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AN ECONOMIC ANALYSIS OF THE DIET, GROWTH, AND HEALTH OF YOUNG CHILDREN IN THE UNITED STATES

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ABSTRACT

The purpose of this paper is to investigate the extent to which family income and education are obstacles to the provision of adequate diets for young children in the United States. An examination of the Health and Nutrition Examination Survey reveals the following:

1. Average nutrient intakes of young children are well above recommended dietary standards, with the exception of iron.

2. Average nutrient intakes for children in households of lower economic status are very similar to intakes of children in households of higher economic status. Rates of children's growth are also similar in these households.

3. Family income and education of the household head have statistically significant but very small positive effects on the nutrient intake levels of young children.

4. There are substantial effects of protein intakes on children's height and head growth, even though protein is consumed in excess of dietary standards. This finding and the apparent correlation between children's growth and their intellectual development brings to question the adequacy of present protein standards. Could American mothers, who provide very high protein diets for their children in households at all levels of socioeconomic status know more about what constitutes an adequate diet for their children than the experts do?

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"One out of every three children under six years of age are living in homes in which incomes are insufficient to meet the costs of procuring many of the essentials of life, particularly food." Congressional testimony of Charles Upton Lowe, Director of the National Institute of Child Health and Development, 1969 (Chase, 1977).

I. Introduction

Interest in the nutritional status of young American children has heightened considerably in the past decade. Much of the concern has resulted from research suggesting varying degrees of under-nutrition in low income American school[1] and pre-school children and from evidence indicating a positive association between children's growth and their intellectual development.[2] In this paper we analyze the choice of diet for children one to five years in the United States and its relation to the children's growth and health. We are particularly interested in the extent to which family income and education may be obstacles to the provision of adequate diets for children in American families. The hypothesis that these obstacles are substantial underlies many government nutrition and income support programs and has led to the Congressional mandate of two separate comprehensive national nutrition surveys, The Ten State Nutrition Survey, 1968-1970, and the Health and Nutrition Examination Survey, 1971-1975.

In a previous paper we used the Ten State Nutrition Survey (TSNS) data to examine the nutritional status of children up to the age of 36 months in poor American families (Chernichovsky and Coate, 1978). The picture that emerged from the analysis of TSNS data was generally contrary to the impressions left by much previous research. The data indicated that low income parents had pushed the growth of their children through choice of diet nearly as much as possible. Protein, a relatively high priced nutrient, was consumed in quantities two to three times recommended dietary standards and to an extent where its marginal impact on the growth of children was very small. Family income and mother's education were shown not to be significant (in the statistical sense) barriers to the provision of adequate protein and calorie intakes for children in poor American families. In the TSNS data average protein and calorie consumption was in excess of dietary standards whether the data was stratified by children's age, family income, or ethnic group. Protein intakes in these cross-tabulations were consistently two to three hundred percent of dietary standards.

In this paper we analyze the Health and Nutrition Examination Survey (HANES) data to provide further evidence on the choice of diet for young American children and its effect on their growth and health. This paper is divided into five sections. In the following section we describe the conceptual framework and specify a general model of children's diet, health, and growth. This is followed by a discussion of the data that includes important descriptive statistics. In Section IV, we present the estimated econometric model. The final section summarizes the research.

II. Conceptual Framework

As a point of departure we postulate that the utility of parents is a positive function of their children's growth. That is, within the bounds of perceived norms, parents desire heavier and taller children.[3] For our analysis it is not necessary that this desire be based on known correlations between current period height and weight of children and their current and future period health status and intellectual development. Rather, we only argue that this desire does exist and that parents make sacrifices or forego other pleasures in order to augment the growth of their children.[4]

Although constrained by genetic and physiological factors, parents influence the growth of their children by their choice of diet for the children and by their investment in their children's health (medical care, parental care, sanitary conditions, etc.). The interdependencies among children's growth, children's health and their diet are formalized in the following model.

