text{nutrition labels})_i + b_{12}\ \ln(\text{low-fat diet})_i \\
&\quad + b_{13}\ \ln(\text{fruits and vegetables})_i + b_{14}\ \ln(\text{save money})_i \\
&\quad + b_{15}\ (\text{number of shopping trips})_i \\
&\quad + b_{16}\ \ln(\text{days from food stamps receipt})_i \\
&\quad + b_{17}\ \ln(\text{proportion skipped meals})_i + v_i. \qquad (2)
\end{aligned}
$$

In the models for nutrient densities, the AME^2 variable was dropped, since the non-linear effects of household size on energy use were found not to carry over to diet quality. Moreover, alternative versions of model 3 in equation 2 were estimated where AME and the percentage of meals consumed outside the home were replaced by ENU based on energy or the ENU based on the RDA of specific nutrients. In contrast with the model for energy use, including ENU based on RDA could lower the maximum values of the likelihood functions. This was because nutrient densities were likely to be similar for household members and need not correspond to individuals' RDA. Last, the indicator variable for guests was dropped from equation 2 because it was not a significant predictor of nutrient densities.

Statistical analysis

Cronbach (1984) α were computed for the five indices used in the analysis: 'food pyramid'; 'nutrition labels'; 'low-fat diet'; 'fruits and vegetables'; 'save money'. These statistics measure the internal consistency of the variables combined to form the indices; $\alpha > 0{\cdot}80$ are usually regarded as indicating 'high' internal consistency, especially if the numbers of items combined are small. The models 1, 2 and 3 in equations 1 and 2 were estimated using the least squares option in the procedure MIXED of the statistical package SAS (version 8, 2000; SAS Institute Inc., Cary, NC, USA). The maximized values of the log-likelihood function and the Akaike information criterion are calculated in this procedure using the estimated residual variances and the number of model parameters. Lower values of the Akaike information criteria indicate a preference for that specification. The models were estimated with zero values of the indices increased to 0·1 before the logarithmic transformation and where all the values were increased by unity before the transformation. While the results were similar in terms of statistical significance of the coefficients, Tables 2–6 report the result where only the zero values were increased to 0·1. Thus, the coefficients of the variables in logarithms were the 'elasticities' (percentage change in the dependent variable resulting from a 1 % change in the explanatory variable). The zero values of the proportion of meals consumed outside the home were set to 0·001 before the logarithmic transformation; sensitivity analyses were performed and the results were robust.

Results

Descriptive statistics

The sample mean values of the variables used in the analysis are reported in Table 1. The average household size was 2·98; in terms of AME, ENU and ENU taking account of guests, the household sizes were 2·15, 1·79 and 1·85 respectively. Approximately 40 % of the households were black, 46 % were white and 12 % were Hispanic. Only 7 % of the heads of households had a college degree; 33 % of the households were participating in the WIC. The average monthly income was US$667 and the average monthly food stamp benefit was US$165.

The average values of the five indices were near the midpoint of the range. However, 52 % of the households scored zero on the 'food pyramid' index, 21 % scored zero on the 'low-fat diet' index and 7 % scored zero on the 'fruits and vegetables' index. These scores were low from the viewpoint of healthy eating and merit attention in nutrition education programmes. Cronbach α for 'food pyramid', 'nutrition labels', 'low-fat diet', 'fruits and vegetables' and 'save money' indices were 0·92, 0·40, 0·72, 0·61 and 0·68 respectively. Further analysis of the 'nutrition labels' index, dropping the last two items enquiring if subjects had changed their shopping practices after reading labels, led to an increase of α to 0·67. This definition of the index was also used in models 1, 2 and 3 for energy and nutrient densities, but the results were similar.

