IMPACT OF DOMESTIC FOOD PROGRAMS ON NUTRIENT INTAKE OF LOW-INCOME PERSONS IN THE UNITED STATES

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Domestic food programs in the United States originated in the 1930s, primarily in response to the needs of the agricultural sector. They served as a disposal mechanism for agricultural surpluses and were designed to stimulate demand. However, the nature of U.S. food programs has changed significantly during the last two decades. Out of a growing concern for the poor and the needy, their primary focus has become the improvement of the nutritional status of low-income families (Paarlberg, pp. 99–102.). This policy shift has been associated with a rapid escalation of the domestic food assistance programs. From 1969 to 1979, annual federal expenditures on such programs rose eightfold to over $9 billion (Longen).[1] These spiraling costs have recently led some to question the effectiveness of U.S. food programs. For example, Paarlberg (p. 109) argues that the Food Stamp Program may have expanded beyond its optimum point. Moreover, steps taken by the present administration to tighten food stamp eligibility requirements and to reduce the federal subsidy for school lunches have engendered the concern of various interests supporting these programs.

The controversial history of domestic food programs has motivated a considerable research effort to evaluate the effects of food assistance programs on food consumption (Lane; West and Price; Neenan and Davis; Chavas and Yeung) and nutritional status. The research results indicate that the Food Stamp Program tends to have a positive impact on the consumption of a number of nutrients by participating families (Lane; Scearce and Jensen; Davis and Neenan). Also, Price et al. provided some evidence that the School Lunch and School Breakfast programs increase the intake of some nutrients among public school students in Washington.

However, the effects of food programs may not be uniform and may vary among different socio-demographic groups. Indeed, Buse and Salathe have presented evidence that many socio-demographic variables that influence household food consumption (such as income, race, location, family size) have complex interactions effects. Chavas and Yeung, in a study of household food expenditures, found that such interaction effects also exist between food stamp bonus and race or location. It indicates that the effectiveness of the Food Stamp Program may depend on a number of socio-demographic variables. Lane suspected this when she wrote that "further research on interactive effects of variables affecting nutritional achievement levels of households appears to be indicated" (Lane, p. 115). However, previous research on individual nutrient intakes has, in general, not focused on interaction variables (e.g., Adrian and Daniel; Price et al.; Scearce and Jensen; Allen and Gadson). Thus, there is a need to further investigate possible interaction effects between variables that influence nutrient consumption. This is particularly important if the interaction variables involve food assistance programs, since they can then provide evidence of the differential impact of the food programs on different socio-demographic groups.

The objective of this paper is to determine the effects of domestic food programs on the nutrient intake of persons from low-income households in the U.S. Specifically, the Food Stamp Program, the School Lunch Program, the School Breakfast Program, the Group Meal Service for the Elderly, and the Special Supplemental Food Program for Women, Infants, and Children (WIC) are analyzed. Particular attention is given to the interaction between the effects of these programs and a number of economic and socio-demographic variables (such as income, race, urbanization, employment status), implying that different groups of individuals may react differently to nutrition intervention efforts. The analysis provides some new evidence on how policy variables, as well as selected socio-economic variables, affect nutritional achievement of persons in low-income households.

THE MODEL

Using cross-section data, the Engel function, which relates changes in consumption to changes in income, is typically the basis of consumption analysis. Such a function is derived from consumer theory by assuming that the consumer chooses his consumption bundle so as to maximize his utility subject to a budget constraint. Recognizing that consumers' preferences may vary with various socio-demographic variables (denoted by the vector S), this maximization leads to the traditional Engel function[2]

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[1] In 1979, federal expenditures for USDA food programs were $6.4 billion on bonus food stamps; $0.5 billion on the Special Supplemental Food Program for Women, Infants and Children (WIC); $2 billion for the School Lunch Program and $.2 billion for the School Breakfast Program (Longen).

[2] Although prices can still vary in cross-section analysis because of regional price differences, the price effects are captured in (1) by regional and location dummy variables included in the vector S.

(1) $X_i = X_i(INC, S)$

where X_i is the consumption of the *ith* commodity, and INC is consumer income. Equation (1) provides the basis for cross-sectional analysis of food demand (e.g., West and Price; Buse and Salathe).

This approach can be easily extended for studying nutrient intakes. Indeed, if b_{ij} denotes the amount of the *jth* nutrient contained in one unit of the *ith* food item, then the consumption of the *jth* nutrient (Y_j) by a particular consumer can be written as

(2) $Y_j = \sum_i b_{ij} X_i$

where X_i is the consumption of the *ith* food item.

Substituting (1) into (2) leads to the demand function for nutrients

(3) $Y_j = Y_j(INC, S)$.

In an attempt to refine the role of the socio-demographic variables in (1) and (3), Gorman; Becker; and Lancaster have developed the new "household production theory." It assumes that the consumer obtains utility from some underlying goods that cannot be bought in the market but are instead produced by the consumer from inputs of market goods and his leisure time. In our case, the market goods would be food items, while the nonmarket goods would be the nutrients contained in food, implying that the consumption of nutrients is obtained from combining various foods with shopping, cooking, and eating time. This approach has proved useful by providing possible explanations for phenomena that were not well understood (e.g., Stigler and Becker). It gives a basis for motivating the inclusion of a number of socio-demographic variables in demand analysis (such as employment status, education).