We begin by relating the parent's choice of the initial diet, D_o, for a new born to birth weight, BW, which is a proxy for the infant's demand for food, and initial period socioeconomic influences, E_o, that impact on the quantity and quality of diet.

$$D_o = f^o(BW, E_o). \tag{1}$$

In each subsequent period the child's growth, G_t, is determined by genetic and parental traits, Z, and by diet, D_{t-1}, and health status, H_{t-1}, in the preceding period. Health status can be interpreted as an efficiency parameter that affects the rate at which nutrients are converted into children's growth. Formally,

$$G_t = f\ (Z, D_{t-1}, H_{t-1}). \tag{2}$$

The diet in each period is a function of the child's growth, which serves as a proxy for appetite or the child's demand for food, and the economic status of the household.

$$D_t = g(G_t, E_t). \tag{3}$$

The child's health status is a function of his diet, growth and other inputs which produce good health, X_t,

$$H_t = h(X_t, G_t, D_t). \tag{4}$$

The levels of X_t are determined by socioeconomic status:

$$X_t = e(E_t). \tag{5}$$

In order to statistically identify certain key relationships and to make the model consistent with available cross-section data, several assumptions are necessary, some of which are explicit in equations 1-5. First, birth weight is considered exogenous to our model of children's growth, diet and health. A more sophisticated model could include birth weight as an endogenous variable and relate it to parental characteristics, diet of the mother and socioeconomic variables. We also assume that some variables are serially correlated (e.g., diet, household income) or constant (e.g., mother's education, parental traits) over t and that the time increments are infinitesimal.

To isolate the role of diet as a bridge from socioeconomic status to children's growth, we can, given the assumptions detailed above, derive the following simultaneous equations from (2), (3), and (4):

$$G = g(\hat{D}, \hat{H}, t, Z, BW) \tag{6}$$

$$D = f(\hat{G}, E) \tag{7}$$

$$H = h(\hat{D}, \hat{G}, E) \tag{8}$$

which specifies D, G, and H as endogenous variables. Equation (6) is basically a technical relationship, describing how children's growth responds to diet and health levels, given age, birth weight and parental and genetic characteristics. Equations (7) and (8) are primarily behavioral relationships, explaining the choice of diet in the household for the children, given socioeconomic constraints, and the subsequent influence of diet and growth on health levels.

III. The Data

HANES is a national sample of the population of the United States, with oversampling of low income families. The entire HANES sample, which was collected between 1971 and 1975 by the National Center for Health Statistics, contains approximately 28,000 individuals between the ages of 1 and 74. Slightly less than 3,000 children aged 1 to 5 years were included in the sample. Dietary intake data for the previous 24 hours were collected for children less than five years of age by interview of the homemaker. A working sample of 2515 was created by deleting all observations (children) with missing data. The roughly 450 children deleted from the sample did not differ significantly from the working sample in terms of age and sex specific nutrient intakes or height, head, and weight growth. HANES is described in detail by the National Center for Health Statistics (1973, 1977).

Descriptive statistics for variables collected in HANES relevant to our analysis are presented in Table 1. Endogenous variables in our econometric specifications are selected from the measures of children's diet, health, and growth. Measures of children's growth are height, weight, and head circumference. Measures of children's health are lifetime number of overnight hospitalizations and number of colds in the six months prior to the medical history. Children's diet is measured by calorie, protein, calcium, iron, vitamin A and vitamin C intakes.

Exogenous variables in the growth equations are measures of genetic and parental traits, namely children's age, sex, birth weight, birth order, race, mother's height and weight, and father's height. Exogenous variables in the nutrient intake and health equations are family income, family size, and dummy variables representing education of the household head and whether the head is female.