The average percentage of meals consumed outside the home was 14 and those skipped was 15. Possible reasons

Table 1. Selected variables for 919 households in the National Food Stamp Program Survey*

(Mean values and standard deviations)

Variable	Mean	SD
Black (yes, 1; no, 0)	0·40	0·49
White (yes, 1; no, 0)	0·46	0·50
Hispanic (yes, 1; no, 0)	0·12	0·33
Members in the household (*n*)	2·98	1·76
Members >60 years old (yes, 1; no, 0)	0·27	0·44
Members <18 years old (yes, 1; no, 0)	0·61	0·49
Guests (yes, 1; no, 0)	0·30	0·46
AME	2·15	1·31
ENU (based on energy)	1·79	1·17
ENU (correcting for guests)	1·85	1·19
College education (yes, 1; no, 0)	0·07	0·25
WIC participant (yes, 1; no, 0)	0·33	0·47
Time from food stamp receipt (d)	14·73	8·79
Income (US$ per month)	666·84	643·79
Food stamp benefits (US$ per month)	165·08	118·48
Nutrient intakes		
Energy (kJ/7 d)	186 757	142 383
Energy/AME (kJ/7 d)	96 518	66 513
Energy/ENU (kJ/7 d)	116 491	75 769
β-Carotene (mg/7 d)	7832	9851
Ca (mg/7 d)	15 759	12 273
Carbohydrate (g/7 d)	5094	4103
Protein (g/7 d)	1614	1216
Fibre (g/7 d)	269	230
Fe (mg/7 d)	313	261
Saturated fat (g/7 d)	820	1257
Monounsaturated (g/7 d)	764	628
Polyunsaturated fat (g/7 d)	394	390
Vitamin C (mg/7 d)	2262	2132
Proportion of skipped meals (per 7 d)	0·14	0·16
Proportion of meals away (per 7 d)	0·15	0·18
Behavioural and dietary indices†		
'Food pyramid' index (0–6)	2·22	2·31
'Nutrition labels' index (0–5)	3·87	1·20
'Low-fat diet' index (0–6)	2·86	2·03
'Fruits and vegetables' index (0–5)	2·62	1·72
'Save money' index (0–6)	3·58	1·75
Number of shopping trips (*n* per month)	2·39	1·04
n	919	

WIC, supplemental Food Program for Women, Infants and Children; AME, adult male equivalent; ENU, equivalent nutritional unit.

* For details of procedures, see p. 498.

† For details of indices, see p. 498.

for skipping meals such as dieting, lack of food, or illness were not asked in the questionnaire. The households' average energy intake for the 7 d period was 186·757 MJ; the sample mean values of energy intake in terms of AME and ENU were 96·518 MJ and 116·491 MJ respectively. Using the averages for the intakes of saturated, monounsaturated and polyunsaturated fats from Table 1, the % energy derived from the three fats were 16·5, 15·4, and 8·0 respectively, i.e. 40 % energy was derived from fat. Approximately 45 % energy was derived from carbohydrate. The average number of shopping trips per month was 2·39.

Empirical results for the households' energy use

The results from models 1 and 2 for households' energy use are presented in Table 2; the results in the far right-hand column used ENU variables that also took into account food used by the guests. The results for the three formulations in Table 2 were very similar, although the maximum values of the likelihood functions (and minimum values of the Akaike information criteria) indicated a preference for the model that included guest-corrected ENU as explanatory variables. The salient features of the results in Table 2 were, first, that the relationship between the logarithms of energy use and AME was a quadratic one, with energy use increasing with household size but at a declining rate. The indicator variable for presence of guests in model 1 was a significant predictor ($P<0·05$) of higher energy use. Households with children <18 years old used significantly greater dietary energy. Second, ethnic differences in energy use were not statistically significant. Household income including the food stamp benefits was not a significant predictor, presumably because all households were food stamp participants; increases in income would decrease the benefits. Participation in the WIC and the college education of the household head were not statistically significant predictors of energy use. Third, the 'food pyramid', 'nutrition labels', 'low-fat diet' and 'fruits and vegetables' indices were not significant predictors in the models for energy use. By contrast, the 'save money' index was a statistically significant predictor in the three versions of the model. Thus, subjects taking advantage of savings offered by grocery stores, searching for bargains and using shopping lists were from households that had higher energy use. Further, the number of days from the receipt of food stamp benefits was significantly negatively associated with energy use in model 1 with AME, and was significant ($P<0·10$) in model 2 where ENU were included. The variable measuring the proportion of skipped meals was significantly negatively associated with energy use in all three formulations. Because the reasons for skipping meals were not covered in the questionnaire, we did not model the potential dependence between energy use and skipping meals decisions for households lacking economic resources. Last, R^2 adjusted for the number of estimated parameters were approximately 0·50, indicating that the explanatory variables accounted for 50 % of the variation in the dependent variable.