Biological data also indicate that anthropomorphic variables such as height, weight, age, and sex are important in determining nutritional requirements (Food and Nutrition Board). These variables are thus expected to influence nutrient intakes. Similarly, economic theory suggests that in-kind transfers have an income effect equal to or greater than an equivalent cash transfer (Mittelhammer and West). This validates the inclusion of policy variables (e.g., food stamp bonus) in a model of nutrient intake.

Finally, results of previous research provide evidence on how a number of socio-demographic variables affect food consumption behavior and nutrient intake. For example, household size, location, and race have been found to significantly influence food and nutrient consumption (e.g., Buse and Salathe).

Thus, by refining expression (3), a general model formulation for individual nutrient intake can be expressed as

(4) $Y_j = Y_j(SOC, ANTHR, INC, DFP)$;
$j = 1, 2, \ldots, 12$,

where nutrient intakes (Y_j) are dependent variables, while various socio-demographic (SOC: household size, occupation, education, region, location, race) and anthropomorphic (ANTHR: age, height, weight, sex) variables as well as income (INC) and the domestic food program (DFP: food stamp, school lunch, school breakfast, meal service for the elderly, WIC) are specified as explanatory variables. Twelve nutrients were selected for the analysis: energy, protein, calcium, iron, phosphorus, vitamin A, niacin, thiamin, riboflavin, vitamin B6, vitamin B12, and vitamin C.

Correct specification of a model explaining consumer behavior, such as (4), can be considered a hypothetical standard, especially in cross-section analysis, due to the variety and complexity of factors influencing an individual's behavior. In this study, model (4) was specified as a linear model. One exception was income where a squared term was also included in order to investigate possible nonlinearities in the Engel relationship. Another exception was age, which was specified as a cubic spline function (Poirier) in an attempt to better approximate the relationship between age and nutrient intake.[3] Also, in an effort to isolate the effects of various food programs on particular subgroups of the population, appropriate interaction variables involving food programs and socio-demographic variables were introduced in (4) in cases where important or noteworthy inferences could be made.

DATA

Two data sets from the spring quarter of the USDA 1977–78 Nationwide Food Consumption Survey were used in the analysis: the Survey of Food Intake of Individuals in the United States and the Survey of Household Food Consumption in the United States. Since the analysis was conducted on the nutrient intake of individuals, nutrient intake information was drawn from the individual survey.[4] In addition, most socio-demographic and economic variables were supplied by the individual survey. The household survey supplied all of the policy variables (such as food stamps, school breakfast). After selecting the appropriate variables, the two data sets were merged by household identification number. A three-day average nutrient intake per individual, the Y_j variable in (4), was calculated from the data, resulting in 8,691 observations. In order to obtain a sample representing a more homogeneous population, a low-income subset of the sample containing only individuals who qualified for the Food

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[3] The intervals chosen for the cubic spline functions were 0–20 years old, 20–50 years old, and 50–70 years old. Nutrient intake was assumed to be constant beyond 70 years of age. A different spline function was estimated for male and female, although they were assumed to go through the same point at age = 0. This general approach is similar to the one used by Buse and Salathe in modeling the influence of age on food consumption.

[4] Note that the nutrient-intake data reflects nutrients available for consumption, which by ignoring wastes usually overestimates actual consumption. Also, the analysis is subject to the limitations of the recall information used in collecting the data (Madden et al.).

Stamp Program was analyzed. Subsetting by the household size and income combinations that satisfy the eligibility criterion for food stamps (see Table 1) yielded a data set containing 1,580 low-income observations. The analysis of this data set is presented below.

RESULTS

Model (4) was estimated by ordinary least squares. Because of space limitation, only selected results are presented here[5] (Table 2). In particular, Table 2 reports results on the effects of family size, income, education, and domestic food programs on nutrient intakes. Due to the multiplicity and complexity of factors influencing individual food consumption, $\bar{R}$-squares, as expected, are relatively low. They range in value from 0.068 to 0.365 (Table 2). The marginal impacts of income and the food programs on nutrient intakes, as estimated from the model, are reported in Table 3.

Family size is found to have negative influence on individual nutrient consumption (Table 2). This influence is highly significant[6] for all nutrients, except vitamin B12. Thus, an increase in family size is associated with a decrease in individual nutrient intake, *ceteris paribus*.

Annual household income (INC) is a significant factor affecting nutrient consumption. While the income coefficients are not significantly different from zero for most nutrients, the income-squared coefficients are positive and highly significant for all nutrients except vitamin B12 (Table 2). This indicates that individual nutrient intakes, as a function of income, tend to increase at an increasing rate. This is illustrated in Table 3, where the predicted marginal effects of income ($\partial Y_i/\partial INC$), as well as the corresponding income elasticities, are presented. For an income of $2,000, all income elasticities are very small and not significantly different from zero. However, when income increases to $8,000,[7] all the income elasticities become positive and large, varying between 0.22 for calcium and 0.75 for vitamin C. Except for calcium, vitamin A, and vitamin B12, they are all significantly different from zero. These results suggest that nutrient responsiveness to income is small for very low income households, which raises questions about the effectiveness of a policy aimed at generating nutritionally adequate diets through income transfers for such households. However, as income increases, nutrient intakes become positively more responsive to income. These results are in agreement with Adrian and Daniel's findings. Also, the low-nutrient income elasticities reported in previous research for high-income households (e.g., Adrian and Daniel) apparently occur for income levels beyond those of our sample. This suggests that the Engel function has the general shape presented in Figure 1, and that the portion AC of the curve corresponds to our analysis, while BE corresponds to Adrian and Daniel's analysis. The portion AB of the curve, indicating a consumption threshold possibly related to a survival level, would then best be perceived by analyzing low-income households.