Table 1

Summary Statistics

Variable	Mean	Standard Deviation
Daily calories	1516	584
Daily protein (gm)	55.84	23.06
Daily Vitamin C (mg)	78.45	86.73
Daily iron (mg)	8.01	4.51
Daily calcium (mg)	872	469
Daily Vitamin A (IU)	3576	3743
Weight (kg)	15.48	3.82
Height (cm)	97.86	11.95
Head circumference (cm)	49.23	2.21
Hospitalizations	.30	.45
Colds (last six months)	1.42	1.32
Age (months)	42.63	17.62
Sex (1 = male)	.51	.50
Birth weight (oz.)	115.94	19.80
Birth order	1.45	2.19
Race (1 = non-white)	.23	.42
Mother's height (in.)	64.05	2.69
Father's height (in.)	69.87	3.18
Mother's weight (lbs.)	139.14	29.21
Household income	9280	5563
Household size	5.05	2.03
Years of schooling of household head		
Schooling 1 (1 = less than 12)	.37	.46
Schooling 2 (1 = 12)	.38	.48
Schooling 3 (1 = 13 to 16)	.19	.39
Schooling 4 (1 = more than 16)	.06	.24
Sex of household head (1 = female)	.16	.36

The mean family income of $9,280 is considerably below the 1972 national average of $12,500 and is indicative of the oversampling of low income families. The mean calorie and protein intakes of 1516 and 56 grams are considerably above the protein and calorie standards of roughly 1330 and 26 grams for children of the age and weight corresponding to the sample means.[5] This finding of higher average protein and calorie intakes than dietary standards is not surprising given the similar results from the TSNS, a sample characterized by significantly lower family incomes. Children's intakes of calcium, vitamin A and vitamin C average two to three times recommended dietary standards in the HANES working sample. In the case of iron, the average intake is two-thirds of dietary standards.

In column 1 of Table 2, levels of growth, health, and nutrient intakes are presented for children in households falling into the upper and lower thirty percentiles of the poverty index (PIR) distribution.[6] There are no significant differences in height, weight, or head growth between these groups, nor in protein, calorie, vitamin A, or iron intakes. In the cases of vitamin C and calcium intakes a statistically significant difference emerges in favor of the higher PIR group. For both groups mean nutrient intake levels consistently exceed dietary standards, with the exception of iron. There are also no significant differences in hospitalizations although the lower PIR group had a significantly greater number of colds in the six months prior to the medical history. The average family income and household size for the higher PIR group are $14,766 and 4.2. The same figures for the lower PIR group are $3,673 and 5.7.

In the remaining portion of Table 2 similar high and low PIR comparisons are made for blacks and for whites in the working sample. The patterns of statistical significance within these stratifications are similar to that for the sample as a whole.

Table 2

Mean Levels of Growth, Nutrient Intakes, and Health for Families in the Upper and Lower Thirty Percentiles of the Poverty Index Distribution[a]

	All Families			White Families			Non-White Families		
	Lower Thirty Percentile	Upper Thirty Percentile	t[b]	Lower Thirty Percentile	Upper Thirty Percentile	t[b]	Lower Thirty Percentile	Upper Thirty Percentile	t[b]
Daily calories	1498	1510	.45	1520	1514	-.19	1475	1469	-.10
Daily protein (gm)	54.96	56.14	1.08	56.46	56.26	-.15	53.44	55.00	.55
Daily Vitamin C (mg)	69.12	87.43	5.18	67.64	87.94	4.64	70.62	82.56	1.33
Daily iron (mg)	7.89	8.23	1.56	7.97	8.27	1.01	7.80	7.86	.15
Daily calcium (mg)	819	922	4.82	910	935	.93	72.54	79.67	1.33
Daily Vitamin A (IU)	3577	3694	.42	3621	3595	-.16	3532	4177	1.08
Weight (kg)	15.42	15.51	.53	15.41	15.50	.43	15.42	15.54	.27
Height (cm)	97.63	97.94	.57	97.14	97.99	1.31	98.14	97.51	-.43
Head (cm)	49.17	49.24	.80	49.09	49.24	1.21	49.24	49.30	.24
Hospitalizations	.31	.29	-.72	.32	.30	-.91	.29	.24	-1.03
Colds (last six months)	1.51	1.31	-3.46	1.46	1.29	-2.43	1.57	1.54	-.20

[a]The sample sizes for the lower and upper thirty percentiles are, for the entire sample, 1036 and 918; for whites, 521 and 831; for non-whites 515 and 87. The imbalance in the white and non-white categories results from the use of the entire sample thirty percentile cut-off values for these sub-sample stratifications.