Empirical results for the households' nutrient densities

The results for households' dietary Ca densities are shown in Table 3 for model 3 using AME, ENU based on energy and ENU based on the RDA for Ca; this presentation was helpful for illustrating the methodological approach in the present paper. The values of the log-likelihood functions were highest when AME and proportion of meals away from home were used, followed by the model with energy-based ENU; the log-likelihood function was lowest when ENU based on the RDA for Ca were included. A similar ranking for model preference was obtained using the Akaike information criteria and the adjusted R^2 reported in Table 3. Thus, the statistical criteria favoured the inclusion of the variable AME for explaining Ca densities. While the results for the three models were close, statistical significance ($P<0·05$) was reached, for example, for the coefficient of the indicator variable for children <18 years old only in the model that included the AME variable.

Table 2. Results from regression models for households' 7 d energy use in logarithms, explained by background, socio-economic and behavioural factors using alternative definitions of household size†‡

(Regression coefficients with their standard errors)

	Models for households' energy use (kJ)§					
	Model 1 with household size using AME		Model 2 with household size using ENU		Model 2 with household size using ENU corrected for guests	
Independent variable	Coefficient	SE	Coefficient	SE	Coefficient	SE
Black (0–1)	0·036	0·039	0·042	0·038	0·021	0·037
Hispanic (0–1)	0·014	0·057	−0·016	0·056	−0·030	0·056
Members > 60 years old (0–1)	−0·055	0·049	−0·059	0·047	−0·062	0·047
Members < 18 years old (0–1)	0·198*	0·062	0·224*	0·054	0·238*	0·053
Guests (0–1)	0·205*	0·040	0·190*	0·039		
Ln(AME)	0·706*	0·071				
$(\text{Ln(AME)})^2$	−0·078	0·046				
Ln(ENU based on energy)			0·609*	0·039		
$(\text{Ln(ENU based on energy)})^2$			−0·027	0·029		
Ln(ENU including guests)					0·630*	0·039
$(\text{Ln(ENU including guests)})^2$					−0·027	0·029
College education (0–1)	0·031	0·072	0·012	0·071	0·008	0·070
WIC participant (0–1)	0·018	0·044	0·035	0·044	0·024	0·043
Ln(days from food stamp receipt)	−0·055*	0·025	−0·048	0·025	−0·043	0·025
Ln(income + food stamp benefits)	0·019	0·025	0·010	0·024	0·010	0·024
Ln(proportion of skipped meals)	−0·063*	0·013	−0·051*	0·012	−0·050*	0·012
Ln(proportion of meals away)	−0·050*	0·007				
Ln(food pyramid)	0·012	0·010	0·011	0·010	0·014	0·010
Ln(nutrition labels)	0·011	0·024	0·002	0·023	0·013	0·023
Ln(low-fat diet)	−0·021	0·013	−0·025	0·013	−0·024	0·013
Ln(fruits and vegetables)	−0·004	0·020	−0·004	0·019	−0·006	0·019
Ln(save money)	0·086*	0·019	0·091*	0·018	0·091*	0·018
Number of shopping trips	0·009	0·017	0·016	0·017	0·018	0·017
Constant	10·887*	0·184	11·257*	0·178	11·268*	0·176
Adjusted R^2	0·48		0·50		0·51	
Log-likelihood function	−725·1		−707·1		−704·3	
Akaike information criterion‖	1492·2		1454·2		1446·6	
n	919		919		919	

AME, adult male equivalent; ENU, equivalent nutritional unit; WIC, Supplemental Food program for Women, Infants and Children.
* $P < 0·05$.
† For details of subjects and procedures, see Table 1 and pp. 498–500.
‡ All the *F* values for joint significance of the regression coefficients were statistically significant ($P < 0·05$).
§ See equation 1 (p. 499) for the definition of models 1 and 2.
‖ Akaike (1973).