A positive relationship is found between most nutrient intake and the educational attainments of the female head and male head of the household (see Table 2). In particular, *ceteris paribus*, the number of years of education of the female head (FED) has a positive and significant impact on the consumption of eight of the twelve nutrients investigated. Similarly, the education of the male head (MED) increases significantly the consumption of six nutrients. Note that the coefficient of the FED variable tends to be larger than the coefficient of the MED variable (see Table 2). These results indicate that improving education of the family head (and especially of the female head) tends to increase nutrient intakes for low-income household members, presumably because of better nutritional awareness.[8]

Participation in organized group meal service for the elderly was introduced as a dummy variable in the model (MEALS). The regression results and the estimated impacts presented in Tables 2 and 3, respectively, show that organized group meal service has a positive and significant influence on consumption of iron, vitamin A, riboflavin, and vitamin C. The influence on other nutrients, while usually positive, is not significant.

The School Lunch Program (SL = number of school lunches/week) enters the model with interactions with race (BL = 1 for black; = 0 otherwise) and income (INC) (Table 2). The coefficient of the school lunch variable, SL, is not significantly different from zero for

Table 1. Maximum Allowable Income to Qualify for Food Stamps by Household Size 1977.

Household Size	Maximum Net Income ($/month)	Calculated Maximum Gross Income ($/year)[a]
1	245	5031
2	322	5742
3	433	6766
4	553	7874
5	660	8862
6	787	10034
7	873	10828
8	993	11935
9	1120	13440
10	1247	14964
11	1374	16488
12	1501	18012
13	1628	19536
14	1755	21060

[a] Since food stamp eligibility was based on net income as determined by gross income minus certain deductions, maximum gross income was adjusted upwards following the 1977 food stamp eligibility criteria.

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[5] Complete results on the socio-demographic and anthropomorphic variables not discussed here may be obtained from the author.

[6] Unless otherwise indicated, significance refers to statistical significance at the 10-percent level.

[7] The average income in the low-income sample used in the analysis is $4,947.

[8] By improving human capital, education of the meal planner is expected to improve his or her ability to plan meals or cook. Our results may then simply reflect the fact that most homemakers are female. However, they also suggest that the male head of the household may have some input in the planning of meals.

Table 2. Regression Results for Selected Explanatory Variables.[a,b]

Dependent Variable	F ratio	$\bar{R}^2$	SIZEH	INC	INC^2	MED	FED	MEALS	SL	SL x BL	SL x INC	SB
Energy (kcal)	14.8**	.365	-58.02** (13.12)	.0000770 (.0000013)	.00000552** (.0000013)	3.325 (3.51)	18.21** (6.08)	9.827 (128.4)	10.55 (22.84)	38.61** (19.00)	-.00608** (.0030)	348.7** (87.9)
Protein (g)	11.96**	.314	-23.44** (5.75)	.00148 (.0075)	.0000020** (.0000007)	1.763 (1.541)	7.062** (2.666)	45.32 (56.28)	9.68 (10.010)	5.781 (8.330)	-.0035 (.0013)	181.3** (38.5)
Calcium (mg)	7.00**	.200	-18.83** (8.061)	-.0144 (.0106)	.0000020** (.0000008)	2.047 (2.159)	13.21** (3.73)	18.27 (78.85)	3.095 (14.02)	16.62 (11.67)	-.0016 (.0018)	160.46** (53.99)
Iron (mg x 10)	8.77**	.245	-5.129** (1.117)	.00020 (.0014)	.00000051** (.00000011)	.3295 (.2994)	1.003** (.5178)	17.84* (10.93)	2.907 (1.944)	1.193 (1.617)	-.000589** (.000255)	20.86** (7.48)
Phosphorus (mg)	10.84**	.284	-41.93** (9.33)	-.0233* (.0122)	.0000044** (.0000009)	5.105** (2.500)	11.454** (4.323)	15.47 (91.26)	8.06 (16.23)	16.39 (13.50)	-.00429** (.0021)	259.58** (62.48)
Vitamin A (I.U.)	3.19**	.084	-318.3** (132.2)	-.1597 (.1734)	.0000330** (.000013)	77.46** (35.41)	80.01 (61.24)	5880** (1292)	-91.69 (229.9)	223.2 (191.4)	-.0231 (.0302)	321.9 (885.2)
Niacin (mg x 10)	8.73**	.244	-6.964** (1.587)	.00109 (.00208)	.00000047** (.00000016)	.8443** (.4253)	1.172 (.736)	15.08 (15.53)	.932 (2.762)	1.860 (2.298)	-.000672* (.000363)	45.98** (10.63)
Thiamin (mg x 100)	9.50**	.262	-3.179** (1.236)	-.0057** (.0016)	.00000092** (.00000012)	.0610 (.3311)	1.529** (.573)	-6.94 (12.09)	1.137 (2.150)	3.318* (1.789)	-.000754** (.000283)	32.88** (8.27)
Riboflavin (mg x 100)	6.34**	.183	-4.451** (1.747)	-.00080 (.0023)	.00000043** (.00000017)	1.031** (.468)	1.255 (.809)	33.84** (17.09)	.788 (3.039)	3.951 (2.529)	-.000644* (.000400)	40.86** (11.69)
Vitamin B6 (mg x 100)	7.85**	.222	-7.065** (1.341)	.0010 (.0017)	.00000043** (.00000013)	.8418** (.3592)	1.546** (.6213)	9.75 (13.11)	-.765 (2.333)	2.428 (1.941)	-.000408 (.000307)	43.45** (8.98)
Vitamin B12 (mg x 100)	2.74**	.068	-15.50 (16.09)	-.0088 (.0211)	.0000014 (.0000016)	9.423** (4.311)	-6.779 (7.456)	932.4** (157.4)	28.05 (27.99)	-4.59 (23.29)	-.00489 (.00368)	-2.7 (107.7)
Vitamin C (mg)	3.08**	.080	-7.387* (1.265)	-.00343** (.00166)	.00000066** (.00000012)	.2067 (.3389)	1.436** (.5862)	33.78** (12.37)	2.370 (2.201)	.459 (1.832)	-.000656** (.000290)	9.829 (8.473)