[b]t values are for significance test of difference between means.

Further information on the nutritional status of young American children can be obtained by examining the diets of children light for their age and sex. In our HANES working sample the calorie and protein intakes of children below the 10th percentile in weight for their age and sex are 1440 and 53 grams, not significantly different from the working sample means and indicative of more than adequate intakes of these nutrients according to dietary standards. The mean family income for this group of light children is $8470. Unless present and past nutrient intakes are not correlated, these numbers imply that influences other than diet may be responsible for producing the condition usually associated with undernutrition. The consideration of the emprical results in the next section will enable us to come to firmer conclusions about the role of socioeconomic variables in the choice of diet by parents for their children and about the subsequent effect of nutrient intakes on children's growth.

IV. Empirical Results

At the empirical level we have estimated several variations of our model of children's diet, health, and growth. With the exception of calories and protein, the nutrient intake variables did not approach statistical significance on the growth equations, either because of their high correlations with protein and calorie intakes or because they have very small impacts on growth at the margin. The health variables also performed poorly in the growth equations in the statistical sense, apparently because these conditions have minor or very short term growth effects that are rapidly overcome.

In the presentation of the empirical results, therefore, we emphasize a model with the following endogenous variables: height, weight, head circumference, protein intake, and calorie intake. We also report results for the colds variable and for vitamin C intake.

A. Reduced Forms

The reduced form relationships derived from equations (6)-(8) relate children's growth, health, and nutrient intakes to genetic and parental traits measured by age, sex, race, parent's heights, mother's weight, birthweight and birth order; and socioeconomic influences measured by household income, household size, and dummy variables indicating the education of the household head, and whether the head is female. The reduced form results are presented in Table 3. We are particularly interested in the children's growth reduced forms because of the information they provide on the significance of the genetic and parental trait variables versus the socioeconomic and behavioral indicators in the determination of children's growth. The results show that the latter set of variables are of limited significance in explaining children's growth. The family income and mother's education coefficients generally have low t-values and the addition of these variables and household size to children's growth regressions that already include the genetic and parental trait variables only slightly reduces the unexplained variance in the dependent variables.[7]

Another interesting aspect of the reduced form results is the low R^2's of the nutrient intake equations, none of which exceed .14. The fact that the exogenous variables in our model explain such a small proportion of the variation in nutrient intakes brings to question the importance of these variables in the diet decision for young children.

B. Children's Growth

The simultaneous equation estimates of the children's growth equations are presented in Table 4.[8] The protein variable has been excluded from the weight equation because it was statistically insignificant if calories were also included as an explanatory variable. Calories, however, approached statistical significance in these equations even when protein also appeared. The number of calories then seems to better explain weight growth than the protein content

Table 3

Reduced Form Estimates[a]