The AME variable was significantly negatively associated with Ca densities, indicating relatively lower use in larger households. However, participation in the WIC implied significantly higher densities of Ca. Ca densities were lower for black households in comparison with white households; the indicator variable for Hispanic households was not statistically significant. A greater score on the 'food pyramid' index was significantly associated with higher densities of Ca. The number of shopping trips per month was a significant and positive predictor of Ca density. Households where the members skipped meals had significantly lower Ca densities. Because of the similarity between the results from the three versions of model 3, we report the results for remaining nutrient densities where AME and proportion of meals away from home were included as explanatory variables.

The results from model 3 for protein, fibre and Fe densities are shown in Table 4; results for carbohydrate, β-carotene and vitamin C are shown in Table 5, and those for saturated, monounsaturated and polyunsaturated fats are shown in Table 6. The results in Table 4 showed that larger households had significantly lower protein, fibre and Fe densities. The fibre densities were significantly higher in households where an elderly member was present. Black households used significantly lower fibre densities, whereas fibre density was significantly higher in Hispanic households. Moreover, in comparison with white households, protein density was higher and Fe density was lower in black households. Participation in the WIC was significantly associated with higher Fe densities. However, calculation of absorbable Fe was not feasible in the NFSPS data because it would have required data on food use by meals (Monsen & Balintfy, 1982).

Of the behavioural factors, the 'nutrition labels' index was negatively associated with protein density and was positively associated with fibre density ($P < 0·05$). Households scoring high on the 'low-fat diet' index had significantly higher protein densities. The 'save money' index was not a significant predictor of protein, fibre and Fe densities. The number of shopping trips per month was significantly associated with fibre density. The skipped meals variable was estimated with significant negative coefficients in the models for the fibre and Fe densities.

Table 3. Regression models for households' 7 d calcium densities in logarithms, explained by background, socio-economic and behavioural factors using alternative definitions of household size†‡

(Regression coefficients with their standard errors)

	Models for calcium densities§					
	Model 3 with household size using AME and proportion of meals away		Model 3 with household size using ENU based on energy		Model 3 with household size using ENU based on RDA for Ca	
Independent variable	Coefficient	SE	Coefficient	SE	Coefficient	SE
Black (0–1)	−0·257*	0·029	−0·263*	0·029	−0·267*	0·029
Hispanic (0–1)	−0·046	0·043	−0·049	0·043	−0·053	0·043
Members >60 years old (0–1)	0·042	0·036	0·042	0·036	0·045	0·036
Members <18 years old (0–1)	0·100*	0·046	0·070	0·041	0·060	0·044
Ln(AME)	−0·082*	0·031				
Ln(ENU based on energy)			−0·044	0·026		
Ln(ENU based on Ca)					−0·024	0·027
College education (0–1)	−0·019	0·054	−0·018	0·054	−0·020	0·054
WIC participant (0–1)	0·112*	0·033	0·110*	0·033	0·112*	0·034
Ln(days from food stamp receipt)	0·001	0·019	0·001	0·019	0·001	0·019
Ln(income + food stamp benefits)	0·012	0·019	0·008	0·019	0·006	0·019
Ln(proportion of skipped meals)	−0·030*	0·009	−0·031*	0·009	−0·031*	0·009
Ln(proportion of meals away)	0·005	0·005				
Ln(food pyramid)	0·015*	0·008	0·016*	0·008	0·016*	0·008
Ln(nutrition labels)	0·006	0·018	0·006	0·018	0·005	0·018
Ln(low-fat diet)	0·014	0·010	0·016	0·010	0·017	0·010
Ln(fruits and vegetables)	0·033*	0·015	0·033*	0·015	0·033*	0·015
Ln(save money)	−0·025	0·014	−0·026	0·014	−0·027	0·014
Number of shopping trips	0·032*	0·013	0·030*	0·013	0·029*	0·013
Constant	−2·690*	0·139	−2·690*	0·136	−2·661*	0·135
Adjusted R^2	0·16		0·16		0·15	
Log-likelihood function	−467·5		−469·85		−470·9	
Akaike information criterion‖	973		975·7		977·8	
n	919		919		919	

AME, adult male equivalent; ENU, equivalent nutritional unit; WIC, Supplemental Food Program for Women, Infants and Children.
* $P<0·05$.
† For details of subjects and procedures, see Table 1 and p. 500.
‡ All the *F* values for joint significance of the regression coefficients were statisfically significant ($P<0·05$).
§ See equation 2 on p. 500 for the definition of model 3.
‖ Akaike (1973).