Table 2. Continued

Dependent Variable	SB x RUR	SB x BL	SB x INC	WIC	WIC x BL	WIC x INC	BON	BON x RET	BON x BL	BON x STD	BON x SNGL	BON x INC
Energy (kcal)	- 253.7** (69.6)	-398.8** (72.4)	-.00591 (.00982)	796.2** (135.0)	-240.8** (118.7)	-.1261 (.0212)	.1544 (.9721)	5.582** (2.513)	1.270* (.761)	-26.87** (10.21)	7.197** (3.770)	.0000779 (.000160)
Protein (g)	-127.5** (30.5)	-172.7** (31.7)	-.00714* (.0043)	258.7** (59.2)	-117.0** (52.0)	-.0429** (.0093)	.4350 (.4260)	3.314** (1.101)	.4316 (.3337)	-12.45 (4.478)	1.233 (1.652)	-.0000025 (.000070)
Calcium (mg)	-70.93** (42.74)	-147.03** (44.46)	-.0111* (.0060)	136.9* (82.93)	-35.18 (72.92)	-.0309** (.0131)	-.3800 (.5970)	1.762 (1.543)	.2475 (.4674)	-6.985 (6.274)	.5805 (2.315)	.000098 (.000098)
Iron (mg x 10)	-12.88** (5.92)	-22.55** (6.16)	-.00079 (.00084)	81.31** (11.49)	-26.76** (10.11)	-.0110** (.0018)	.0633 (.0827)	.2760 (.2139)	.0969 (.0648)	-2.203** (.869)	.2647 (.3209)	.0000013 (.000014)
Phosphorus (mg)	-151.98** (49.47)	-262.61** (51.46)	-.0130* (.0069)	427.33** (95.98)	-2.77 (84.39)	-.0754** (.0151)	.0557 (.6909)	3.315* (1.786)	.6236 (.5411)	-17.74** (7.26)	3.272 (2.679)	.000116 (.000114)
Vitamin A (I.U.)	81.4 (700.8)	-375.2 (729.0)	.0044 (.0989)	2856** (1359)	-1933* (1195)	-.3537* (.2143)	13.64 (9.79)	5.50 (25.29)	-7.750 (7.665)	16.4 (102.8)	28.12 (37.98)	-.00137 (.00161)
Niacin (mg x 10)	-29.27** (8.42)	-33.76** (8.76)	-.00217* (.00119)	80.81** (16.33)	-37.05** (14.36)	-.0101** (.0026)	.2375** (.1175)	.5318* (.3038)	.0958 (.0921)	-3.679** (1.236)	.9574** (.4560)	-.000026 (.000019)
Thiamin (mg x 100)	-22.99** (6.55)	-32.05** (6.81)	-.00054 (.00092)	68.91** (12.71)	-12.67 (11.18)	-.0107** (.0020)	.0392 (.0915)	.4360* (.2365)	.1478** (.0716)	-2.694** (.9618)	.7256** (.3549)	-.0000013 (.000015)
Riboflavin (mg x 100)	-22.31** (9.26)	-34.44** (9.63)	-.00193 (.00130)	68.51** (17.97)	-17.18 (15.80)	-.0104** (.0028)	.2716** (.1294)	.1348 (.3344)	.0347 (.1013)	-2.560* (1.359)	.8337* (.5017)	-.0000314 (.0000213)
Vitamin B6 (mg x 100)	-28.66** (7.11)	-29.31** (7.39)	-.00248** (.0010)	82.51** (13.79)	-12.99 (12.13)	-.0123** (.0022)	.2158** (.0993)	.4003 (.2566)	.0870 (.0777)	-2.835** (1.043)	.4132 (.3850)	-.0000246 (.0000164)
Vitamin B12 (mg x 100)	4.79 (85.31)	-62.82 (88.75)	.0045 (.0120)	390.14** (165.53)	-107.5 (145.5)	-.0513** (.0261)	2.496** (1.191)	-1.955 (3.079)	-.8688 (.9331)	-8.93 (12.52)	2.36 (4.62)	-.000291 (.000196)
Vitamin C (mg)	-4.046 (6.709)	-1.560 (6.978)	-.000616 (.000947)	27.73** (13.01)	-20.19* (11.44)	-.0052** (.0020)	-.0440 (.0937)	.1221 (.2422)	.0035 (.0734)	-1.221 (.985)	-.5813* (.3633)	.0000061 (.000015)

[a] The variables are: SIZEH = household size (# of persons in household); INC = income ($); MED = education of male head (years); FED = education of female head (years); MEALS = participation in organized group meal service for the elderly (0 = No; 1 = Yes); SL = participation in the school lunch program (# lunches/week); BL = black (0 = No; 1 = Yes); SB = participation in the school breakfast program (# breakfasts/week); RUR = rural (0 = No; 1 = Yes); WIC = participation in the WIC program (# persons in the household); BON = participation in the food stamp program (bonus value of stamps received); RET = retired (0 = No; 1 = Yes); STD = student (0 = No; 1 = Yes); SNGL = single (0 = No; 1 = Yes).