Independent Variables	Weight	Head Circumference	Height	Calories	Protein	Vitamin C	Colds
Constant	4.71	36.21	20.73	-278.48	6.06	17.76	2.81
	(3.59)	(34.61)	(8.45)	(-0.79)	(0.42)	(0.32)	(3.36)
Age	0.14	0.13	0.84	18.55	0.16	1.39	-0.01
	(11.16)	(14.27)	(34.20)	(5.24)	(1.13)	(2.47)	(-1.88)
Age squared	0.000	-0.000	-2.49	-0.09	0.001	-0.01	0.000
	(2.38)	(-7.90)	(-8.84)	(-2.45)	(0.75)	(-1.88)	(0.94)
Sex	0.42	1.12	0.81	149.05	4.17	9.09	-0.02
	(5.21)	(17.14)	(5.32)	(6.80)	(4.66)	(2.61)	(-0.43)
Birth weight	0.02	0.01	0.45	0.04	0.01	-0.03	0.001
	(12.53)	(9.18)	(10.12)	(0.07)	(0.65)	(-0.34)	(0.90)
Birth order	-0.05	-0.009	-0.08	-1.37	-0.16	-0.99	0.001
	(-1.92)	(-0.42)	(-1.55)	(-0.18)	(-0.56)	(-0.85)	(0.06)
Mother's weight	0.01	0.001	0.70	0.64	0.28	0.05	-0.001
	(5.95)	(1.13)	(2.41)	(1.55)	(1.67)	(0.79)	(-1.09)
Mother's height	0.07	0.05	0.37	8.38	0.09	-0.37	-0.001
	(4.54)	(4.32)	(12.15)	(1.91)	(0.51)	(-0.53)	(-0.16)
Father's height	0.05	0.03	0.24	6.72	0.30	0.39	-0.002
	(4.37)	(3.20)	(9.98)	(1.89)	(2.12)	(0.70)	(0.32)
Race	0.40	0.35	1.41	48.31	-2.61	0.42	0.29
	(3.45)	(3.82)	(6.42)	(1.54)	(-2.04)	(0.85)	(3.92)
Income	0.000	0.000	0.000	0.000	0.000	0.000	-0.000
	(2.15)	(1.77)	(2.77)	(0.13)	(0.60)	(2.37)	(-1.51)
Household size	-0.04	0.002	-0.10	18.77	0.80	-0.53	-0.02
	(-1.33)	(0.11)	(-1.93)	(2.32)	(2.43)	(-4.21)	(-1.41)
Schooling 2	-0.01	0.005	0.15	113.30	3.79	5.19	-0.12
	(-0.11)	(0.06)	(0.81)	(4.25)	(3.49)	(1.23)	(-1.94)
Schooling 3	-0.01	0.16	0.34	81.40	3.73	13.92	-0.05
	(-0.08)	(1.65)	(1.45)	(2.39)	(2.69)	(2.58)	(-0.69)
Schooling 4	-0.63	0.05	-1.40	56.97	3.78	9.22	0.08
	(-3.26)	(0.36)	(-3.84)	(1.09)	(1.78)	(1.11)	(0.66)
Sex of head	-0.18	0.09	-0.30	125.51	5.55	-1.44	-0.05
	(-0.14)	(0.95)	(-1.28)	(3.69)	(4.00)	(-2.67)	(-0.68)
$\bar{R}^2$	.71	.46	.89	.14	.08	.02	.03
F	278.9	96.0	973.0	18.8	10.5	3.1	5.2
N	2515	2515	2515	2515	2515	2515	2515

[a]t statistics in parentheses.

Table 4a

Structural Equation Estimates for Children's Growth and Health, Three Stage Least Squares[a]

Independent Variables[b]	Height	Weight	Head Circumference	Colds
	Dependent Variables			
Protein^	.087 (4.39)		.22 (11.76)	.01 (1.49)
Calories^		.002 (5.02)		
Vitamin C^				.011 (.10)
Age	.84 (31.52)	.09 (5.71)	.24 (8.57)	-.17 (-8.6)
Age squared	-.002 (-9.45)	.001 (5.10)	-.002 (-7.10)	.001 (6.91)
Sex	.48 (2.63)	.13 (1.28)	.36 (1.84)	-.82 (-6.11)
Birth weight	.003 (8.53)	.02 (11.06)	.002 (.72)	
Birth order	-.19 (-3.82)	-.07 (-4.21)	.10 (3.36)	
Mother's height	.51 (20.8)	-.11 (-.92)	.42 (23.96)	
Father's height	.40 (18.11)	-.06 (6.13)		
Mother's weight	.002 (1.03)	-.008 (5.61)	-.01 (-7.3)	
Race	1.24 (5.19)	3.1 (2.53)	-.71 (-3.24)	
Income				-.001 (-6.44)
Household size				.06 (1.86)
Schooling 2				.72 (-4.90)
Schooling 3				-1.40 (-6.83)
Schooling 4				-.79 (-2.84)

[a] N = 2515

[b] ^ indicates endogenous variable.