Table 5 presents the results for the use of carbohydrate, β-carotene and vitamin C densities. Black households were using significantly lower carbohydrate and β-carotene densities, while Hispanic households were using significantly higher β-carotene and vitamin C densities. Households that scored high on 'nutrition labels' index were using significantly greater carbohydrate and β-carotene densities. Skipping meals was significantly negatively associated with carbohydrate, β-carotene and vitamin C densities. Higher AME was significantly associated with lower use of β-carotene and vitamin C densities; households with elderly members had significantly greater β-carotene and vitamin C densities. The 'food pyramid' and 'fruits and vegetables' indices were positively and significantly associated with the β-carotene density. The number of shopping trips was significantly positively associated with β-carotene density. The skipped meals variable was negatively associated with vitamin C density ($P<0·05$).

The results in Table 6 showed that black households had higher densities of monounsaturated and polyunsaturated fats than white households. By contrast, for Hispanic households, the saturated and monounsaturated fat densities were lower and the polyunsaturated fat density was higher. College education was negatively associated with monounsaturated fat density ($P<0·10$). The 'nutrition labels' index was negatively associated with monounsaturated fat density ($P<0·05$). The 'save money' index was positively associated with polyunsaturated fat density and the number of shopping trips per month was negatively associated with monounsaturated and polyunsaturated fat densities. The skipped meals variable was positively associated with monounsaturated fat density.

Last, in comparison with the ENU, inclusion of the variables AME and proportion of meals consumed outside the home led to higher values of the log-likelihood functions (and lower values of the Akaike information criterion) for all densities except those of protein and monounsaturated fat use (results not shown). In these two cases, the differences between the log-likelihood functions were practically negligible. Overall, the model parameters were more precisely estimated when AME and proportion of meals consumed outside the home were included as explanatory variables in the models for nutrient densities.

Discussion

The present paper presents a comprehensive analysis of the effects of background, socio-economic and behavioural factors on food use in the NFSPS data. Because the

Table 4. Regression models for households' 7 d protein, fibre and iron densities in logarithms, explained by background, socio-economic and behavioural factors

(Regression coefficients with their standard errors)†‡

	Model 3 for protein densities§		Model 3 for fibre densities§		Model 3 for Fe densities§	
Independent variable	Coefficient	SE	Coefficient	SE	Coefficient	SE
Black (0–1)	0·073*	0·016	−0·151*	0·029	−0·057*	0·022
Hispanic (0–1)	0·032	0·024	0·247*	0·043	−0·036	0·033
Members >60 years old (0–1)	−0·030	0·020	0·148*	0·036	0·028	0·027
Members <18 years old (0–1)	−0·073*	0·025	−0·001	0·045	0·042	0·035
Ln(AME)	−0·053*	0·017	−0·110*	0·031	−0·043*	0·024
College education (0–1)	−0·039	0·030	0·026	0·054	−0·021	0·041
WIC participant (0–1)	0·014	0·019	−0·043	0·033	0·066*	0·025
Ln(days from food stamp receipt)	0·010	0·011	−0·001	0·019	−0·002	0·014
Ln(income + food stamp benefits)	0·012	0·010	0·022	0·019	0·038*	0·014
Ln(proportion of skipped meals)	−0·008	0·005	−0·037*	0·009	−0·021*	0·007
Ln(proportion of meals away)	0·003	0·003	0·010	0·005	−0·002	0·004
Ln(food pyramid)	0·001	0·004	0·014	0·008	−0·001	0·006
Ln(nutrition labels)	−0·025*	0·010	0·046*	0·018	0·016	0·014
Ln(low-fat diet)	0·019*	0·006	0·008	0·010	0·013	0·008
Ln(fruits and vegetables)	0·007	0·008	0·012	0·015	0·011	0·011
Ln(save money)	−0·009	0·008	0·001	0·014	0·002	0·011
Number of shopping trips	0·013	0·007	0·044*	0·013	0·015	0·010
Constant	−4·800*	0·077	−6·902*	0·138	−6·797*	0·105
Adjusted R^2	0·07		0·18		0·05	
n	919		919		919	

AME, adult male equivalent; ENU, equivalent nutritional unit; WIC, Supplemental Food Program for Women, Infants and Children.
* $P<0·05$.
† For details of subjects and procedures, see Table 1 and p. 500.
‡ All the *F* values for joint significance of the regression coefficients were statistically significant ($P<0·05$).
§ See equation 2 on p. 500 for the definition of model 3.