[b] Standard errors are in parentheses; ** = significantly different from zero at the 5 percent level.
* = significantly different from zero at the 10 percent level.

any nutrient. However, the SL × BL interaction variable is positive and significant for energy and thiamin, implying that the School Lunch Program has a stronger impact on the consumption of these two nutrients for a black person than for a nonblack person[9] (Table 2). Also, the SL × INC interaction variable has a negative and significant impact on the consumption of seven nutrients. It follows that the marginal nutri-

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[9] This result implies that either school lunches of blacks and whites are nutritionally different or that the degree of substitution between school lunch and family meal differ between white and black persons.

Table 3. Selected Estimates of the Impacts of Income and Food Programs on Nutrient Intakes.[a,b]

Item	Energy (kcal)	Protein (g)	Calcium (mg)	Iron (mgx10)	Phosphorus (mg)	Vit. A (I.U.)	Niacin (mgx10)	Thiamin (mgx100)	Riboflavin (mgx100)	Vit. B6 (mgx100)	Vit. B12 (mgx100)	Vit. C (mg)
Income												
$\partial \hat{Y}_i/\partial INC^c$												
INC = $2,000	.0221 [.024]	.0094 [.023]	-.0064 [-.021]	.0022 [.031]	-.0057 [-.010]	-.028 [-.016]	.0030 [.030]	-.002 [-.031]	.001 [.044]	.003 [.044]	-.003 [-.019]	-.001 [-.032]
INC = $8,000	.0883** [.323]	.0330** [.292]	.0178 [.225]	.0084** [.418]	.0473** [.300]	.368 [.687]	.0064** [.230]	.0091** [.497]	.0061* [.317]	.0080** [.415]	.014 [.327]	.007** [.746]
Meal Service												
$\partial \hat{Y}_i/\partial MEALS$	9.83	45.32	18.27	17.83*	15.47	5880**	15.08	-6.94	33.84**	9.75	932.4**	33.79**
School Lunch												
$\partial \hat{Y}_i/\partial SL$												
White	-1.59	2.60	-.19	1.73	-.52	-137.7	-.41	-.37	-.5	-1.58	1827	1.06
Black	37.02	8.38	16.43	2.92	15.88	85.50	1.45	2.95	3.45	.85	13.68	1.52
School Breakfast												
$\partial \hat{Y}_i/\partial SB$												
Urban White	336.9**	167.1**	138.26**	19.28**	233.6**	330.8	50.31**	31.78**	37.00**	38.47**	11.87	8.60
Rural White	83.19	39.60	67.33	6.40	81.60	412.2	21.04	8.79	14.69	9.81	16.66	4.55
Urban Black	-61.93	-5.61	-8.77	-3.26	-29.03	-44.40	16.55	-.27	2.56	9.16	-50.95	7.04
WIC												
$\partial \hat{Y}_i/\partial WIC$												
White	544.0**	172.9**	75.18	59.31**	276.5**	2148	60.6**	47.5**	47.9**	57.9**	298.5*	17.2
Black	303.2*	55.9	40.00	32.55**	273.7**	215	23.6	34.8**	30.7	44.9**	180.0	-2.96
Food Stamps												
$\partial \hat{Y}_i/\partial BON$												
White	.310	.430	-.183	.066	.286	10.9	.185	.038	.209	.167	1.91	-.032
White Retired	5.89**	3.744**	1.58	.342	3.60*	16.4	.717**	.511**	.343	.567**	-.041	.090
Black	1.58	.861	.064	.163	.909	3.17	.281*	.185	.243	.254*	1.045	-.028
White Student	-26.56**	-12.02**	-7.17	-2.14*	-17.5**	27.3	-3.50**	-2.65**	-2.35*	-2.67**	-7.02	-1.25

[a] Unless otherwise indicated, these results are for a white person, living in a city or a suburb, not single, not a student, not retired, and with a family income of $2,000. $\hat{Y}_i$ denotes the predicted value of Y_i from the model.

[b] ** = significantly different from zero at the 5 percent level.
   * = significantly different from zero at the 10 percent level.

[c] Income elasticities $[\partial \hat{Y}_i/\partial INC) \bullet (INC\hat{Y}_i)]$ are in brackets below the estimated marginal effects $(\partial \hat{Y}_i/\partial INC)$.

tional impacts of the School Lunch Program ($\partial Y_i/\partial SL$) tend to decrease as income increases. For a $2,000 income, these marginal impacts are presented in Table 3. The results show that while the School Lunch Program affects a black person more favorably than a white person, school lunch participants do not exhibit a significant increase in their overall nutritional status. Although such findings differ from those of Price et al., they are in agreement with results obtained by Hoagland.