TABLE 4b

Elasticities of Selected Variables[a]

Independent Variables[b]	Dependent Variables: Height	Weight	Head Circumference
$\hat{\text{Protein}}$	.05		.25
$\hat{\text{Calories}}$		.20	
Age	.38	.42	.21
Birth weight	.004	.16	.005
Mother's weight	.004	.07	.01
Mother's height	.33	.46	.54
Father's height	.27	.27	
Race	.003	.001	-.005
Sex	.003	.004	.003

[a]Computed at mean values of dependent and independent variables.

[b] ^ indicates endogenous variable.

of the diet. Protein and calories are highly colinear (r = .82) so a good portion of the protein influence is captured by the calorie variable. An argument with a similar framework explains why protein appears in the height and head growth equations while calories does not.[9]

In elasticity terms the most important variables in the growth equations are children's age and height of the mother and height of the father. These results were expected and demonstrate again the importance of variables beyond the influence of the household decision maker in the children's growth process. A result that is surprising is the rather substantial elasticities of children's growth with respect to nutrient intakes. The elasticities (at the means) of height and head circumference with respect to protein are .05 and .25, respectively, and the elasticity of weight with respect to calories is .20. These results imply that an increase in daily protein consumption of ten percent or about five and one-half grams would increase height by an average of one-fifth of one inch and head circumference by an average of one-half of one inch. A ten percent increase in calorie intakes would increase children's weight by an average of seven-tenths of one pound. The protein elasticities in the height and head circumference equations seem particularly large in light of the fact that protein intakes average more than twice dietary standards. The protein effects on growth seem to be linear throughout the range of intakes characterizing the HANES working sample: that is, we do not appear to be approximating a non-linear protein effect with a very small impact on growth at the margin.[10]

These substantial elasticities of growth with respect to nutrients that are consumed in excess of dietary standards is consistent with the findings of the evaluation of the Special Supplemental Food Program for Women, Infants and Children (WIC). This analysis showed that although children in poor American households generally consumed nutrients well in excess of dietary standards, their growth could be accelerated by increasing nutrient intakes. In light of these findings the WIC evaluators recommended a reassessment of dietary standards and singled out protein in particular (Edozien, et.al., 1976).

C. Nutrient Intake Equations

The simultaneous equation estimates of the protein, calorie, and vitamin C equations are presented in Table 5. The results are similar for each of the nutrients. Simply stated they indicate, within the context of our model, that children get the amount of these nutrients that they "ask for." The child's demand for nutrients, represented by weight of the child, is a very important determinant of intakes. The nutrient-weight elasticities are about one in each case and the t-values of the weight coefficients are substantial. The family income coefficients approach statistical significance but imply very small elasticities (about .02 in each case).

Education of the household head has a positive but nonlinear effect on nutrient intakes. Children in families where the head has 12 years of schooling receive about five percent more of these nutrients relative to children in families where the head has less than 12 years of schooling. However, this education differential falls when children in families where the head has college or graduate education are compared to children in families where the head has less than 12 years of schooling.

V. Summary

A primary purpose of this paper was to investigate the extent to which family income and education are obstacles to the provision of adequate diets for young children in the United States. Based on our examination of the HANES data we have found that:

1. Average nutrient intakes of young children are well above recommended dietary standards, with the exception of iron.

TABLE 5a

Structural Equation Estimates for Children's Nutrient Intakes[a]

Independent Variables[b]	Dependent Variables		
	Protein	Calories	Vitamin C
Weight (^)	4.03 (12.78)	78.80 (10.36)	.89 (.93)
Age	-.18 (-1.06)	11.43 (2.80)	2.24 (4.27)
Age squared	-.003 (-1.9)	-.02 (-5.07)	-.002 (-4.89)
Sex	2.25 (2.38)	111.1 (4.89)	9.30 (2.65)
Income	.001 (1.92)	.003 (1.46)	.001 (3.03)
Household size	.60 (3.32)	14.27 (3.13)	-.95 (-1.12)
Schooling 2	2.32 (2.68)	82.1 (3.71)	6.01 (1.47)
Schooling 3	2.39 (2.28)	52.6 (1.94)	15.35 (2.93)
Schooling 4	.09 (.05)	-23.1 (-.56)	9.71 (1.21)
Sex of head	-.02 (-.03)	17.72 (.70)	-2.87 (-1.16)

[a]N = 2515.