Table 5. Regression models for households' 7 d carbohydrate, β-carotene and vitamin C densities in logarithms, explained by background, socio-economic and behavioural factors†‡

	Model 3 for carbohydrate densities§		Model 3 for β-carotene densities§		Model 3 for vitamin C densities§	
Independent variable	Coefficient	SE	Coefficient	SE	Coefficient	SE
Black (0–1)	−0·120*	0·017	−0·176*	0·075	0·012	0·048
Hispanic (0–1)	0·003	0·026	0·283*	0·112	0·265*	0·072
Members >60 years old (0–1)	0·033	0·022	0·340*	0·093	0·141*	0·060
Members <18 years old (0–1)	0·051	0·027	0·186	0·118	0·159*	0·076
Ln(AME)	−0·011	0·019	−0·177*	0·081	−0·119*	0·052
College education (0–1)	0·044	0·033	0·008	0·140	−0·018	0·090
WIC participant (0–1)	−0·021	0·020	−0·152	0·086	0·071	0·055
Ln(days from food stamp receipt)	−0·003	0·011	−0·010	0·049	0·000	0·032
Ln(income + food stamp benefits)	0·020	0·011	−0·008	0·048	0·017	0·031
Ln(proportion skipped meals)	−0·011*	0·006	−0·052*	0·024	−0·044*	0·016
Ln(proportion meals away)	0·001	0·003	−0·014	0·014	0·009	0·009
Ln(food pyramid)	0·003	0·005	0·046*	0·020	0·018	0·013
Ln(nutrition labels)	0·035*	0·011	0·097*	0·046	0·054	0·030
Ln(low-fat diet)	0·002	0·006	0·045	0·026	0·022	0·017
Ln(fruits and vegetables)	0·005	0·009	0·129*	0·038	0·035	0·025
Ln(save money)	0·008	0·009	0·047	0·037	0·037	0·024
Number of shopping trips	0·006	0·008	0·075*	0·034	0·027	0·022
Constant	−3·829*	0·083	−4·130*	0·357	−5·070*	0·230
Adjusted R^2	0·09		0·10		0·06	
n	919		919		919	

AME, adult male equivalent; WIC, Supplemental Food Program for Women, Infants and Children.
* $P<0·05$.
† For details of subjects and procedures, see Table 1 and p. 500.
‡ All the *F* values for the joint significance of the regression coefficients were significant ($P<0·05$).
§ See equation 2 on p. 500 for the definition of model 3.

Table 6. Regression models for households' 7 d saturated, monounsaturated and polyunsaturated fat densities in logarithms, explained by background, socio-economic and behavioural factors†‡

Independent variable	Model 3 for saturated fat densities§		Model 3 for monounsaturated fat densities§		Model 3 for polyunsaturated fat densities§	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
Black (0–1)	0·047	0·029	0·119*	0·019	0·131*	0·031
Hispanic (0–1)	−0·098*	0·044	−0·067*	0·029	0·186*	0·047
Members >60 years old (0–1)	−0·041	0·037	−0·027	0·024	0·028	0·039
Members <18 years old (0–1)	0·068	0·046	0·003	0·031	0·042	0·049
Ln(AME)	−0·046	0·032	0·008	0·021	0·045	0·034
College education (0–1)	−0·053	0·055	−0·066	0·036	0·052	0·059
WIC participant (0–1)	−0·003	0·034	−0·011	0·022	−0·071*	0·036
Ln(days from food stamp receipt)	0·001	0·019	−0·006	0·013	−0·009	0·021
Ln(income + food stamp benefits)	−0·002	0·019	−0·007	0·013	0·020	0·020
Ln(proportion of skipped meals)	−0·010	0·010	0·016*	0·006	0·000	0·010
Ln(proportion of meals away)	−0·002	0·006	−0·001	0·004	−0·008	0·006
Ln(food pyramid)	0·010	0·008	0·002	0·005	−0·004	0·008
Ln(nutrition labels)	−0·023	0·018	−0·030*	0·012	0·012	0·019
Ln(low-fat diet)	−0·013	0·010	−0·013	0·007	−0·002	0·011
Ln(fruits and vegetables)	−0·009	0·015	−0·014	0·010	0·010	0·016
Ln(save money)	0·005	0·014	0·002	0·010	0·036*	0·015
Number of shopping trips	0·002	0·013	−0·017*	0·009	−0·030*	0·014
Constant	−5·572*	0·140	−5·389*	0·093	−6·555*	0·150
Adjusted R^2	0·01		0·09		0·04	
n	919		919		919	