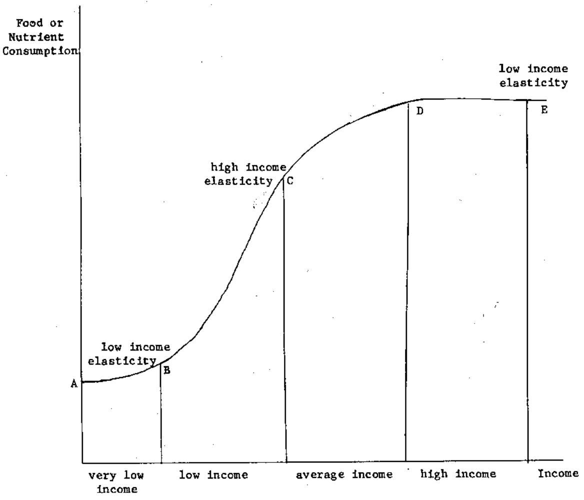

Figure 1. Typical Engel Curve

The School Breakfast Program (SB = number of school breakfasts/week) interacts with location (RUR = 1 for rural; O otherwise), race (BL) and income (INC) (Table 2). Except for vitamin A, vitamin C, and vitamin B12, the coefficient of the school breakfast variable SB is positive and significant. Also, the interaction variables SB × RUR, SB × BL and SB × INC are significantly different from zero for a number of nutrients.[10] In particular, when significant, each variable has a negative influence on nutrient intake, implying that living in a rural area, being black, or having a high income tends to decrease the marginal impact of the School Breakfast Program ($\partial Y_i/\partial SB$). These marginal impacts, presented in Table 3, show that participating in the School Breakfast Program increases the intake of all nutrients for urban white persons. These results show that the School Breakfast Program involves the overall nutritional status of white urban children from low-income households. However, such evidence does not exist for other groups. Indeed, the marginal impacts presented in Table 3 imply that the influence of the School Breakfast Program on nutrient intakes is small and not significantly different from zero when participants are rural white or urban black. It suggests that the School Breakfast Program may be biased toward white persons living in urban areas.

The WIC program, like the School Lunch Program,

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[10] Note that the interaction variable (SB X INC) has a rather weak effect: its coefficient is significantly different from zero (at the 10-percent level) for only five nutrients.

enters the model with interactions with race (BL) and income (INC) (Table 2). The coefficient of the WIC variable is positive and significant for all nutrients. The coefficients of the interaction variables WIC × BL and WIC × INC are negative for all nutrients and significant for a number of them (Table 2). This suggests that WIC is very effective at increasing nutrient intakes of low-income persons, but rapidly loses effectiveness with increasing income. It also provides some evidence that WIC may be more effective for whites than for blacks. These results are further illustrated by the marginal impacts of WIC presented in Table 3. They indicate the effectiveness of WIC in improving nutritional status, as well as its possible bias toward white persons.

Finally, the Food Stamp Program is analyzed through the impact of the food stamp bonus (BON) and its interaction with RET (= retired), BL (= black), STD (= student), SNGL (= single) and INC (= income), (Table 2). The coefficient of the bonus variable, when significant, is positive, as in the case of niacin, riboflavin, vitamins B6 and B12. The positive and significant coefficients of the BON × RET and BON × BL variables indicate that being retired or being black tends to increase the effectiveness of the Food Stamp Program for some nutrients. However, being a student appears to lower its effectiveness, as evidenced by the negative and significant coefficients of the BON × STD variable for 7 of the 12 nutrients. Finally, the BON × INC interaction variables do not have a significant impact on nutrient intake for any of the nutrients. In general, Table 2 indicates that black, retired persons and one-member households are more responsive to bonus stamps than white, nonretired and multimember households for some nutrients. These results are further illustrated in Table 3, where the marginal impacts of the Food Stamp Program ($\partial Y_i/\partial BON$) are presented for a \$2,000 income level. For a nonstudent participant, these marginal impacts are, in general, positive (Table 3). However, they are not significantly different from zero for a white, nonretired person. For a white retired or a black person, the marginal effects of the bonus tend to be larger and more significant. For example, the Food Stamp Program significantly increases the intake of energy, protein, phosphorus, niacin, thiamin, and vitamin B6 for a white, retired person (Table 3). However, for a white student, the marginal impact of bonus is found to be negative and significant for a number of nutrients.[11] If the objective of the Food Stamp Program is to improve nutrient intake, these results raise a question about the eligibility of students to participate in the program.

NUTRITIONAL ACHIEVEMENT

The model just presented can be used to predict the nutritional status of a particular individual, given its anthropomorphic, economic and socio-demographic characteristics. Selected estimates of individual nutrient intakes (Y_i) are presented in Table 4, along with their standard errors. For illustration, the predicted intakes for a white male, living in a suburb, in the northeastern United States, in a family of four, with a family income of \$2,000.[12] The large standard errors reported in Table 4 reflect the unaccountable variability among individuals.

In Table 4, the estimated nutrient intakes are used to evaluate the nutritional achievement of individuals of different ages (10, 40, and 70 years old) and under selected food programs (School Breakfast, School Lunch, Food Stamps, and Meal Service for the Elderly). This is done by comparing the estimated intakes (Y_i) to the Recommended Daily Allowances[13] (RDA) published by the Food and Nutrition Board of the National Academy of Science. These allowances are not average nor minimum requirements. Except for energy, they are designed to afford a margin sufficiently above average nutritional requirements to cover most of the individual variations. For this reason, dietary records are frequently evaluated on the basis of achieving at least two-thirds of the RDA, except for energy, where the target is usually 100 percent of the RDA[14] (Food and Nutrition Board).