[b]^ indicates endogenous variable.

Table 5b

Elasticities of Selected Variables[a]

Independent Variables[b]	Dependent Variables	
	Protein	Calories
$\hat{\text{Weight}}$	1.11	.80
Age	.31	.32
Sex	.02	.04
Income	.02	.02
Household Size	.05	.05

[a]Computed at mean values of dependent and independent variables.

[b]^ indicates endogenous variable.

2. Average nutrient intakes for children in households of lower economic status are very similar to intakes of children in households of higher economic status. Rates of children's growth are also similar in these households.

3. Family income and education of the household head have statistically significant but very small positive effects on the nutrient intake levels of young children in the model of children's diet, growth, and health estimated in this paper.

These findings are very consistent with those from a similar analysis we performed with the Ten State Nutrition Survey. A most interesting result of the present study is the rather substantial estimated effects of protein intakes on children's height and head growth, even though protein is consumed well in excess of dietary standards. This finding and the apparent correlation between children's growth and their intellectual development brings to question the adequacy of present protein standards. Could American mothers, who provide very high protein diets for their children in households at all levels of socioeconomic status know more about what constitutes an adequate diet for their children than the experts do?

Footnotes

[1]For examples of research into the problem of undernutrition in American school and pre-school children in the U.S., see Christakis (1968), Owen (1969), Sims and Morris (1974), and Owen (1974).

[2]Owen (1977), in his review of the effects of nutrition on growth and cognitive development, concludes that the "evidence, which still should be considered preliminary in nature, ... [indicates] that bigger is smarter, at least among pre-school children."

[3]More formally, it could be argued that rates of children's growth enter the utility function in a non-linear fashion and that excessive rates of growth (e.g. obesity) are negatively related to parent's utility.

[4]It is often pointed out that in agricultural societies parents are very concerned about the size of their children because physical strength is an important correlate of individual output. Although a desire for larger children in modern societies may not be based on a similar observation, there is evidence that the height or weight of children at younger ages correlate with their intellectual development and health in later years, and thus with their future earnings.

[5]The dietary standards cited in the text are those of the HANES dietary standards committee for children 24-47 months weighing the sample mean of 15.5 kilograms.

[6]As computed in HANES, the poverty index ratio takes account of household income, household size, and household diet requirements as reflected by the age distribution of the household members.

[7]Adjusted R^2's increased by less than .01 when the socioeconomic variables were added to either height, weight, or head size regressions that already contained age, the square of age, sex, parent's height, birthweight and birthorder. It should also be pointed out that the limited significance of the socioeconomic variables does not appear to be due to colinearity with the genetic and parental trait variables. The t-values of the socioeconomic variables do not increase markedly even when the genetic and parental trait variables are excluded from the children's growth equations.

[8]The results for the colds variable are also presented in Table 4 but are not discussed in the text. Household income and education of the household head are inversely related to the number of children's colds while protein and vitamin C intakes do not have statistically significant impacts.

[9]Because the growth equations formed part of a simultaneous system traditional F tests could not be employed to test the individual and joint contributions of the protein and calorie variables. Results from OLS regressions indicate that protein makes a significant incremental contribution to explaining the variance in height and head growth when added to regressions containing the other independent variables, while calories does not. When both diet variables are added jointly to height and head growth regressions the incremental contribution is insignificant. For the weight equation, the incremental contribution to explained variance is significant when the protein and calorie variables are entered individually or jointly to regressions containing the other independent variables.

[10]Predicted protein and the square of predicted protein were entered as independent variables in the height and head circumference equations in the final stage of a two-stage least squares process. No evidence of a non-linear protein effect was uncovered.

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