AME, adult male equivalent; WIC, Supplemental Food Program for Women, Infants and Children.
* $P<0·05$.
† For details of subjects and procedures, see Table 1 and p. 500.
‡ All the F values for joint significance of the regression coefficients were statistically significant ($P<0·05$).
§ See equation 2 (p. 500) for the definition of model 3.

subjects in low-income households in the USA are typically less educated, it was important to analyse the factors affecting energy intake and diet quality in a broad analytical framework. The empirical results provided insights that can be used to refine nutrition education programmes.

First, the zero scores by many households on indices of 'food pyramid', 'low-fat diet' and 'fruits and vegetables' suggested that nutrition education programmes should seek to enhance subjects' dietary knowledge. Moreover, many subjects may not understand issues such as what constitutes a low-fat diet (Bhargava & Hays, 2004). While the importance of fruits and vegetables has been emphasized in programmes such as '5 a day' (National Cancer Institute, 2001) and empirical evidence from several dietary interventions has been summarized in Agency for Healthcare Research & Quality (2001), it is essential that such advice reach a large number of low-income households. This could be achieved by distributing nutritional information and recipes for healthy meals via offices, providing food stamp benefits and through other programmes (Lutz *et al.* 1999). Moreover, resources allocated to nutrition education (US Department of Agriculture, 1999) can be channelled more effectively after investigating, via brief questionnaires, the behavioural and socio-economic aspects most in need of modifications.

Second, the results from the model for energy use showed the importance of variables covered in the 'save money' index. It is important for decision-makers in low-income households to improve shopping practices for increasing food availability without a concomitant increase in food expenditures. However, some aspects of shopping practices may have evolved in the NFSPS data with the households' needs for increasing food supplies to meet the members' energy needs. Even so, taking advantage of the discounts offered by grocery stores is likely to increase food availability.

Third, duration from the receipt of food stamp benefits was negatively associated with energy use, thereby supporting previous findings of declines in food intakes as households moved further from the receipt of benefits (Wilde & Ranney, 2000). Disbursement of half the food stamp benefits via the electronic benefit transfer every 2 weeks is likely to stabilize food availability for many participating households.

Fourth, from the standpoint of dietary quality of food used, the results showed the importance of making regular trips to grocery stores; shopping trips were significantly positively associated with Ca, fibre and β-carotene densities, and were negatively associated with the densities of monounsaturated and polyunsaturated fat. Elderly members of households may be reluctant or unable to make regular trips, food delivery at a nominal price by grocery stores can enable members to stabilize the availability of nutrient-dense foods such as fruits and vegetables. Involvement of younger relatives in shopping for the elderly living in the vicinity could be a potentially useful strategy for improving nutrition and should be examined in future studies.

Finally, the scores on the 'food pyramid' index were significant predictors of the Ca and β-carotene densities; the 'nutrition labels' index was significantly associated with the densities of fibre, carbohydrate and β-carotene, and was negatively associated with monounsaturated fat density. The 'fruits and vegetables' index was positively associated with β-carotene density. Thus, it is important to improve subjects' understanding of the food pyramid through detailed presentations by dietitians and nutritionists. Nutrition labels could provide further guidance, such as the need to limit the consumption of energy-dense foods. Moreover, programmes such as 'Pick the tick' in New Zealand (Young & Swinburn, 2002) have been successful in reducing the salt content of processed foods. In view of the steep rise of obesity rates in the USA and the concomitant medical conditions, increased nutrition education together with greater availability of healthier foods in grocery stores would seem essential for promoting long-term health, especially of the poor.

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