In order to investigate the nutritional achievement of individuals, nutrient adequacy ratios (NAR), defined as the ratio of nutrient intake (Y_i) to the RDA, are calculated (Table 4). They show that protein and phosphorus intakes are more than adequate, with NAR being well above 1. They also indicate possible nutritional problems with NAR as low as 0.66 for energy or 0.56 for vitamin B6. However, because of the great individual variation in nutrient needs, such results should be interpreted with caution. Indeed, because of the manner in which the RDA are established, they can be used only to assess the *risk* of malnutrition that an individual incurs (Food and Nutrition Board). In an attempt to measure this risk, the probability that the estimated nutrient intake (Y_i) falls below some reference level K_i is calculated, assuming a normal distribution. The reference level K_i is taken to be two-thirds of the RDA for all nutrients, except for energy, where K_i = RDA. This probability is indicated by asterisks in Table 4. The higher this probability, the higher the risk of malnutrition for a particular individual.

The results suggest a serious underconsumption of energy by low-income persons. Without food programs and for any age, the probability that energy intake is less than its RDA is at least 0.9. The school breakfast for children (with SB = 2) reduces this probability substantially by increasing the NAR from 0.66 to 0.93.[15] However, the School Lunch Program, the Food Stamp Program, and the Meal Service for the Elderly appear to give only marginal improvement in

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[11] This may reflect the fact that students may have, in general, little concern for the quality of their diet.

[12] Nutritional achievements for other socio-demographic characteristics have also been calculated but are not presented here because of space limitation. They can be obtained from the author upon request.

[13] The RDA take sex and age of persons into consideration.

[14] This is because both underconsumption and overconsumption of energy have adverse health effects.

[15] Since both underconsumption and overconsumption of energy have adverse health effects, the optimum NAR for energy is probably around 1, with a 0.5 probability of underconsumption and a 0.5 probability of overconsumption.

Table 4. Selected Estimates of Individual Nutrient Intakes and Nutrient Adequacy Ratios (NAR).[a,b]

Item	Energy (kcal)	Protein (g)	Calcium (mg)	Iron (mgx10)	Phos-phorus (mg)	Vit. A (I.U.)	Niacin (mgx10)	Thiamin (mgx100)	Ribo-flavin (mgx100)	Vit. B6 (mgx100)	Vit. B12 (mgx100)	Vit. C (mg)
10 years old[c]												
SB = SL = BON = 0	1690****	674	815*	100*	1160	3027*	160	131	166	124*	272*	67*
	(580)	(254)	(356)	(49)	(412)	(5840)	(70)	(54)	(77)	(59)	(710)	(55)
NAR	.66	1.68	.81	.71	1.16	1.07	.94	1.0	1.11	.73	.91	1.42
SL = 2	1687****	679	814*	104*	1159	2751*	160	130	165	121*	309*	69
	(579)	(254)	(356)	(49)	(412)	(5838)	(70)	(54)	(77)	(59)	(710)	(55)
NAR	.66	1.69	.81	.74	1.16	.97	.94	1.0	1.10	.71	1.03	1.47
SB = 2	2364**	1008	1091	139	1628	3688*	243	194	240	201	285*	84
	(579)	(261)	(366)	(51)	(424)	(6015)	(72)	(56)	(79)	(61)	(732)	(57)
NAR	.93	2.52	1.09	.99	1.63	1.30	1.43	1.49	1.60	1.18	.95	1.79
BON = 200	1752****	760	778*	114*	1218	5209*	197	139	208	158	655*	61*
	(592)	(260)	(364)	(50)	(421)	(5969)	(72)	(56)	(79)	(60)	(726)	(57)
NAR	.69	1.9	.78	.81	1.22	1.84	1.16	1.07	1.39	.93	2.18	1.30
40 years old[c]												
BON = 0	1850****	778	596*	129	1135	3267*	189	125*	133*	123**	313*	58*
	(582)	(255)	(358)	(50)	(414)	(5866)	(70)	(55)	(77)	(59)	(714)	(56)
NAR	.68	1.39	.74	1.29	1.42	.98	1.05	.89	.83	.56	1.04	.97
BON = 200	1912****	864	559*	142	1193	5448*	226	132	174	156*	696	52*
	(595)	(261)	(365)	(51)	(423)	(5991)	(72)	(56)	(79)	(61)	(729)	(57)
NAR	.71	1.54	.70	1.42	1.49	1.63	1.25)	.94	1.09	.71	2.32	.87
70 years old[c]												
BON = MEALS = 0	1662****	718	583*	122	1078	5916*	175	128	157	130**	620*	60*
	(582)	(255)	(358)	(50)	(414)	(5869)	(70)	(54)	(77)	(59)	(714)	(56)
NAR	.69	1.56	.73	1.22	1.35	1.77	1.09	1.07	1.12	.59	2.07	1.0
MEALS = 1	1672***	764	601*	139	1094	11797	190	122	191	140**	1552	94
	(595)	(260)	(365)	(51)	(423)	(5993)	(72)	(56)	(79)	(61)	(729)	(57)
NAR	.70	1.66	.75	1.39	1.37	3.54	1.19	1.02	1.36	.64	5.17	1.57
BON = 200	1724***	804	547*	135	1136	8098	212	136	198	164*	1003	54*
	(596)	(261)	(366)	(51)	(424)	(6006)	(72)	(56)	(79)	(61)	(731)	(57)
NAR	.72	1.75	.68	1.35	1.42	2.43	1.32	1.13	1.41	.74	3.34	.90

[a] These results are for a white male living in the suburbs in the North-East of the United States, in a family of 4 with family income of $2,000.

[b] Standard errors for predicted individual nutrient intakes are in parentheses below the predicted intakes ($\hat{Y}_i$). Nutrient adequacy ratio are calculated as NAR: $= \hat{Y}_i/RDA_i$, where RDA_i = recommended daily allowances. Finally, nutritional risk is evaluated by the probability: $P_r[\hat{Y}_i \leqslant K_i]$, where $K_i = RDA_i$ for energy and $K_i = 2/3 \bullet RDA_i$ for other nutrients: **** = ($P_r \geqslant .9$); *** = ($.9 \geqslant P_r \geqslant .75$); ** = ($.75 \geqslant P_r \geqslant .5$); * = ($.5 \geqslant P_r \geqslant .25$).

[c] Height and weight used in the calculation of predicted nutrient intake are the mean height and weight for a particular age, as reported by the *Food and Nutrition Board*.

energy intake. This illustrates the differential impact of the domestic food programs on nutritional achievement of low-income persons. This differential impact is likely due to varying degrees of substitution for food intake between the different food programs and family meals.

The results in Table 4 show some risk of malnutrition for calcium, vitamin A, vitamin B6, vitamin B12, and vitamin C: without food programs, the probability of underconsumption of these nutrients is at least 0.25 at any age. Also, possible nutritional problems are identified for children (10 years old) with respect to iron, and for adults (40 years old) with respect to thiamin and riboflavin.

Although participation in the domestic food programs tends to increase NAR for most nutrients, the effects vary with the program. For example, the School Lunch Program appears to provide only a marginal improvement in nutrition, while the Food Stamp Program generates a large increase in NAR for vitamin A and vitamin B12. The School Breakfast Program is found to improve the nutritional status of participants for most nutrients, suggesting that it is a very effective food program for urban white children. Finally, the Meal Service for the Elderly exhibits a rather small increase in NAR for most nutrients, except for vitamin A, vitamin B12, and vitamin C, which show substantial improvement.

SUMMARY AND CONCLUDING REMARKS

This study investigated the impact of domestic food programs as well as selected socio-demographic variables on nutrient intake for low-income persons in the United States. The main results of the analysis can be summarized as follows:

1. Individual nutrient intake decreases significantly with the size of the household, implying that members of large households are more likely to be at nutritional risk.
2. Nutrient consumption is not responsive to income for very low-income households, implying that income transfers are not effective in improving the diet of members of such households. It is only for average-income families that this responsiveness becomes important and statistically significant.
3. Education of the household head tends to be positively related to nutrient intake, implying that poorly educated families are more likely to be at nutritional risk.
4. The WIC program appears to be very effective in improving the nutritional status of its participants. Its impact on a number of nutrients is positive and significant. This effectiveness may not be surprising since WIC is very precisely targeted and highly controlled. Only pregnant and breast-feeding women, and infants and children under four years of age are eligible. In addition, the applicants must show evidence of nutritional deficiency. Finally, the implementation of WIC involves the delivery of selected food items to the recipients. Such factors are probably the key of the nutritional success of the WIC program.
5. The Meal Service for the Elderly also appears

reasonably effective in that it significantly increases the intake of a number of nutrients.

6. The School Lunch Program does not have a significant influence on the consumption of any of the nutrients investigated. As such, it is the least effective of the nutrition programs analyzed.
7. The Food Stamp Program and the School Breakfast Program do exhibit some positive influence on nutrient intakes. However, such effects appear to depend critically on the socio-demographic characteristics of the participants. For example, the School Breakfast Program appears to be very effective for white urban children. However, its impact on the nutritional achievement of black or rural children is not statistically significant, suggesting that the School Breakfast Program may be biased toward white urban individuals. Similarly, the Food Stamp Program exhibits some nutritional effectiveness for black or retired individuals. However, its influence on the nutrient intake of white, nonretired persons is small and statistically nonsignificantly different from zero. Finally, our results indicate, that, if the objective of the Food Stamp Program is to improve the nutritional achievement of participants, then students should not be eligible to participate.
8. Without domestic food programs, some evidence of nutritional risk for low-income persons is found for energy, calcium, and vitamins A, B6, B12, and C. Also, possible nutritional risk is identified for children with respect to iron and for adults with respect to thiamin and riboflavin. Depending on the program and the socio-demographic characteristics of the individual, the improvement in the nutritional status of the particular food program can vary from marginal to substantial.

These findings illustrate the importance of interaction variables in consumption models. When such variables involve policy variables, the models can then provide evidence on how the effectiveness of a particular program may vary with the socio-demographic characteristics of the recipients. Such evidence can be used to evaluate current domestic food programs and can help better define target groups for particular policy actions.

Although our analysis helps improve our understanding of nutrient intake of low-income persons, more research is needed to further evaluate the influence of domestic food programs on nutritional achievement. For example, our results are subject to the limitations of food-recall information (Madden et al.). A complete nutritional impact assessment would require an investigation of dietary, biochemical, and clinical data of low-income individuals.

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